

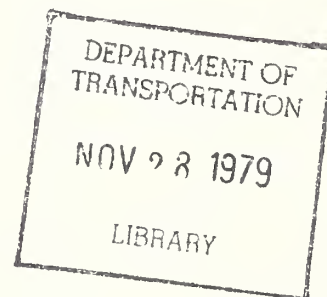
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# IMPROVED HYBRID COMPUTER VEHICLE HANDLING PROGRAM

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FINAL REPORT

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16. Abstract The Improved Hybrid Computer Vehicle Handling Program (IHVHP) is an extension of the Hybrid Computer Handling Program (HVHP) described in DOT-HS-802-059, Jul 1976. The computing tasks have been redistributed between the analog and digital computers. Many of the simplifications that existed in the HVHP have been removed. The equations of motion for the sprung and unsprung masses of a vehicle have been expanded to include higher order terms and large pitch and roll angles. Numerous geometric and kinematic calculations have been modified to include large pitch and roll angles. The hybrid computer simulation for vehicle handling studies has been in use for 6 years and can simulate (a) independent front and rear axles, (b) independent front with solid rear axle, (c) independent front and solid rear axle with dual rear tires, (d) solid front and rear axles, and (e) solid front and rear axles with dual rear tires. For validation purposes, braking, steering, and combinations of braking and steering were put into the simulated mathematical model; the simulation time histories were then compared to fullscale test data. The hybrid vehicle handling program can be used for general studies of vehicle dynamics. Performance of the National Highway Traffic Safety Administration (NHTSA) standard passenger car Vehicle Handling Test Procedures (VHTP's) and calculation of the associated performance comparison variables (PCV's) are simulation options. A special interactive user's interface allows program use by vehicle engineers as well as by computer specialists.			
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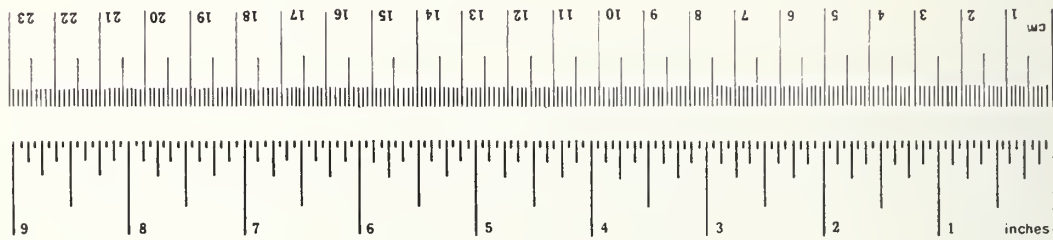
# METRIC CONVERSION FACTORS

## Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
<b>AREA</b>				
m <sup>2</sup>	square inches	6.5	square centimeters	cm <sup>2</sup>
ft <sup>2</sup>	square feet	0.09	square meters	m <sup>2</sup>
yd <sup>2</sup>	square yards	0.8	square meters	m <sup>2</sup>
mi <sup>2</sup>	square miles	2.6	square kilometers	km <sup>2</sup>
	acres	0.4	hectares	ha
<b>MASS (weight)</b>				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons	0.9	tonnes	t
<b>VOLUME</b>				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft <sup>3</sup>	cubic feet	0.03	cubic meters	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.76	cubic meters	m <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

## Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
km	kilometers	1.1	yards	yd
		0.6	miles	mi
<b>AREA</b>				
cm <sup>2</sup>	square centimeters	0.16	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	1.2	square yards	yd <sup>2</sup>
km <sup>2</sup>	square kilometers	0.4	square miles	mi <sup>2</sup>
ha	hectares (10,000 m <sup>2</sup> )	2.5	acres	
<b>MASS (weight)</b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
<b>VOLUME</b>				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m <sup>3</sup>	cubic meters	35	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.3	cubic yards	yd <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



\*1 in = 2.54 (exact). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price \$2.25, SO Catalog No. C13.10-286.

## ABSTRACT

The Improved Hybrid Computer Vehicle Handling Program (IHVHP) is an extension of the Hybrid Computer Handling Program (HVHP) described in DOT-HS-802-059, Jul 1976. The computing tasks have been redistributed between the analog and digital computers. Many of the simplifications that existed in the HVHP have been removed. The equations of motion for the sprung and unsprung masses of a vehicle have been expanded to include higher order terms and large pitch and roll angles. Numerous geometric and kinematic calculations have been modified to include large pitch and roll angles.

The hybrid computer simulation for vehicle handling studies has been in use for 6 years and has been validated for a large class of two-axle vehicles. The following suspensions can be simulated: (a) independent front and rear axles, (b) independent front with solid rear axle, (c) independent front and solid rear axle with dual rear tires, (d) solid front and rear axles, and (e) solid front and rear axles with dual rear tires.

For validation purposes, braking, steering, and combinations of braking and steering were put into the simulated mathematical model, and the simulation time histories were then compared to full-scale test data.

The hybrid vehicle handling program can be used for general studies of vehicle dynamics. Performance of the National Highway Traffic Safety Administration (NHTSA) standard passenger car Vehicle Handling Test Procedures (VHTP's) and calculation of the associated performance comparison variables (PCV's) are simulation options. A special interactive user's interface is available to allow program use by vehicle engineers as well as by computer specialists.



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## Section 1

### SUMMARY AND INTRODUCTION

#### 1.1 SUMMARY

This document presents the latest version of the National Highway Traffic Safety Administration (NHTSA) Improved Hybrid Computer Vehicle Handling Program (IHVHP), which is operational at the Applied Physics Laboratory of The Johns Hopkins University (APL/JHU). The IHVHP evolved from the Hybrid Computer Vehicle Handling Program (HVHP), which is described in Ref. 1. Many refinements have been incorporated into the current simulation, the major changes being that (a) the equations of motion for the sprung and unsprung masses of a vehicle have been expanded to include higher order terms and large pitch and roll angles and (b) numerous geometric and kinematic calculations have been modified.

#### 1.2 INTRODUCTION

APL first became involved in the prediction of vehicle dynamic performance via simulation in May 1972. At that time, NHTSA requested APL to move an existing vehicle simulation operational on the hybrid computer from the Bendix Research Laboratories (BRL) to APL (Refs. 2 and 3). NHTSA's reason for moving the simulation was to make it available to all NHTSA contractors for vehicle

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Ref. 1. P. F. Bohn and R. J. Keenan, Hybrid Computer Vehicle Handling Program -- Second Edition, DOT-HS-802-059, Applied Physics Laboratory, The Johns Hopkins University, July 1976.

Ref. 2. Vehicle Handling, Final Report, Vol. II, Technical Report, DOT HS-800-282, Bendix Research Laboratories, Southfield, Michigan, April 1970.

Ref. 3. Computer Simulation of Vehicle Handling, DOT HS-800-789, NHTSA Control FH-11-7563, Bendix Research Laboratories, Southfield, Michigan, September 1972.

research. APL reprogrammed the BRL simulation for its hybrid computer without changing the model; the result was published in Ref. 4. The derivation of the original HVHP model is presented in Ref. 5.

Work with NHTSA contractors began in July 1973, when APL started providing simulation service to the Calspan Corporation on the NHTSA research on the effects of tire properties on vehicle handling (Ref. 6). During the work with Calspan, two primary simulation modifications were completed by APL:

- A very flexible user interface for interactive simulation control designed at APL was added, and
- A new tire force and moment model specified by Calspan was added.

Also added to the simulation about this time was the capability automatically to initialize the simulation to perform any of the six Vehicle Handling Test Procedures (VHTP's) and to collect and process the data required to calculate the vehicle performance comparison variables (PCV's). These VHTP's and PCV's were originally developed by the Highway Safety Research Institute (HSRI), University of Michigan (Refs. 7 and 8) and restated for computer

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Ref. 4. P. F. Bohn, R. J. Keenan, and J. Prowznik, Operational Hybrid Computer Simulation for Vehicle Handling Studies, DOT HS-800-764, Applied Physics Laboratory, The Johns Hopkins University, September 1972.

Ref. 5. F. Jindra, Mathematical Model of Four-Wheel Vehicle for Hybrid Computer Vehicle Handling Program, DOT HS-801-800, Ultrasystems, Inc., The Dynamic Science Division, October 1975.

Ref. 6. Research on the Influence of Tire Properties on Vehicle Handling, Final Report, Contract DOT HS-053-3-727, Calspan Corporation, June 1974.

Ref. 7. R. D. Ervin, P. Grote, P. S. Fancher, C. C. Mac-Adam, and L. Segel, Vehicle Handling Performance, DOT HS-800-758, Highway Safety Research Institute, University of Michigan, November 1972.

Ref. 8. P. S. Fancher, R. D. Ervin, P. Grote, C. C. Mac-Adam, and L. Segel, Limit Handling Performance as Influenced by Degradation of Steering and Suspension, DOT HS-800-761, Highway Safety Research Institute, University of Michigan, November 1972.

implementation by APL (Ref. 9). The result of this work was the HVHP documented in Ref. 10.

The computer program was further extended in 1974 by the Dynamic Science Division of Ultrasystems, Inc., to simulate features of recreational vehicles (Ref. 11). These features included aerodynamic effects, solid front axle, dual rear wheels, and four-wheel drive.

The HVHP model equations describing tire-road reaction moments about the kingpin axis were modified during a recent roadway disturbance study conducted by Systems Technology, Inc. (Ref. 12). The change was required to account for the effect of the tilt of the tire contact patch with respect to the horizontal plane.

These program modifications have been implemented and verified with full-scale vehicle test results. Currently, dynamic performance of vehicles of the following suspension types can be predicted by the IHVHP:

- Independent front and rear suspensions
- Independent front with solid rear axle
- Independent front and solid rear axle with dual rear tires
- Solid front and rear axles
- Solid front and rear axles with dual rear tires

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Ref. 9. P. F. Bohn, "Modeling and Simulation in Vehicle Handling," DOT HS-82-306, Vehicle Safety Research Integration Symposium, Applied Physics Laboratory, The Johns Hopkins University, 30 May 1973.

Ref. 10. P. F. Bohn and R. J. Keenan, Hybrid Computer Vehicle Handling Program, DOT HS-801-290, Applied Physics Laboratory, The Johns Hopkins University, July 1974.

Ref. 11. Handling Test Procedures for Light Trucks, Vans, and Recreational Vehicles, Final Report, DOT HS-801-824, Ultrasystems, Inc., The Dynamic Science Division, February 1976.

Ref. 12. Influence of Roadway Disturbances on Vehicle Handling, Final Report, DOT HS-802-210, Systems Technology, Inc., February 1977.

Validation of each suspension type has been accomplished by comparison of simulation and full-scale test data.

In its work with NHTSA contractors, APL has added to the simulation model any refinements required by a contractor to complete his research successfully; the simulation has proven to be economical for vehicle dynamic performance prediction. User experience with the IHVHP has shown that, while performing parametric runs, 500 s of vehicle motion can be simulated in 1 h of computer use. This translates to a cost of less than \$0.50/s of simulated motion and represents a 50% utilization of the available computing time. Since this simulation, running at one-fourth real time, is capable of 900 s of simulated motion per hour, approximately 50% of the time is utilized for observing data and changing parameters. The \$0.50/s should be viewed as the current lower cost limit.

For program debugging and model checkout, fewer runs are made in a given time period than when parametric data are being produced. Therefore, the cost per second of simulated motion would increase. However, general experience has indicated that on-line data observation for debugging decreases the total time required for program checkout. During the debug phase, IHVHP cost usually ranges between \$1.00 and \$2.00/s of simulated motion, with a decreasing trend toward the \$0.50/s cost.



## Section 2

### IMPROVED HYBRID COMPUTER VEHICLE HANDLING PROGRAM

#### 2.1 INTRODUCTION

This section describes the Improved Hybrid Computer Vehicle Handling Program (IHVHP). The basic mathematical model, contained in Appendix A, is described in terms of 17 degrees of freedom (DOF). The perturbing forces and moments that act on the vehicle are also considered. The simulation implementation and validation are discussed.

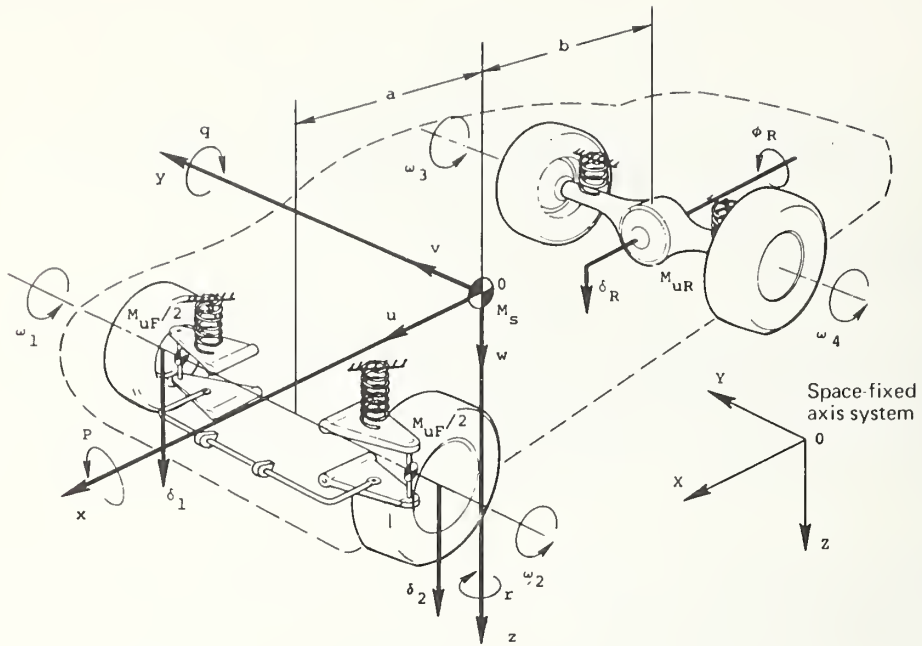
#### 2.2 SIMULATION

##### 2.2.1 Mathematical Model

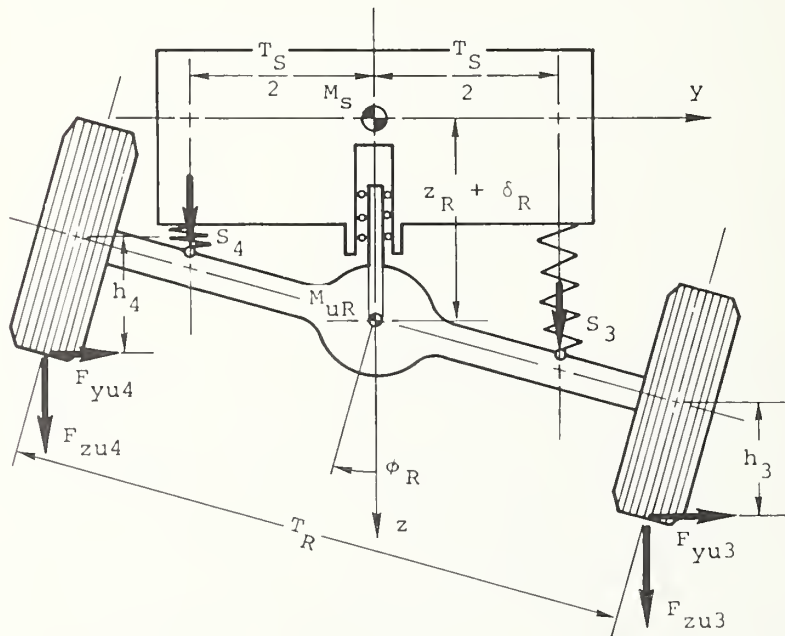
The simulated vehicle is represented by a 17-DOF model that consists of

- A basic 6-DOF model of the vehicle sprung mass
- A 2-DOF front wheel or front axle model
- A 2-DOF rear wheel or rear axle model
- A 3-DOF steering system model
- A 4-DOF wheel rotational dynamics model

The 6 DOF's of the sprung mass model are the 6 standard translational and rotational DOF's of a body moving in inertial space: translation along three axes and rotation about each axis. The 2 front wheel DOF's represent the motion of the front unsprung masses. For an independent front suspension, the 2 DOF's are the vertical motion of each front wheel. If the front suspension represents a solid axle configuration, the 2 DOF's are the rotation and vertical motion of the front axle. The 2 rear wheel DOF's are analogous. An analytical representation of the vehicle model showing independent front and solid rear axle suspensions is illustrated in Fig. 2-1. A solid rear axle representation is presented in Fig. 2-2.



**Fig. 2-1 Analytical Representation of the Vehicle Model**



**Fig. 2-2 Analytical Representation of the Solid Rear Axle Model**

The vehicle model allows the following options:

- Independent rear suspension (two rear unsprung masses) with 2 DOF's corresponding to the vertical motion of each rear wheel,
- Solid front axle (front unsprung mass) with 2 DOF's corresponding to the vertical motion and rotation of the front axle, and
- Dual tires on a solid rear axle with either independent front suspension or solid front axle.

Inertial coupling between the sprung mass and the front and rear unsprung masses is considered, but external forces and moments due to rolling resistance and gyroscopic effects of the rotating parts are neglected.

The steering system is represented by a lumped parameter model with 3 DOF's corresponding to the rotational motion of each front wheel about its steering pivot and translational motion of the connecting steering rod and associated mass elements. The effects of steering system friction and compliance are included. The tire moments about each kingpin axis are functions of the circumferential and side tire forces, tire aligning torque, the inclination and caster of the kingpins, and the caster trail effects of the tires. Steering wheel displacement is the steering system input.

Four additional DOF's (for the total of 17) are contained in the rotational equations of motion about the spin axis of each wheel. These equations, which include the differential effects of the front or rear wheels, yield the wheel rotation rates from which slip and, in turn, the circumferential and lateral friction coefficients are computed. The differential equations for wheel rotation are assumed to be isolated from the coupled differential equations of motion of the sprung and unsprung masses, but inertial interaction between the drive wheels is included.

Forces are transmitted between the sprung and unsprung masses through the suspension system. The suspension forces include spring effects, shock absorbers, auxiliary roll stiffness, coulomb friction, and "anti" forces such as antipitch and antiroll. The suspension deflections are calculated relative to the suspension equilibrium position, which varies with vehicle weight. The angular orientation (camber angle, toe angle, caster angle) of an independently suspended wheel relative to the vehicle body is specified as a function of the suspension deflection. These functions

are input relative to the equilibrium vehicle suspension position and then corrected to the new equilibrium position for varying vehicle weight configurations. Compliance coefficients are used to relate the change in camber angle and steer angle with applied forces and moments at the tire. Provisions are also incorporated to investigate the effects of degraded suspension components.

The force of gravity, aerodynamic forces and moments, and tire forces and moments generated at the tire-road interface are considered the only important externally applied forces and moments acting on the vehicle. The tire forces include the normal force arising from radial tire deflection, the side force due to slip angle and inclination angle, and the circumferential force arising from applied torque. Since the roadway is treated as a flat horizontal plane, a "point-contact" representation of the tire is used to obtain the radial loading. The circumferential force calculation uses a two-straight-line approximation of friction coefficient-slip behavior. The side force calculations are based on slip-angle and inclination-angle properties of the tires that are saturated at large angles. Interaction between circumferential and side forces utilizes a modified "friction-ellipse" concept that "rolls off" side force as a function of tire slip. The rolloff characteristic is an empirical relationship obtained from tire test data. The tire-aligning torque and overturning moment are modeled as non-linear functions of lateral force, normal force, and inclination angle. To account for differences in tire characteristics at the front and rear wheels, provisions are made to input separate parametric sets for front and rear tires.

Open-loop control inputs can be entered in the form of steering wheel angle and drive or brake torque. The drive torque is generated to maintain a constant velocity of the vehicle. The brake torque magnitude is determined from input data functions of brake line pressure at the front and rear wheels. Since the equations of motion are written in terms of a moving vehicle's axis system, a coordinate transformation is required to relate the vehicle's position and orientation with respect to an orthogonal coordinate system fixed in space.

### 2.2.2 Allocation of Analog and Digital Computer Tasks

Since the model is solved on a hybrid computer, it must be subdivided into equations to be solved on the analog computer and those to be solved on the digital computer. Computing tasks were allocated using the following guidelines:

- Function generation requiring extensive algebraic calculations or references to tables of values should be performed on the digital computer.
- System variables determined from the solution of differential equations should be graded according to response time (time constant). The differential equations representing the fastest variables should be solved on the analog computer and the remaining equations solved on the digital computer.

Slight compromises to the task allocation as determined by the above rules were required due to limitations in digital computer computation speed, numbers of analog computer computation modules, and available analog-to-digital and digital-to-analog data communication modules.

The present allocation of computing tasks between the analog and digital computers is presented in Fig. 2-3. Calculated in the digital portion are the longitudinal wheel slip, circumferential coefficient of friction, wheel orientation angle equations, and tire force equations, as well as wheel brake and drive torques, velocities of the tire contact point, and resultant forces and moments.

The analog computations include the suspension forces, shock absorber and wheel sprung functions, and wheel spin velocities. In addition, the equations of motion of the sprung and unsprung masses and steering system equations are solved on the analog computer.

The hybrid simulation is time scaled to run normally at one-fourth real time, i.e., 20 s of clock-on-the-wall time is required for 5 s of vehicle simulation. However, one-half real-time operation, with subsequent cost savings, is possible.

### 2.2.3 Implementation of the Mathematical Model

2.2.3.1 Analog Portion. The APL/JHU hybrid computer facility (Appendix B) contains analog machines manufactured by Electronic Associates, Inc. (EAI). The portion of the model programmed on the analog computer is divided between models of EAI analog computers. The entire steering system is contained on an EAI 231-R, and the rotational wheel dynamics, equations of motion, and suspension dynamics are contained on an EAI 680. Data communication with the digital computer is provided by 24 multiplying digital-to-analog converters (MDAC's), 24 nonmultiplying DAC's, and 48 analog-to-digital converters (ADC's). The system contains a control interface

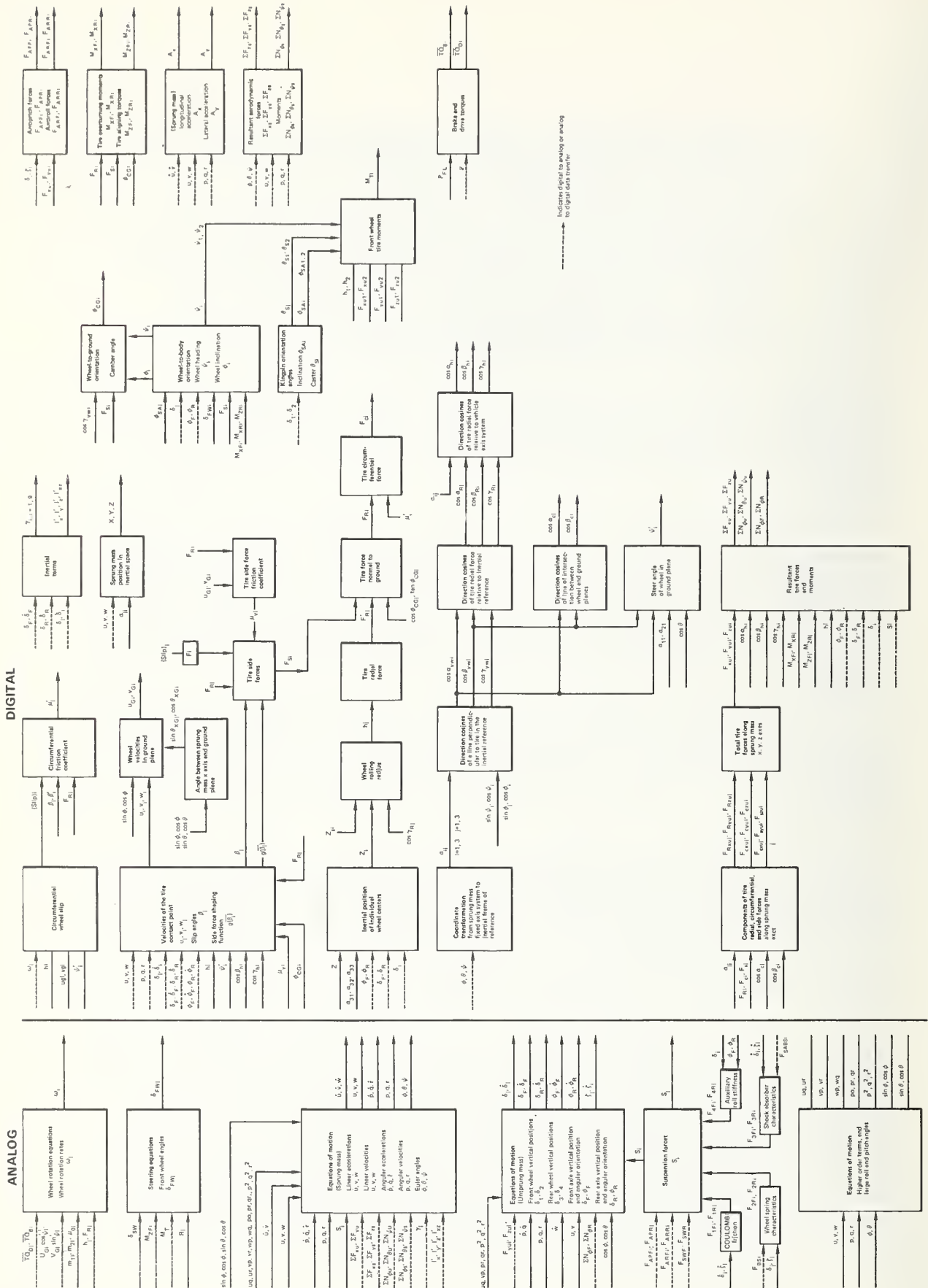


Fig. 2-3 Hybrid Simulation Block Diagram of the IHVHP Model

that allows complete control of the 680 analog computer and data interface by the digital computer.

To expedite setup and checkout of the analog portion, a static analog test program for three suspension configurations was used:

- Independent front and rear
- Independent front with solid rear axle
- Solid front and rear axles

This was accomplished by programming the mathematical model equations solved on the analog computer as a digital simulation language program (Ref. 13). The digital program output provided an independent check of the simulation. The static check results verify that the programmed analog portion of the simulation represented the particular vehicle mathematical model equations.

2.2.3.2 Digital Portion. The APL/JHU hybrid computer facility (Appendix B) uses an IBM 360/91 for digital calculations. Model coding is performed in the Fortran IV language. Model calculations not assigned to the analog computers are performed digitally.

## 2.3 USER'S INTERFACE

The interface between the engineering user and the computer has been designed to maximize user control and information retrieval from the hybrid computer (Ref. 14). The interface has been implemented by a set of generalized input/output subroutines. Using these communication routines, the following necessary tasks can be accomplished interactively at the CRT hybrid control console:

- Interrogation of any digital variable, including arrays, by name,
- Assignment of new values to any digital parameter or initial condition,

---

Ref. 13. P. F. Bohn, "Simulation Language Generated Static Checks for Hybrid and Analog Simulations," Simulation, September 1971.

Ref. 14. K. W. Colby and P. F. Bohn, "Generalized Man/Machine Communication Subroutines for Hybrid Simulation," Proceedings of the Summer Computer Simulation Conference, July 1974.

- Tracking and printing the values of any digital variable as a function of time,
- Printing the end-of-run values of any digital variable or parameter,
- Performing automatically a group of parametric runs varying one or more parameters or initial conditions by an arbitrary amount,
- Assigning new digital variables to the DAC's and ADC's,
- Rescaling the digital variables output on the DAC's or input on the ADC's,
- Notating the computer output with observations pertinent to the computer runs, and
- Printing the value of all digital variables on command.

The usefulness of these routines is augmented by the following features:

- The output unit for all digital computer responses is selectable (line printer, CRT, or both).
- Extensive subroutine error recovery allows operation by untrained personnel.
- Free format input obviates the need to always insert decimal points, spaces, etc., which is required by Fortran syntax.

An explanation of the modules that are the building blocks of the routines, as well as a discussion of interaction, is presented in Appendix C.

#### 2.4 VHTP MANEUVERS AND PERFORMANCE COMPARISON VARIABLES

Due to the importance of handling test procedures in vehicle research, the IHVHP was programmed to perform automatically those test procedures defined for passenger cars (Ref. 9). The associated performance comparison variables (PCV's) for the Vehicle Handling Test Procedures (VHTP's) are also automatically calculated. Since test procedures generally employ the input commands of braking, steering, and combinations of braking and steering, the IHVHP implementation can generally be used to generate test procedures for all



type of vehicles. The PCV's are less general and refer specifically to the National Highway Traffic Safety Administration (NHTSA) passenger vehicle VHTP's defined in Ref. 9.

#### 2.4.1 VHTP Maneuvers

The simulation has the capability of self-initializing to perform any of the six automobile VHTP maneuvers and of calculating the PCV's appropriate for the selected VHTP. Using the communication routines, a VHTP is selected by addressing the Fortran variable VHTPNO and assigning it a value from 1 to 6. The value of 0 is reserved for a special check run that verifies correct dynamic operation of the simulation. Once a VHTP has been selected, the system forcing function pertinent to the VHTP can be accessed. For all VHTP's, the Fortran variable PFL represents brake line pressure. For VHTP's 2 to 6, the steering wheel input has the Fortran name STR2, STR3, etc. The names PFL, STR2, etc. can be used in the multiple-run routine to simulate a series of VHTP tests in which the brake line pressure or steering wheel input is incremented. By convention, when a VHTP is selected in which the steering input is normally a parameter (VHTP 2, 4, or 5), the STR variable contains the steering wheel rotation required to input  $2.0^\circ$  of normalized steer. This value is required for run series in which the steering is incremented.

#### 2.4.2 VHTP Performance Comparison Variables

PCV's are output in both the single-run and multiple-run modes. If a single run is executed, a general comparison variable format is selected in which all PCV's are output. However, only those pertinent to the selected VHTP will be nonzero. If a series of runs is executed, the output is in a tabular format with the forcing function (steering wheel angle or brake line pressure) starting in the left column followed by the pertinent PCV's. An example is presented in Fig. 2-4, in which the following occur:

1. VHTP is selected.
2. The STR4 variable is interrogated to determine the steering wheel rotation for  $2^\circ$  of normalized steer.
3. The steering wheel input is set equal to  $300^\circ$ .
4. A single run is executed.

```

TERMINAL ACTIVE
      HYBRID VEHICLE HANDLING PROGRAM
HYBRID COMPUTER PROB# 91
CARNEW LOAD MODULE
DODGE71 VEHICLE

```

```

ENGAGE PATCH PANEL FOR TEST
TYPE CR WHEN READY

```

```

****
MAY      12 1976
TIME 11:15: 0.46
OPTION
**** F
ENTER
**** VHTPNO 4
****
OPTION
**** IC
OPTION
**** F
ENTER
**** STR4
      27.93
**** STR4 300
****
OPTION
**** X
MAY      12 1976
TIME 11:16: 0.94
RUN 1 HAS STARTED
OUTPUT BELOW
AXAV= 0.0 DECL TIME= 0.000 AVCUR= 0.720 BTDMAX= 0.222 BTMAX= 0.171 DELBT= 0.172
AYMAX= 0.762 PHIMAX= 7.754 RMAX= 0.572 LANE CHNG DEL= 0.0 DELPSI= 0.0 MAX STEER= 300.000
FTRQMAX= 0. RTRQMAX= 0.

```

```

OPTION
**** F
ENTER
**** VHTPNO 4
****
OPTION
**** MULTI
NUM OF LOOPS,VARS
**** 4 1
VAR
**** STR4
LOOP,VAL,INC
**** 1 27.9 27.9
****
OPTION
**** XM
MAY      12 1976
TIME 11:17:24.42
RUN 2 HAS STARTED
OUTPUT BELOW

```

MULTI	TOTAL	STR4..(	1)	BETAMX(	1)	BETDMX(	1)	CUVRAT(	1)	AYMAX..(	1)	RMAX..(	1)
1	2	27.9		0.363E-02	0.123E-01	0.579E-01	0.754E-01	0.431E-01					
2	3	55.8		0.104E-01	0.331E-01	0.150	0.187	0.114					
3	4	83.7		0.196E-01	0.538E-01	0.247	0.305	0.184					
4	5	112.		0.340E-01	0.761E-01	0.344	0.422	0.256					

```

OPTION
**** TERM
MAY      12 1976
TIME 11:19:11.53
PROGRAM TERMINATED

```

Fig. 2-4 IHVHP User's Interactive Control

5. A run series of four runs is set up with STR4 initialized to 2° normalized steer (NS) and incremented by 2° NS in each run.
6. A multiple run is executed.
7. The program is terminated.

A representative parametric run series for each VHTP is presented in Figs. 2-5 through 2-10. PCV graphs for four vehicles are presented in Appendix D.

## 2.5 VALIDATION

Through cooperative research efforts with different NHTSA contractors, the Hybrid Computer Vehicle Handling Program (HVHP) has been validated at least once for each type of suspension configuration and many times for the standard American passenger car suspension. In each case, validation consisted of the contractor comparing simulation and full-scale test time history responses. Therefore, in addition to APL validation, the HVHP performance has been examined by engineers with extensive backgrounds in vehicle handling.

The IHVHP evolved from the HVHP. The major improvements and refinements are discussed in Subsection 2.5.1.6. For validation purposes, the IHVHP was exercised for each type of suspension configuration. Comparisons of the IHVHP simulation results (transient and steady-state) with previously obtained HVHP simulation results showed acceptable agreement between the two programs.

### 2.5.1 NHTSA Research Programs

The following paragraphs summarize the completed NHTSA research programs in which the HVHP and IHVHP were used.

2.5.1.1 Passenger Car Tire Effects Program. The HVHP was used extensively for vehicle simulation while APL worked cooperatively with the Calspan Corporation on DOT contract HS-053-3-727 (Ref. 6). For this contract, "Research on the Influence of Tire Properties on Vehicle Handling," Calspan was responsible for refining the tire/road interface model that APL incorporated into the HVHP. Calspan monitored the simulation modification and examined the output for authenticity.

```

OPTION
**** F
ENTER VHTPND 1
****
**** VHTPND 1
OPTION
**** IC
OPTION MULTI
**** MULTI
NUM OF LOOPS,VARS
**** 4 1
VAR
**** PFL
LOOP/VAL,INC
**** 1 300 100
****
OPTION XM
**** XM
MAY 10 1976
TIME 10:54:25.90
RUN 7 HAS STARTED
OUTPUT BELOW
MULTI TOTAL PFL... ( 1) AXAVE.( 1) TIMDEC( 1) AYMAX.( 1) SLIFI.( 1) SLIFI.( 2) SLIFI.( 3) SLIFI.( 4)
1 7 300. -0.417 2.74 0.128E-01 0.890E-01 0.889E-01 0.873E-01 0.869E-01
2 8 400. -0.556 2.05 0.110E-01 0.117 0.117 0.119 0.117
3 9 500. -0.650 1.76 0.335E-01 0.140 0.148 1.00 1.00
4 10 600. -0.654 1.74 0.226E-01 1.00 0.998 -1.00 1.00

```

Fig. 2-5 IHVHP Interaction for VHTP 1

```

OPTION
**** F
ENTER VHTPNO 2
****
****
OPTION IC
**** IC
OPTION MULTI
**** MULTI
NUM OF LOOPS/VARS
**** 4 1
VAR
**** PFL
LOOP,VAL,INC
**** 1 300 100
****
OPTION
**** XM 10 1976
MAY 15 9:20.16
RUN 3 HAS STARTED
OUTPUT BELOW
MULTI TOTAL PFL... (
1 3 300.
2 4 400.
3 5 500.
4 6 600.
1) AXAVE.( 1) Aymax.( 1) BETDMX( 1) CUVRAT( 1) SLIPI.( 1) SLIPI.( 2) SLIPI.( 3) SLIPI.( 4)
-0.422 0.300 0.252E-01 1.10 0.915E-01 0.825E-01 0.904E-01 0.813E-01
-0.533 0.300 0.479E-01 1.16 0.121 0.107 1.00 0.117
-0.666 0.300 0.580E-01 0.369 1.00 0.131 1.00 0.156
0.666 0.300 0.738E-01 0.209 1.00 0.999 1.00 1.00

```

Fig. 2-6 IHVHP Interaction for VHTP 2

```

OPTION F
*** F
ENTER VHTFNO 3
****
****
OPTION IC
*** IC
OPTION F
*** F
ENTER STR3 139
****
****
OPTION MULTI
*** MULTI
NUM OF LOOPS,VARS
**** 3 2
VAR
**** BPFN
LOOP,VAL,INC
**** 1 8 0
**** 2 10 0
**** 3 13 0
****
VAR
**** BMFS
LOOP,VAL,INC
**** 1 57.6 0
**** 2 48.0 0
**** 3 37.7 0
****
OPTION XM
*** XM
MAY 10 1976
TIME 15:43:28.49
RUN 2 HAS STARTED
OUTPUT BELOW
MULTI TOTAL EMFN..( 1) BMFS..( 1) Aymax.( 1) RMAX..( 1) CUVRATI 1) BETDMX( 1)
1 2 8.00 57.6 0.584 0.331 0.858 0.129
2 3 10.0 48.0 0.786 0.389 0.876 0.373
3 4 13.0 37.7 0.787 0.336 0.793 0.224

```

Fig. 2-7 IHVHP Interaction for VHTP 3

```

OPTION
**** F
ENTER
**** VHTFNO 4
****
OPTION
**** IC
OPTION
**** F
ENTER
**** STR4
27.93
****
OPTION
**** MULTI
NUM OF LOOPS,VARS
**** 4 1
VAR
**** STR4
LOOP,VAL,INC
**** 1 55.86 55.86
****
OPTION
**** XM 10 1976
MAY 11:11:1.18
RUN 18 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR4..(
1 18 55.9
2 19 112.
3 20 168.
4 21 223.
1) RETAMX( 1) BETDMX( 1) CUVRAT( 1) Aymax.( 1) RMAX..( 1)
0.105E-01 0.336E-01 0.150 0.189 0.115
0.346E-01 0.775E-01 0.346 0.425 0.257
0.709E-01 0.125 0.493 0.589 0.386
0.112 0.177 0.606 0.687 0.474

```

Fig. 2-8 IHVHP Interaction for VHTP 4

```

OPTION
**** F
ENTER VHTPNO 5
****
OPTION IC
OPTION F
ENTER STRS
      27.93
****
OPTION MULTI
NUM OF LOOPS, VARS
**** 4 1
VAR
**** STRS
LOOP, VAL, INC
**** 1 55.86 55.86
****
OPTION XM
MAY 10 1976
TIME 11:17:20.88
RUN 22 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STRS..( 1) Aymax.( 1) DEL..( 1) RETAMX( 1) DELFSI( 1) UIN... ( 1)
1 22 55.9 0.181 9.73 0.141E-01 0.903E-02 45.0
2 23 112. 0.386 6.40 0.411E-01 -0.135E-02 45.0
3 24 168. 0.525 4.54 0.629E-01 -0.142E-01 45.0
4 25 223. 0.640 5.88 0.136 -0.464E-01 45.0

```

Fig. 2-9 IHVHP Interaction for VHTP 5



```

OPTION
*** F
ENTER VHTPNO 6
***
OPTION
*** IC
OPTION
*** F
ENTER BRKON
0.5200
***
OPTION
*** MULTI
NUM OF LOOPS,VARS
*** 3 1
VAR
*** BRKOFF
LOOP,VAL,INC
*** 1 0.9 0.05
***
OPTION
*** XH
MAY 10 1976
TIME 16:40:10.20
RUN 2 HAS STARTED
OUTPUT BELOW
MULTI TOTAL FHTMAX( 1) PHIDMX( 1) RMAX..( 1) ZIMX..( 1) ZIMX..( 2) ZIMX..( 3) ZIMX..( 4) UIN..( 1) BRKOFF( 1)
1 2 0.748 0.455 -0.208E-02 0.676 0.157 0.530 50.0 50.0 0.900
2 3 0.721 0.455 -0.208E-02 0.671 0.151 0.331 50.0 50.0 0.950
3 4 0.682 0.455 -0.220E-02 0.660 0.151 0.334 50.0 50.0 1.00

```

Fig. 2-10 IHVHP Interaction for VHTP 6

In the performance of this research over 2000 simulated VHTP's were run. Four vehicles were simulated: Chevrolet Brookwood station wagon, Dodge Coronet, Pontiac Trans Am, and Volkswagen Superbeetle. For each vehicle, a complete set of VHTP's was performed using simulated original equipment (OE) tires. Parametric studies were then performed varying tire parameters to determine their effects on vehicle handling performance. The PCV graphs for the original equipment tire configuration runs are presented in Appendix D of this report.

2.5.1.2 VHTP's for Recreational Vehicles. The HVHP was used extensively for vehicle simulation while APL worked cooperatively with the Dynamic Science Division of Ultrasystems, Inc., on DOT contract HS-4-00853 (Ref. 11). For this research, "Handling Test Procedures for Light Trucks, Vans, and Recreational Vehicles," Dynamic Science was responsible for redefining the HVHP model to simulate a wider class of vehicles. During the course of the contract, the suspension options were broadened to permit simulation of any of the following suspension types:

- Independent front and rear
- Independent front with solid rear axle
- Independent front and solid rear axle with dual rear tires
- Solid front and rear axles
- Solid front and rear axles with dual rear tires

A model representing vehicle aerodynamic properties was also added at this time.

In the performance of the research, over 2500 recreational vehicle VHTP's were run and five vehicles were simulated: Ford F-250 pickup truck equipped with a representative 11-ft camper, Volkswagen Campmobile, Jeep Wagoneer, Open Road motor home (type C), and a Winnebago motor home (type A). Parametric studies were performed on these vehicles to determine appropriate handling test procedures for small trucks and recreational vehicles. This research effort is documented in Refs. 5 and 11.

2.5.1.3 Truck and Bus Tire Effects Program. The HVHP was used extensively for vehicle simulation while APL worked cooperatively with the Highway Safety Research Institute (HSRI), University

of Michigan, on DOT contract HS-4-00943 (Ref. 15). For this research, "Effects of Tire Properties on Truck and Bus Handling," HSRI provided APL with tire model refinements that simplified the simulation of truck tire forces and moments. Trapezoidal and sinusoidal steer VHTP's were performed using simulated OE tires. Parametric studies were then performed using the same VHTP's but varying tire parameters to determine their effects on vehicle handling performance.

In the performance of this research, over 1500 simulated VHTP's were run and four vehicles were simulated: Ford Econoline Van, Ford F-250 pickup truck, White tractor, and a GMC intercity bus.

2.5.1.4 Passenger Cars Pulling Trailers. The HVHP was used for vehicle simulation while APL worked cooperatively with Systems Technology, Inc. (STI) on DOT contract HS-4-00900 (Ref. 16). For this research, "Passenger Cars and Light Trucks Pulling Trailers," STI was responsible for defining a trailer model that was compatible with the HVHP and could be added to it. During the course of this research, a model of a one- or two-axle trailer connected to a tow vehicle with a ball hitch was incorporated into the HVHP. Braking, steering, and combined braking and steering simulation runs were performed. The simulated tow vehicle was a Chevrolet Caprice station wagon and the towed vehicle was a single-axle trailer.

2.5.1.5 Sublimit Performance Maneuvers. The HVHP simulation was modified to incorporate various steering and suspension degradations during a research study with STI (Ref. 17). The simulation results were used in the selection of maneuver and component degradation levels for full-scale vehicle testing.

2.5.1.6 Development of Vehicle Rollover Maneuver. During this research effort with the Calspan Corporation, the IHVHP evolved.

---

Ref. 15. Research on the Effects of Tire Properties on Truck and Bus Handling, Final Report, Contract DOT HS-4-00943, Highway Safety Research Institute, University of Michigan, June 1976.

Ref. 16. Research on Passenger Cars and Light Trucks Pulling Trailers, Final Report, Contract DOT HS-4-00900, Systems Technology, Inc., June 1976.

Ref. 17. Development of Vehicles - In-Use Sub-Limit Maneuvers, Final Report, Contract DOT HS-5-01191, Systems Technology, Inc., May 1977.

The computing tasks between the analog and digital computers were redistributed. Many of the simplifications that existed in the HVHP were removed. The major modifications are:

1. Expansion of the equations of motion for the sprung and unsprung masses to include the higher order terms,
2. Expansion of the calculation of inertial terms to include the time-varying effects of unsprung mass movements,
3. Modification of the calculation of Euler angles and vehicle position to eliminate the small-angle assumption for roll and pitch,
4. Modification of the calculation of the resultant forces and moments applied to the vehicle to eliminate the small-angle assumption for roll and pitch,
5. Modification of the calculation of wheel center height above the ground to allow large pitch and roll angles,
6. Modification of the calculation of tire contact point velocities to include time-varying unsprung mass positions,
7. Modifications of the calculations of wheel velocity in the ground plane to account for large pitch and roll angles,
8. Change of the computation of tire forces using tire force normal to the ground rather than tire radial force,
9. Modification of the wheel slip angle calculation to include the steer angle in the ground plane rather than the steer angle with respect to the vehicle, and
10. Modification of the calculation of camber angle with respect to the road to eliminate the small angle assumptions on vehicle pitch and roll.

In the past year, the IHVHP has been used for many NHTSA research efforts pertaining to vehicle handling during braking and/or steering maneuvers and is presently being used to study the influences of aerodynamic disturbances on vehicle handling, an NHTSA research study conducted by STI.

During the course of a recent study concerning passenger car braking performance, APL incorporated a Kelsey-Hayes Anti-Lock model into the IHVHP. The NHTSA study was conducted by HSRI which supplied the antilock math model.

## 2.5.2 Vehicle Handling Test Procedures

Time histories for a typical set of VHTP maneuvers are presented in Figs. 2-11 to 2-16. The vehicle simulated for these runs was the 1971 Dodge Coronet. A general discussion of IHVHP simulation output is presented in Appendix E.

2.5.2.1 Straight Line Braking. This run series determines the value of brake line pressure at which two wheels on the same axle lock up. For this vehicle, both rear wheels were locked at 500 psi and all four wheels were locked at 600 psi.

2.5.2.2 Braking In a Turn. This run series determines the value of brake line pressure at which two wheels on the same axle lock up while the vehicle is executing a constant 0.3-g turn. For this vehicle, the inside rear wheel was locked at 400 psi, both inside wheels were locked at 500 psi, and all four wheels were locked at 600 psi.

2.5.2.3 Turning On a Rough Road. For this run series, the vehicle traverses a bump grid while in a steady 0.4-g turn. Three grid frequencies are simulated: 9, 11, and 14 Hz.

2.5.2.4 Trapezoidal Steer. In this run series, trapezoidal steers of 4, 8, 12, and 16° of normalized steer angle were used. For this vehicle, 28° of steering wheel angle is required for 2° of normalized steer.

2.5.2.5 Sinusoidal Steer. In this run series, sinusoidal steers with a maximum amplitude of 4, 8, 12, and 16° of normalized steer angle were used. For this vehicle, 28° of steering wheel angle is required for 2° of normalized steer.

2.5.2.6 Drastic Steer and Brake. The purpose of these runs is to determine vehicle roll-over tendency. For this vehicle, a peak roll angle of 0.14 rad and a peak roll rate of 0.75 rad/s were achieved.

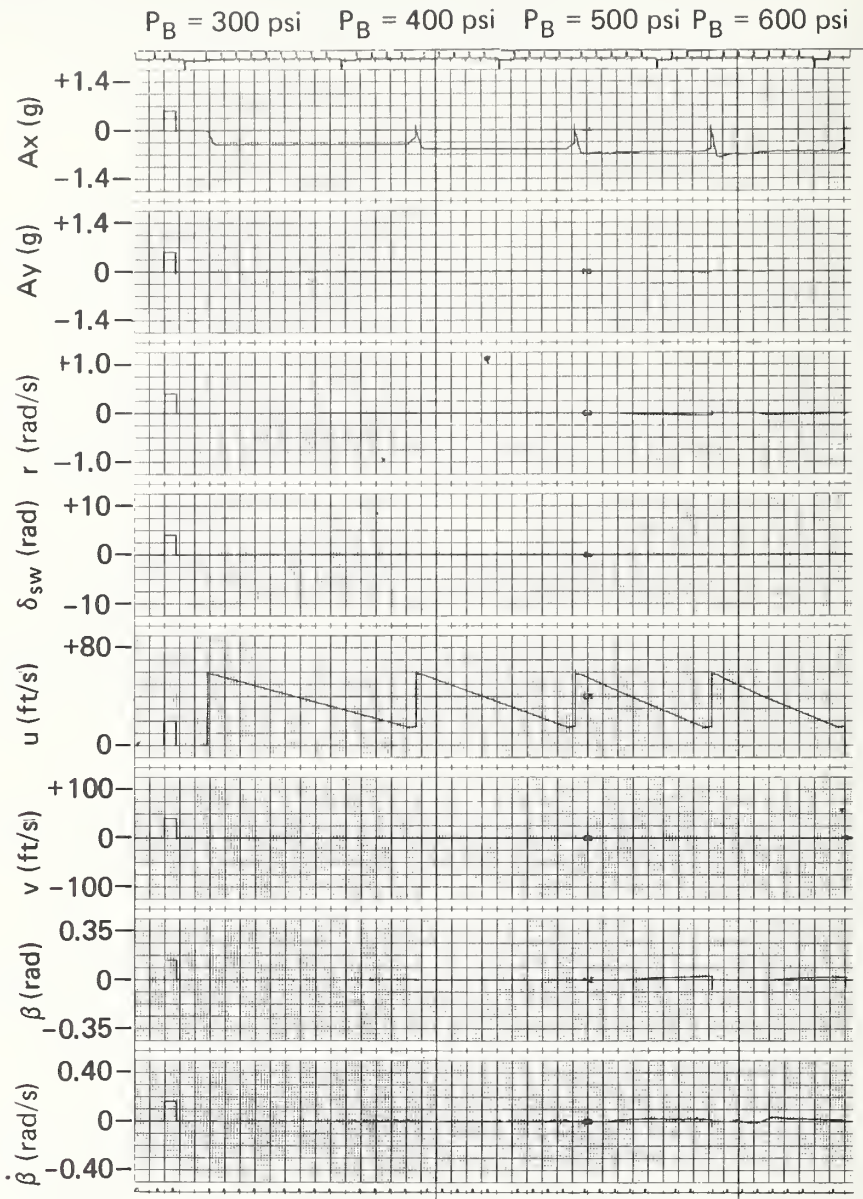


Fig. 2-11 Time Histories – Straight Line Braking (p. 1)

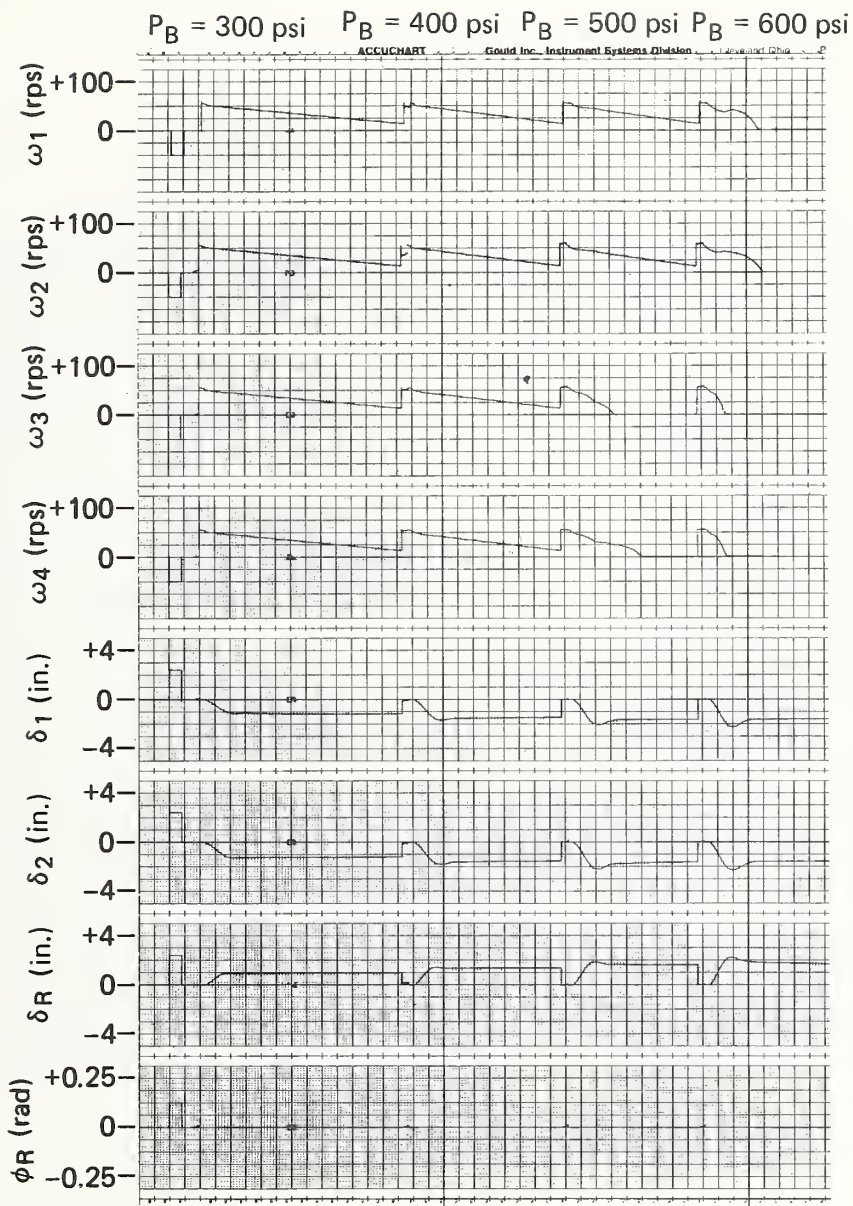


Fig. 2-11 Time Histories – Straight Line Braking (p. 2)

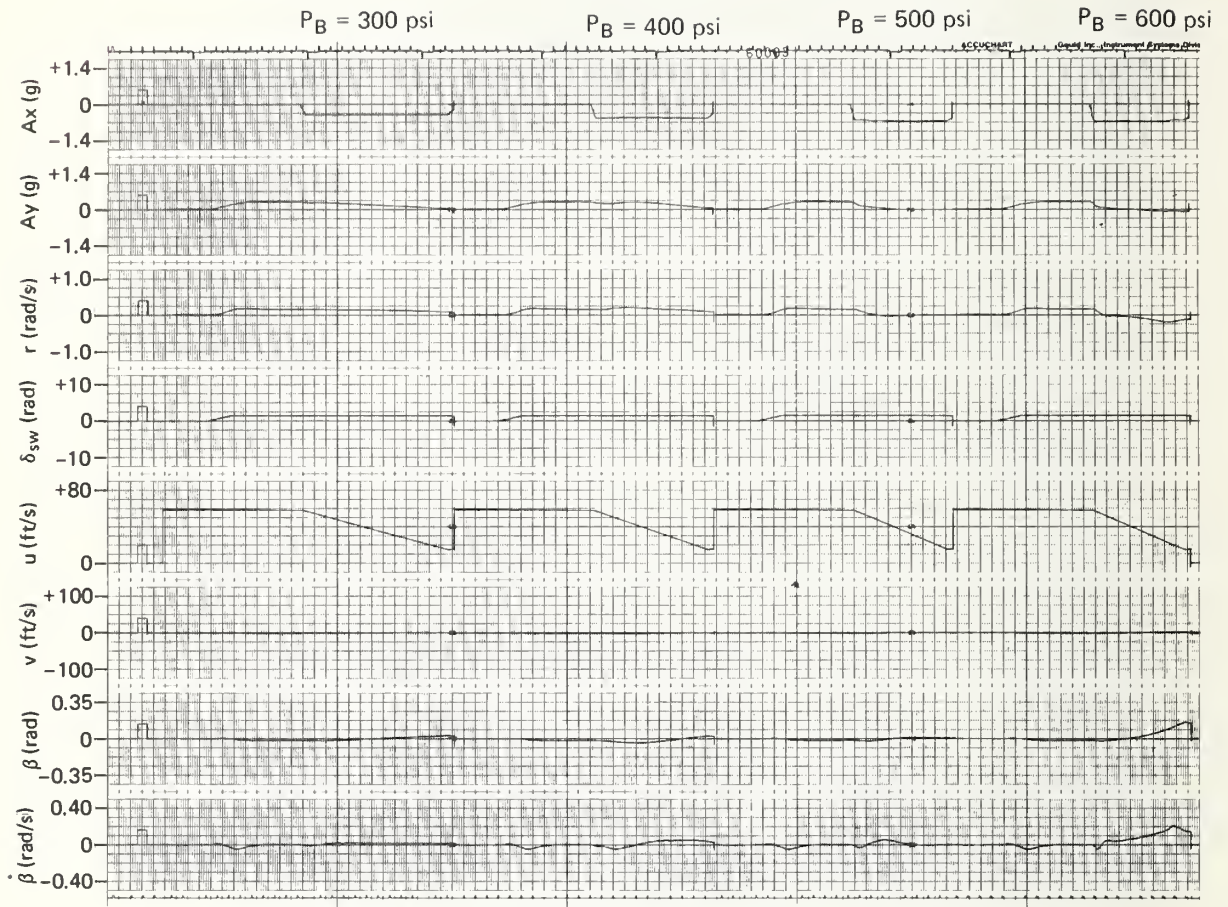


Fig. 2-12 Time Histories – Braking in a Turn (p. 1)



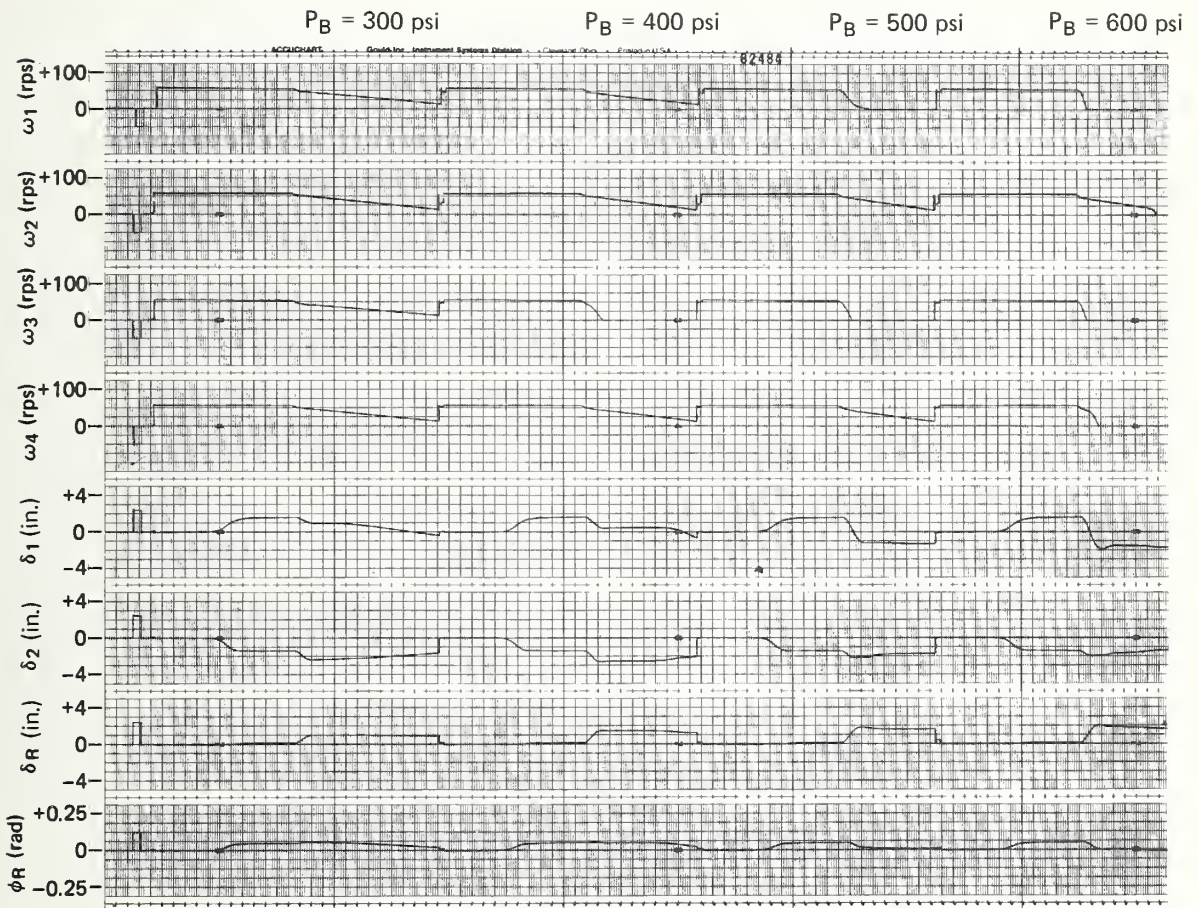


Fig. 2-12 Time Histories — Braking in a Turn (p. 2)

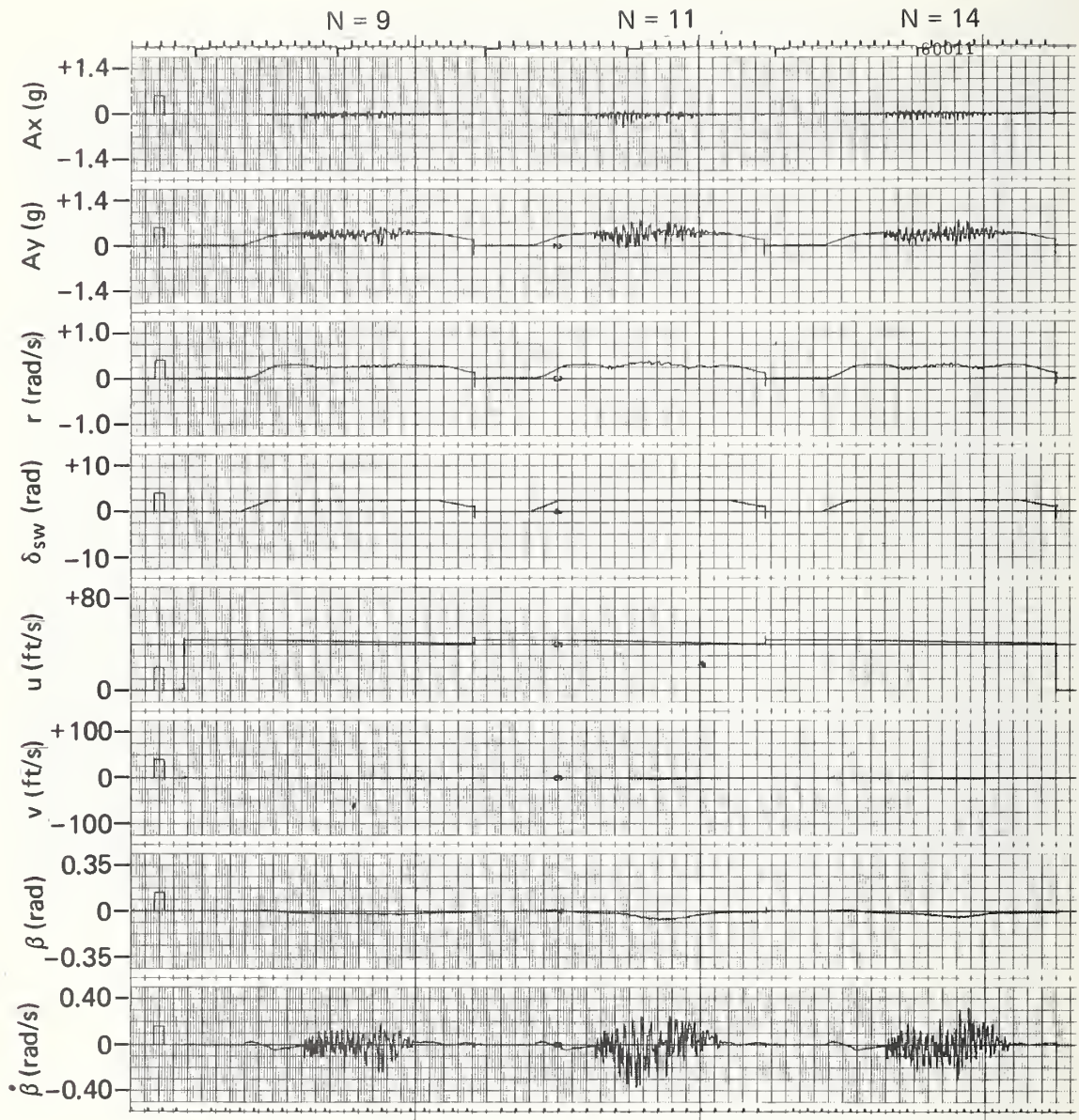


Fig. 2-13 Time Histories – Turning on a Rough Road (p. 1)



Fig. 2-13 Time Histories — Turning on a Rough Road (p. 2)

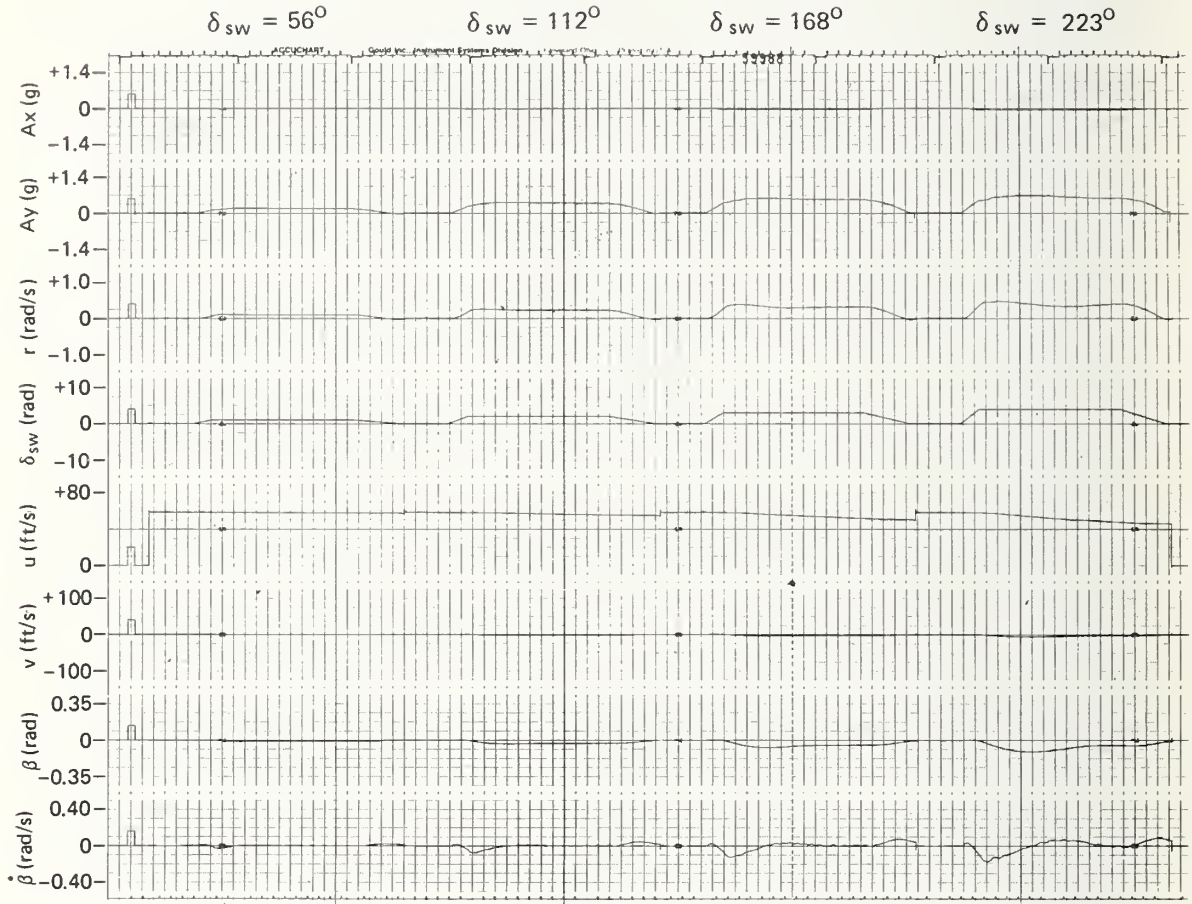


Fig. 2-14 Time Histories – Trapezoidal Steer (p. 1)

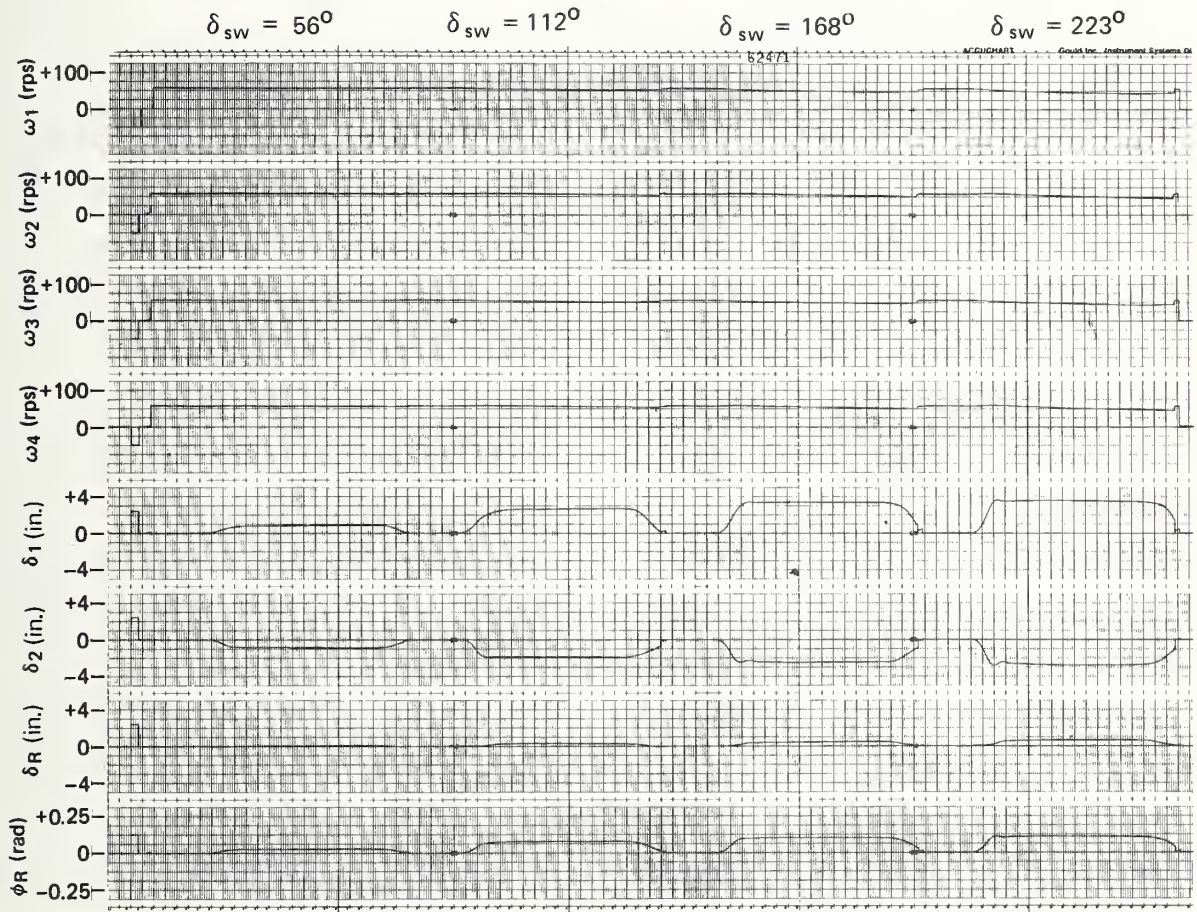


Fig. 2-14 Time Histories – Trapezoidal Steer (p. 2)

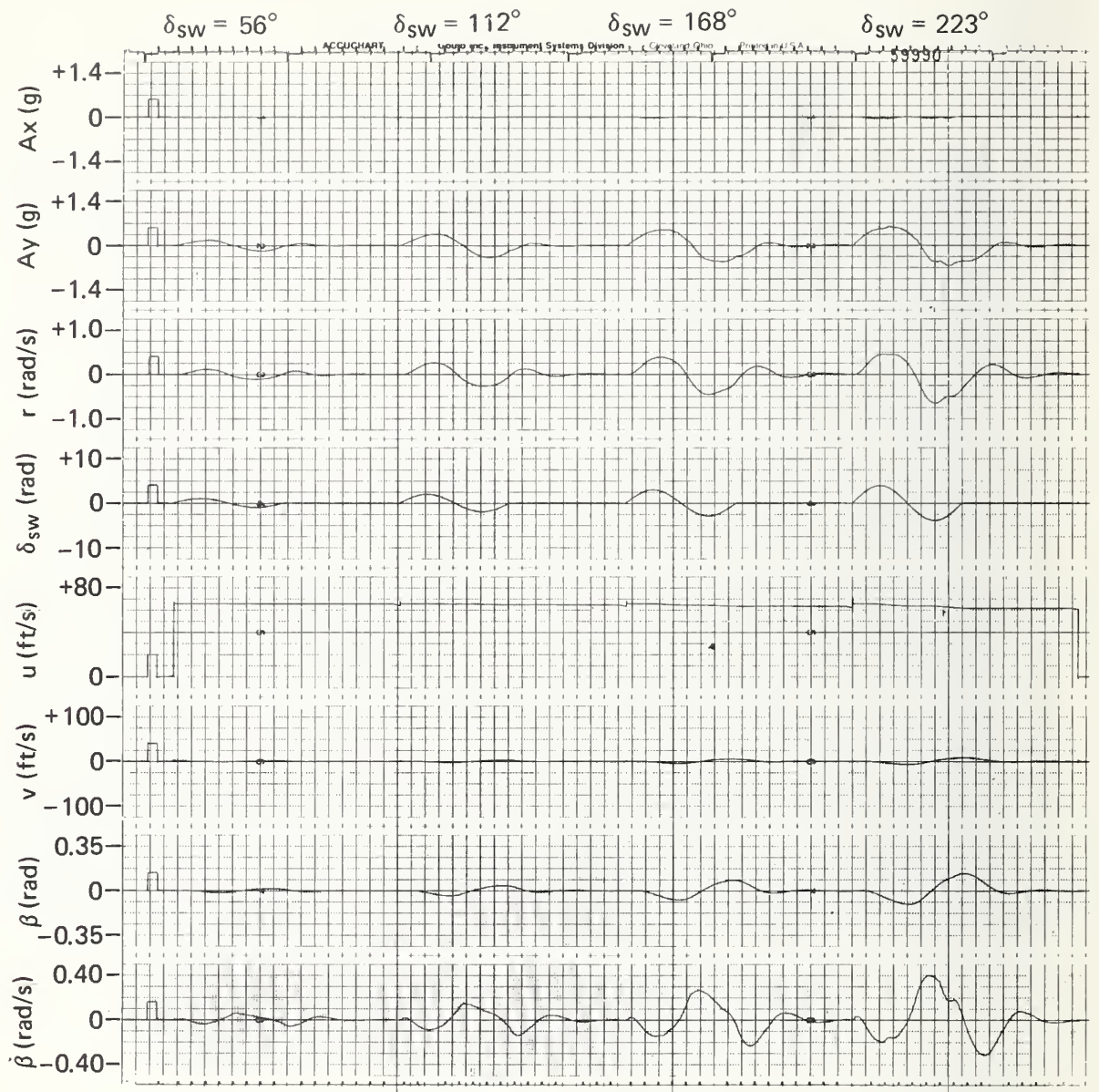


Fig. 2-15 Time Histories — Sinusoidal Steer (p. 1)

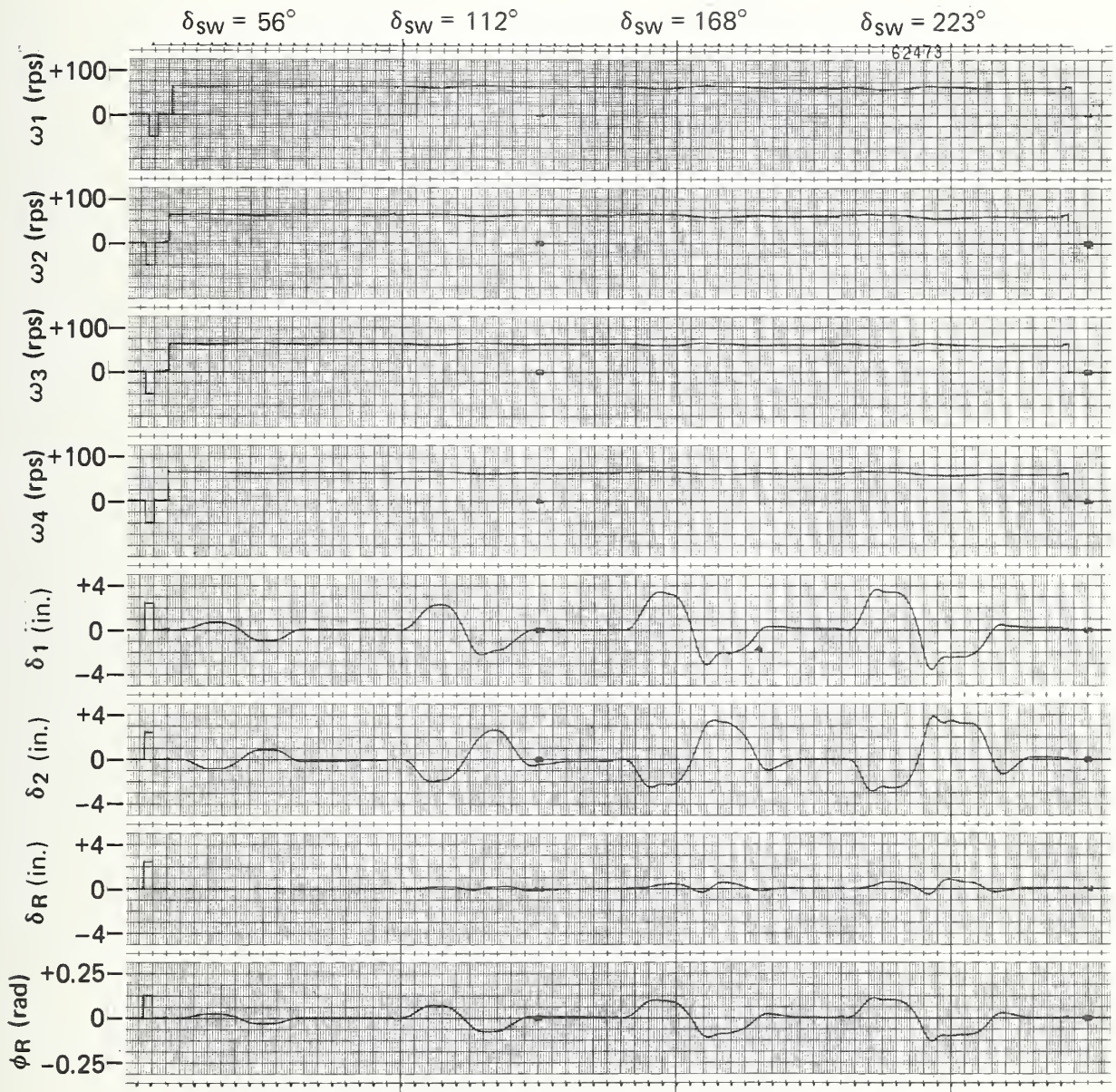


Fig. 2-15 Time Histories — Sinusoidal Steer (p. 2)

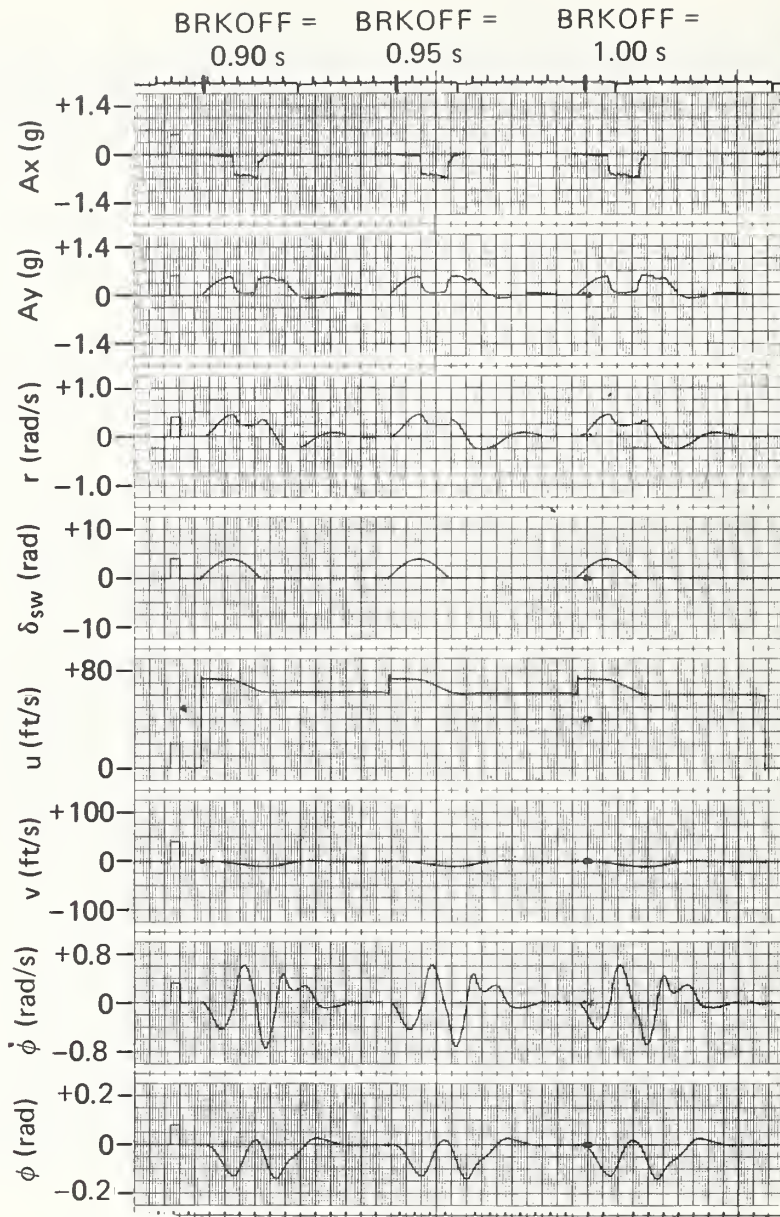


Fig. 2-16 Time Histories – Drastic Steer and Brake (p. 1)



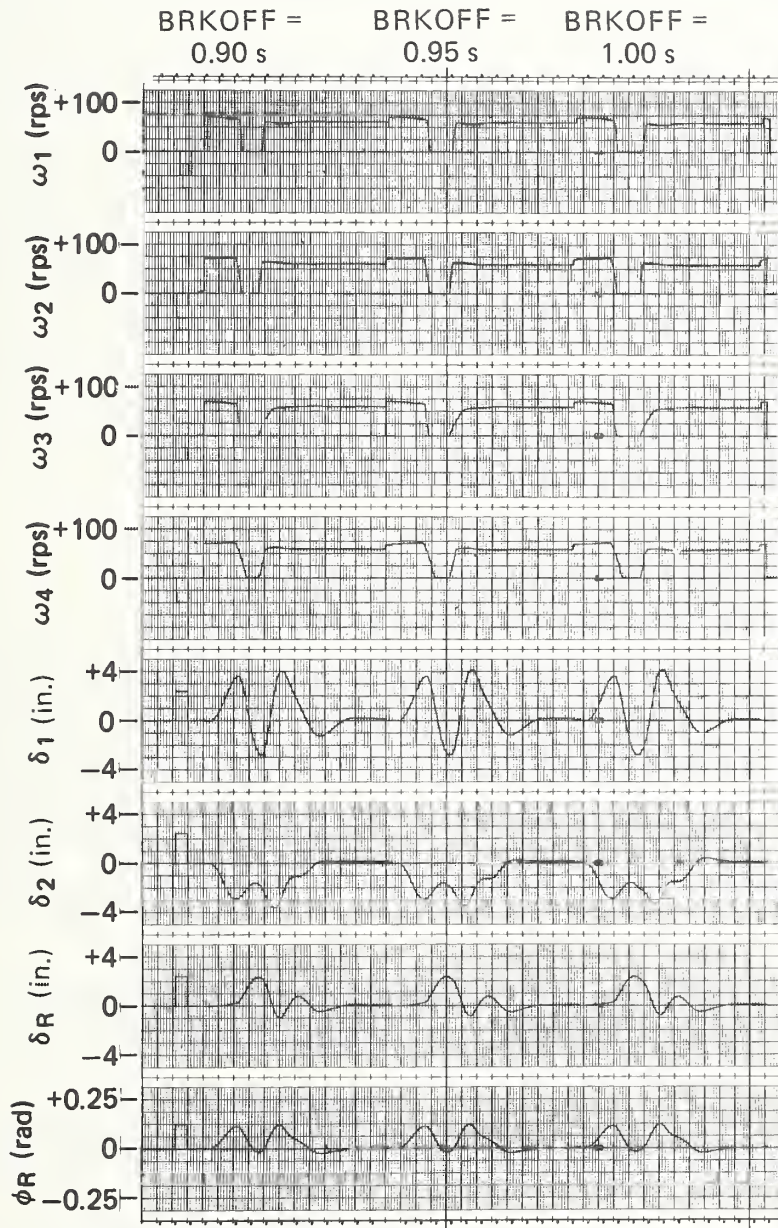


Fig. 2-16 Time Histories – Drastic Steer and Brake (p. 2)

## 2.6 TIRE DATA

As previously stated, the current IHVHP tire/road interface model was defined by Calspan as part of DOT contract HS-053-3-727 (Ref. 6). For this contract, Calspan tested many tires at their Tire Research Facility (TIRF) testing complex (Ref. 18). As a convenience for working with APL and using the IHVHP, the TIRF-associated computer was programmed to process tire data into a format directly compatible with the IHVHP tire model. Therefore, very little effort is required to prepare tire data for input on the TIRF machine. For tires tested on other tire test machines or flatbed testers, APL can convert the data for IHVHP use with the TIRF computer data processing program. When the tire test data have been properly formatted, the program output will be compatible with the IHVHP. However, data preparation for the latter approach can be very time consuming. A recent tire parameter determination research program has made available IHVHP-compatible data on approximately 400 tires of sizes usually found on passenger cars and light trucks. These tire data along with documentation of the research can be found in Ref. 19.

### 2.6.1 Tire Data Validation

A tire/road interface plotting program (Ref. 20) was developed at APL to validate tire model data used as input to the vehicle simulation. The validation approach was to generate families of curves of desired tire/road interface functions for chosen sets of conditions that could be correlated with data obtained from tire tests. Given values for the coefficients and parameters of the tire model equations, the program calculates the tire model functions and produces a data deck compatible with the input requirements of a Calcomp plotting subprogram (Ref. 21). Tire/road in-

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Ref. 18. K. D. Bird and J. F. Martin, "The Calspan Tire Research Facility: Design, Development and Initial Test Results," SAE Paper 730528, May 1973.

Ref. 19. D. J. Schuring, Tire Parameter Determination, Final Report, Contract DOT HS-4-00923, Calspan Corporation, December 1975.

Ref. 20. R. E. Sienicki, "Tire/Road Interface Plotting Program User's Guide and Program Documentation," APL/JHU Memorandum BCE-T-0590, December 1975.

Ref. 21. L. Klein and N. Rubinstein, "General Linear, Semi-Log and Log-Log Calcomp Plot Subroutine (FORTRAN IV)," APL/JHU Memorandum F1C(2)-75-U-026, November 1975.

terface graphs are then generated by the subprogram. Included in TIRF data from Ref. 19 are three carpet plots for each tire: (a) lateral force versus slip angle at various loads, (b) lateral force versus slip angle at various camber angles, and (c) braking force coefficient versus slip ratio at various loads. The same types of carpet plots are generated from the APL plot program and compared with the TIRF plots for validation. Representative graphs are shown in Appendix F.

## 2.7 IHVHP INPUT DATA

### 2.7.1 Data Deck Description

A general input data deck is used with the IHVHP. The following are defined in the data deck:

- Program identification;
- Default output variable list for the Track OPTION;
- Default output variable list for the Table OPTION for VHTP's performed in the multiple-run mode;
- Digital-to-analog converter variable and scale-factor assignments input as pairs of digital variable and corresponding scale factor;
- Analog-to-digital converter variable and scale-factor assignments input as pairs of digital variable and corresponding scale factor;
- Initialization of non-integer parameters for initial conditions;
- Initialization of integer parameters for initial conditions;
- Vehicle simulated;
- Front and rear camber, caster, and toe functions via coefficients for a fifth order polynomial approximation;
- Front and rear brake torques as pairs of brake pressure in, brake torque out data points;
- Lateral friction coefficient degradation with circumferential slip as pairs of percent of slip in, percent of lateral friction coefficient out data points;

- Wind profile data as pairs of distance in, wind velocity out data points;
- Aerodynamic force and moment coefficients as a function of aerodynamic sideslip angle or angle of attack in, aerodynamic coefficient out data points;
- Steer profile data as pairs of steer time in, steer angle out data points;
- Front and rear spring data as pairs of suspension deflection in, spring force out data points;
- Front and rear shock absorber data as pairs of suspension velocity in, shock absorber force out data points;
- PARAM data array members that are used to redefine VHTP condition inputs as sequential numbers representing the PARAM array element number and the corresponding variable value for the initial check run and each VHTP number from 1 to 6; and
- Initial values of individual members of the PARAM vehicle descriptor data array input as pairs of array element number and initial value.

The input data for three simulated vehicles that are representative of the IHVHP suspension types are presented in Appendix G, along with a sample for each vehicle of the PARAM table that is output to the system line printer prior to each simulation run. The tables provide PARAM value documentation. The three vehicles for which data are provided are

- VW Campmobile, independent front and rear suspension;
- Dodge Coronet, independent front, with solid rear axle; and
- Winnebago motor home, solid front and rear axles with dual rear tires.

2.7.1.1 Program Identification. The first data card identifies the APL problem number, the digital computer load module, and the vehicle simulated.

2.7.1.2 Track Output Variables. The next group of cards defines the initial set of interactive variables to be output when

the Track OPTION is enabled. Fifty variables may be selected on as many cards as required. This group of cards is terminated by a blank card. The list may be altered interactively using the Track OPTION.

2.7.1.3 Table Output Variables. The next group of cards defines the variables to be output at the end of each run when the multiple-run execution mode is enabled. This group contains seven cards, one for each VHTP (the first six) and one for the check run. A maximum of nine variables can be specified per card. If the table variables are respecified interactively via the Table OPTION for the execution of a VHTP, the variables in this data group will be restored when that VHTP is reselected.

2.7.1.4 Digital-to-Analog Variables. This group of cards specifies which variables will be output from the digital to the analog computer and the scale factor that will be associated with digital-to-analog conversion. Any variable may be output. If the output variable is used in the closed loop vehicle model, the scale factor must be consistent with the use of the variable on the analog computer. If the output variable is used strictly for strip chart recorder display purposes, the scale factor can take any rational value. The maximum expected value of the variable is an appropriate starting value. Either the variable, the scale factor, or both may be reassigned via the interactive OPTION DACA. Forty-eight cards must be included, one for each digital-to-analog output in the order of assignment to DAC's 0 to 47. Each card contains a variable name followed by its normalizing scale factor. The list is terminated by the character string ENDNODAC.

2.7.1.5 Analog-to-Digital Variables. This group of cards specifies which variables will be input from the analog to the digital computer and the scale factor that will be associated with analog-to-digital conversion. Any variable name that has been specified may be input. The scale factor must be consistent with the use of the variable on the analog computer. The variable, the scale factor, or both may be reassigned via the interactive OPTION ADCA. A change in variable implies a wiring change on the analog patch panel. Thirty-eight cards must be included, one for each analog-to-digital input in the order of assignment to ADC's 0 to 37 (only 38 of the 48 ADC channels are used by the IHVHP). Each card contains a variable name followed by its analog scale factor. The list is terminated by the character string ENDNOADC.

2.7.1.6 Non-Integer Variable Initialization. The next group of cards allows any non-integer initial condition or parameter that has been specified as an interactive variable to be

assigned an initial value. The format is a name followed by the initial value with a maximum of 10 pairs per card. Any number of cards is allowed, and the input is terminated by a blank card.

2.7.1.7 Integer Variable Initialization. The next group of cards allows any integer parameter that has been specified as an interactive variable to be assigned an initial value. The format is a name followed by the initial value with a maximum of 10 pairs per card. Any number of cards is allowed, and the input is terminated by a blank card.

2.7.1.8 Vehicle Identification. This data card is used to document the vehicle being simulated. Any message up to 80 characters is allowed.

2.7.1.9 Camber, Caster, and Toe Functions. The next six data cards define the front and rear wheel camber, caster, and toe functions in degrees for wheel displacement (in.) from the unloaded vehicle suspension equilibrium position. One function is defined per data card, which contains the six coefficients required to specify a fifth order polynomial approximation to the appropriate function. The order of the data is C0, C1, ..., C5. C0 is the value of the function (camber, caster, toe) at the equilibrium suspension position of the unloaded vehicle. The vehicle simulation uses the right front and rear wheels as a reference for camber and toe data. The sign of the coefficients for the left front and rear wheels is changed in the digital program. Data for these functions for the representative vehicles are presented in Appendix G.

2.7.1.10 Brake Torques. The next group of data cards defines the front and rear brake torque functions. The function is specified as pairs of data points with one pair per card, a value of brake line pressure ( $\text{lb/in}^2$ ) and the corresponding value of the brake torque (lb-in.). A group of cards (2 to 19) defining each function is ended by a data card containing the number 99999. A linear interpolation routine is used to obtain torque values for brake line pressures between specified data values. Conventionally, the front and rear brake torque functions are identical, and brake proportioning is accomplished using PARAM array elements 238 to 241.

2.7.1.11 Side Force Shaping Function. The next group of data cards defines the functional relationship between the side force and circumferential slip. Pairs of data points are input with one pair per card, as percent of slip and the corresponding

percent of possible side force that is attained. The function data (2 to 19 cards) are terminated by a card containing the number 99999. Linear interpolation is used between data points to obtain intermediate function values.

2.7.1.12 Wind Profile. The next group of data cards defines the aerodynamic wind disturbance profile. Pairs of data points are input as tabular functions of longitudinal distance to the center of the wind disturbance profile and cross-wind velocity. The function is input as pairs of data points, one pair per card, with a maximum of 19 cards. The format is a distance (in.) followed by the wind velocity (in./s). The data points are terminated by a card containing 99999. A linear interpolation routine is used to obtain cross-wind velocity for longitudinal distance between specified data points.

2.7.1.13 Aerodynamic Coefficients. The next group of data cards (39 maximum) defines the aerodynamic force and moment coefficients as tabular functions of the aerodynamic sideslip angle. The format is sideslip angle (rad) followed by the value of the aerodynamic coefficient. The input order of the functions is axial force ( $C_x$ ), side force ( $C_y$ ), normal force ( $C_z$ ), roll moment ( $C_1$ ), pitch moment ( $C_m$ ), and yaw moment ( $C_n$ ). The data array is terminated by the number 99999. The next group of data cards defines the increment in axial force coefficient as a tabular function of aerodynamic angle of attack. The function is input as pairs of data points, one pair per card, with a maximum of 39 cards. The format is an angle of attack (rad) followed by the value of the aerodynamic coefficients ( $\Delta C_x$ ). The function data cards are terminated by the number 99999. A linear interpolation routine is used to obtain functional values for sideslip angles or angles of attack between specified data values.

2.7.1.14 Steer Profile. The next group of data cards (19 maximum) defines the functional relationship between the steer angle (rad) and time (s). Pairs of data points are input as time and steer angle. The data are terminated by a card containing the number 99999. Linear interpolation is used to obtain functional values between specified time data points.

2.7.1.15 Spring Functions. The next groups of cards define the front and rear spring functions as tabular functions of suspension deflection from the equilibrium position. Each function is input as pairs of data points, one pair per card, with a maximum of nine cards. The format is a suspension deflection

(in.) followed by the spring force (lb). The data are input for the range from full compression to full rebound. The input order of the spring forces is right front, left front, right rear, and left rear. Each function's data cards are terminated by the number 99999. A linear interpolation routine is used to obtain function values for deflections between specified data values.

The spring force at each wheel is implemented as the sum of a linear segment generated on the analog computer and a digital supplement that is the difference between the analog value and the actual spring characteristic. The sign convention for deflections from equilibrium, which is zero (in.) with a corresponding suspension force of zero (lb), is that

- Compression is a negative deflection and produces a negative suspension force, and
- Rebound is a positive deflection and produces a positive suspension force.

Spring data for three representative vehicles are presented in Appendix G.

2.7.1.16 Shock Absorber Functions. The next group of data cards defines the front and rear shock absorber characteristics as tabular functions of suspension velocity. Each function is input as pairs of data points, one pair per card, with a maximum of nine cards. The format is the suspension velocity (in./s) followed by the shock absorber force (lb). The data are input for the range from full compression to full extension. The input order of the shock absorber forces is right front, left front, right rear, and left rear. Each function's data cards are terminated by the number 99999. A linear interpolation routine is used to obtain function values for suspension rates between specified data.

The shock absorber force at each wheel is implemented as the sum of a linear segment generated on the analog computer and a digital supplement that is the difference between the analog value and the actual shock absorber characteristic. The sign convention for the suspension motion from equilibrium, which is zero rate (in./s) and a corresponding zero damping force (lb), is

- A negative suspension deflection rate (compression motion) produces a negative shock absorber force, and
- A positive suspension deflection rate (rebound motion) produces a positive shock absorber force.



Shock absorber data for three representative vehicles are presented in Appendix G.

2.7.1.17. VHTP Initialization Data. The next group of cards allows the input of data that are used for initialization of the simulation for performing a specific VHTP maneuver. Since the data are input, VHTP conditions can easily be varied. Twenty-seven data cards are required, with each card containing a PARAM element address and a value for the variable represented by that address for the check verification run and each VHTP 1 to 6, in that order. The PARAM element addresses shown in the data lists are required for VHTP initialization. However, the input order is not fixed.

2.7.1.18. Vehicle Descriptor and Tire Data. The last group of cards is used to input the initial values of variables that are elements of the PARAM data array. The array is used to input all vehicle descriptor and tire model data. Since the array is also used for purposes other than data input, such as storing values for program calculated initial conditions, program flow switch values, etc., all PARAM elements need not be initialized. The definitions of all PARAM elements are given in Section 4 of Appendix H. The subset of PARAM elements that represents vehicle descriptors or tire model coefficients is presented in Section 5 of Appendix H. Data are input one PARAM element per card by indicating the PARAM element address followed by the assigned value.

## 2.7.2. Load-Dependent Data

Since the IHVHP calculates suspension deflections relative to the suspension equilibrium position for all load configurations, information specifying the suspension travel from the unloaded vehicle suspension position must be provided. Of particular interest are the loaded vehicle configurations for driver control used in VHTP's 1 through 3 and for automatic control used in VHTP's 4 through 6. The vehicle parameters that are load dependent and their corresponding PARAM element addresses are as follows:

<u>Parameter</u>	<u>PARAM Address</u>	<u>Parameter</u>	<u>PARAM Address</u>
MS	1	IX	11
ZF	4	IY	12
ZR	5	IZ	13
A	6	DELF	92
B	7	DELR	93

### Section 3

#### CONCLUSIONS AND RECOMMENDATIONS

The Improved Hybrid Computer Vehicle Handling Program (IHVHP) has demonstrated realistic dynamic simulations of passenger vehicles and trucks with suspensions ranging from four-wheel independent to solid front and rear axles. The performance of simulation runs, especially those involving the six Vehicle Handling Test Procedures (VHTP's), are inexpensively and easily performed. In addition, the performance measuring vehicle performance comparison variables (PCV's) for each VHTP are provided.

Although good correlation between the IHVHP and full-scale test data has been achieved, it is recommended that changes in all areas of the model, including the tire/road interface and vehicle description, be given serious consideration where an improvement in correlation could result. The IHVHP has proved to be a good simulation that is easily extended to meet the increasing needs of predicting vehicle behavior. By critically reviewing the simulation with each use and making improvements, the IHVHP will continue to be a successful engineering tool.

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21. L. Klein and N. Rubinstein, "General Linear, Semi-Log and Log-Log Calcomp Plot Subroutine (FORTRAN IV)," APL/JHU Memorandum F1C(2)-75-U-026, November 1975.

## Appendix A

### VEHICLE MATHEMATICAL MODEL

#### 1. INTRODUCTION

This appendix contains the vehicle mathematical model that was implemented on the APL/JHU hybrid computer. The equation numbers associated with a particular suspension, axial, or tire configuration will include a notation from the following legend:

- A. Solid front axle
- B. Solid rear axle
- C. Independent front suspension
- D. Independent rear suspension
- E. Solid front and rear axles
- F. Independent front suspension and solid rear axle
- G. Independent front and rear suspensions
- H. Independent front suspension and dual tires on solid rear axle
- I. Solid front axle and dual tires on solid rear axle

Figure A-1 is a block diagram of the Improved Hybrid Vehicle Handling Program (IHVHP), and Figs. A-2 and A-3 are analytical representations of the vehicle and solid-rear-axle models, respectively. (The reader should note that the figures are repeated here from the main body of the text for convenience.)

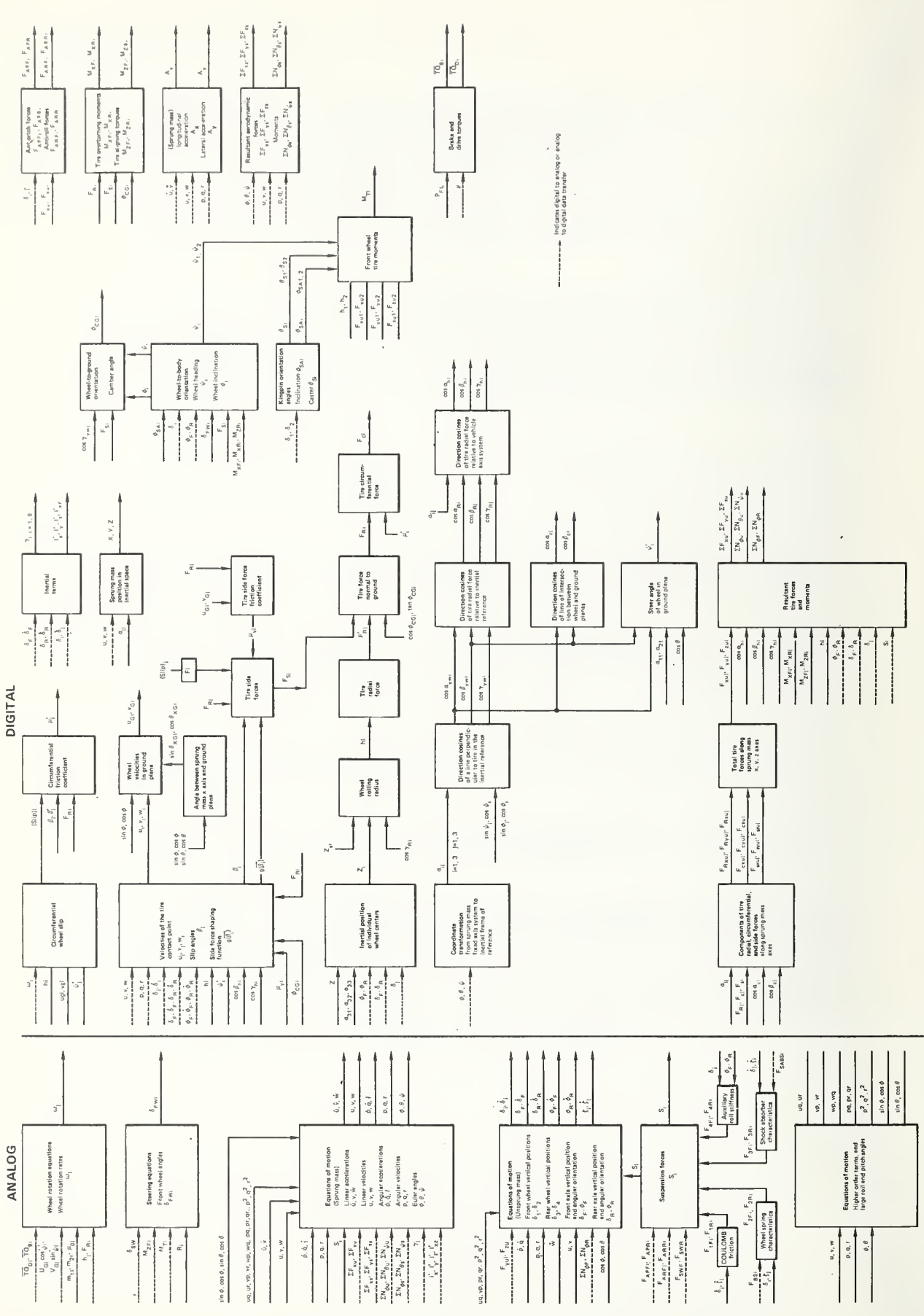


Fig. A-1 Hybrid Simulation Block Diagram of the IHVHP Model

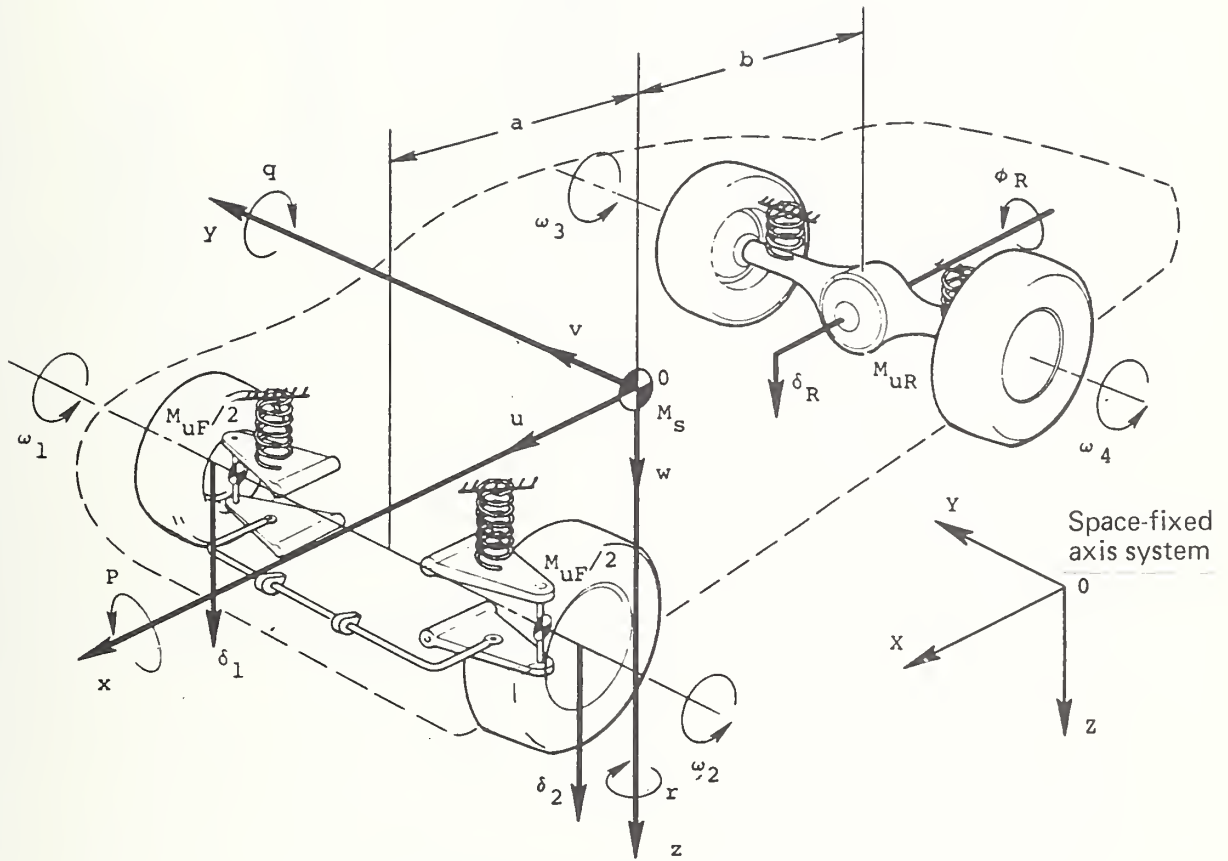


Fig. A-2 Analytical Representation of the Vehicle Model

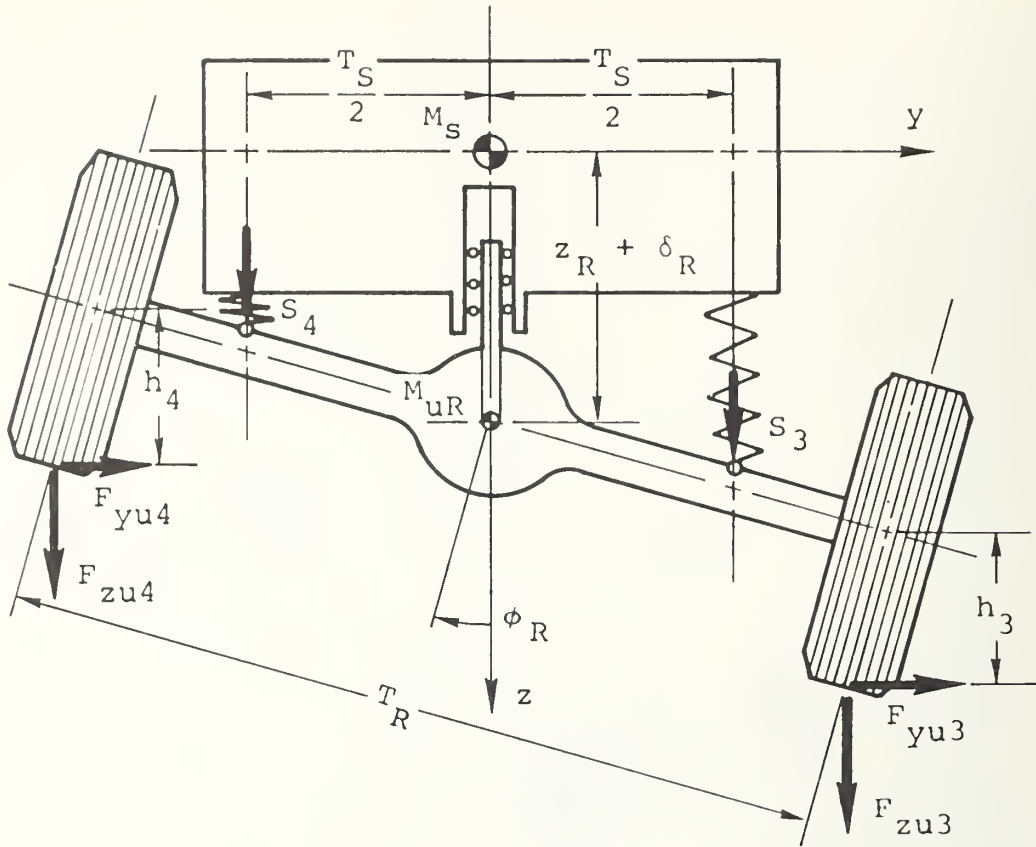


Fig. A-3 Analytical Representation of the Solid Rear Axle Model

## 2. SYSTEM EQUATIONS

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2.2	Equations of Motion (10 degrees of freedom)
2.3	Vehicle Attitude and Position
2.4	Suspension Force
2.4.1	Solid Front Axle
2.4.2	Solid Rear Axle
2.4.3	Independent Front Suspension
2.4.4	Independent Rear Suspension



- 2.5 Wheel Orientations
- 2.6 Resultant Forces and Moments
- 2.7 Radial Tire Force and Rolling Radius
- 2.8 Tire Circumferential Force
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- 2.10 Wheel Slip
- 2.11 Wheel Rotational Equations (4 degrees of freedom)
- 2.12 Brake and Drive Torques
- 2.13 Tire Side Force
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- 2.16 Combined Slip Angle and Camber Shaping Function
- 2.17 Wheel Slip Angle
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- 2.19 Wheel Slip Shaping Function
- 2.20 Tire Moments
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- 2.22 Longitudinal and Lateral Accelerations
- 2.23 Dual Tires on Solid Rear Axle
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  - 2.23.4 Resultant Forces and Moments
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  - 2.23.10 Tire Side Force
  - 2.23.11 Velocities of Tire Contact Points
- 2.24 Resultant Moments of Solid Front Axle and Dual Tires on Solid Rear Axle

## 2.2 Equations of Motion (10 degrees of freedom)

The equations of motion of the sprung and unsprung masses are presented below:

$$\begin{aligned}
 (\Sigma M) \dot{u} + \gamma_2 \dot{q} &= (\Sigma M) (vr - wq - g \sin \theta) + \gamma_1 (q^2 + r^2) \\
 &\quad - \gamma_2 pr - \gamma_6 q + \Sigma F_{xu} + \Sigma F_{xs}
 \end{aligned} \tag{1}$$

$$\begin{aligned}
 (\Sigma M) \dot{v} - \gamma_2 \dot{p} + \gamma_1 \dot{r} &= (\Sigma M) (wp - ur + g \cos \theta \sin \phi) \\
 &\quad - \gamma_1 pq - \gamma_2 qr + \gamma_6 p + \Sigma F_{yu} + \Sigma F_{ys}
 \end{aligned} \tag{2}$$

$$M_s \dot{w} = M_s (uq - vp + g \cos \theta \cos \phi) - \sum_{i=1}^4 S_i + \Sigma F_{zs} \tag{3}$$

$$\begin{aligned}
 -\gamma_3 \dot{v} + (I_x + I'_x) \dot{p} - (I_{xz} + I'_{xz}) \dot{r} \\
 &= \gamma_3 (ur - wp - g \cos \theta \sin \phi) + (I_{xz} + I'_{xz}) pq \\
 &\quad - \gamma_4 (p^2 + r^2) + (I_y - I_z + I'_x) qr - \gamma_7 p + \Sigma N_{\phi u} + \Sigma N_{\phi s}
 \end{aligned} \tag{4}$$

$$\begin{aligned}
 \gamma_2 \dot{u} + (I_y + I'_y) \dot{q} - \gamma_4 \dot{r} &= \gamma_2 (vr - wq - g \sin \theta) \\
 &\quad + I_{xz} (r^2 - p^2) + (I_z - I_x - I'_y) pr - \gamma_4 pq \\
 &\quad - \gamma_7 q + I'_{xz} (q^2 + r^2) + \Sigma N_{\theta u} + \Sigma N_{\theta s}
 \end{aligned} \tag{5}$$

$$\begin{aligned}
 \gamma_1 \dot{v} - (I_{xz} + I'_{xz}) \dot{p} - \gamma_4 \dot{q} + (I_z + I'_z + I_F + I_R) \dot{r} \\
 &= \gamma_1 (wp - ur + g \cos \theta \sin \phi) + (I_x - I_y - \gamma_5) pq \\
 &\quad - (I_{xz} + I'_{xz}) qr + \gamma_8 q + \gamma_4 pr + \gamma_9 p + \Sigma N_{\psi u} + \Sigma N_{\psi s}
 \end{aligned} \tag{6-E}$$

$$\begin{aligned}
\gamma_1 \dot{v} - (I_{xz} + I'_{xz}) \dot{p} - \gamma_4 \dot{q} + (I_z + I'_z + I_R) \dot{r} \\
= \gamma_1 (wp - ur + g \cos \theta \sin \phi) + (I_x - I_y - \gamma_5) pq \\
- (I_{xz} + I'_{xz}) qr + \gamma_8 q + \gamma_4 pr + \gamma_9 p + \Sigma N_{\psi u} + \Sigma N_{\psi s}
\end{aligned} \tag{6-F}$$

$$\begin{aligned}
\gamma_1 \dot{v} - (I_{xz} + I'_{xz}) \dot{p} - \gamma_4 \dot{q} + (I_z + I'_z) \dot{r} \\
= \gamma_1 (wp - ur + g \cos \theta \sin \phi) + (I_x - I_y - \gamma_5) pq \\
- (I_{xz} + I'_{xz}) qr + \gamma_8 q + \gamma_4 pr + \gamma_9 p + \Sigma N_{\psi u} + \Sigma N_{\psi s}
\end{aligned} \tag{6-G}$$

$$\begin{aligned}
M_{uF} \dot{w} - a M_{uF} \dot{q} + M_{uF} \ddot{\delta}_F = M_{uF} [uq - vp - apr \\
+ (z_F + \delta_F) (p^2 + q^2) + g \cos \theta \cos \phi] \\
+ F_{zu1} + F_{zu2} + S_1 + S_2
\end{aligned} \tag{7-A}$$

$$\begin{aligned}
M_{uR} \dot{w} + b M_{uR} \dot{q} + M_{uR} \ddot{\delta}_R = M_{uR} [uq - vp + bpr \\
+ (z_R + \delta_R) (p^2 + q^2) + g \cos \theta \cos \phi] \\
+ F_{zu3} + F_{zu4} + S_3 + S_4
\end{aligned} \tag{8-B}$$

$$I_F \dot{p} + I_F \ddot{\phi}_F = - I_F \phi_F (r^2 - q^2) - I_F qr + \Sigma N_{\phi F} \tag{9-A}$$

$$I_R \dot{p} + I_R \ddot{\phi}_R = - I_R \phi_R (r^2 - q^2) - I_R qr + \Sigma N_{\phi R} \tag{10-B}$$

$$\begin{aligned}
\frac{M_{uF}}{2} \dot{w} + \frac{M_{uF} T_F}{4} \dot{p} - \frac{M_{uF} a}{2} \dot{q} + \frac{M_{uF}}{2} \ddot{\delta}_1 \\
= \frac{M_{uF}}{2} [uq - vp - apr - \frac{T_F}{2} qr + (z_F + \delta_1) (p^2 + q^2) \\
+ g \cos \theta \cos \phi] + F_{zu1} + S_1 - F_{yu1} \tan \left( \frac{2H_{FC}}{T_F} \right)
\end{aligned} \tag{11-C}$$

$$\begin{aligned}
& \frac{M_{uF}}{2} \ddot{w} - \frac{M_{uF} T_F}{4} \dot{p} - \frac{M_{uF} a}{2} \dot{q} + \frac{M_{uF}}{2} \ddot{\delta}_2 \\
& = \frac{M_{uF}}{2} [uq - vp - apr + \frac{T_F}{2} qr + (z_F + \delta_2) (p^2 + q^2) \\
& + g \cos \theta \cos \phi] + F_{zu2} + S_2 + F_{yu2} \tan \frac{2H_{FC}}{T_F}
\end{aligned} \tag{12-C}$$

$$\begin{aligned}
& \frac{M_{uR}}{2} \ddot{w} + \frac{M_{uR} T_R}{4} \dot{p} + \frac{M_{uR} b}{2} \dot{q} + \frac{M_{uR}}{2} \ddot{\delta}_3 \\
& = \frac{M_{uR}}{2} [uq - vp + bpr - \frac{T_R}{2} qr + (z_R + \delta_3) (p^2 + q^2) \\
& + g \cos \theta \cos \phi] + F_{zu3} + S_3 - F_{yu3} \tan \frac{2H_{RC}}{T_R}
\end{aligned} \tag{13-D}$$

$$\begin{aligned}
& \frac{M_{uR}}{2} \ddot{w} - \frac{M_{uR} T_R}{4} \dot{p} + \frac{M_{uR} b}{2} \dot{q} + \frac{M_{uR}}{2} \ddot{\delta}_4 \\
& = \frac{M_{uR}}{2} [uq - vp + bpr + \frac{T_R}{2} qr + (z_R + \delta_4) (p^2 + q^2) \\
& + g \cos \theta \cos \phi] + F_{zu4} + S_4 + F_{yu4} \tan \frac{2H_{RC}}{T_R}
\end{aligned} \tag{14-D}$$

where

$$\Sigma M = M_s + M_{uF} + M_{uR} \tag{15}$$

$$I'_x = I'_y = M_{uF} (z_F + \delta_F)^2 + M_{uR} (z_R + \delta_R)^2 \tag{16-E}$$

$$I'_x = I'_y = \frac{M_{uF}}{2} [(z_F + \delta_1)^2 + (z_F + \delta_2)^2] + M_{uR} (z_R + \delta_R)^2 \tag{16-F}$$

$$I'_{x'} = I'_{y'} = \frac{M_{uF}}{2} [(z_F + \delta_1)^2 + (z_F + \delta_2)^2] + \frac{M_{uR}}{2} [(z_R + \delta_3)^2 + (z_R + \delta_4)^2] \quad (16-G)$$

$$I'_z = M_{uF} a^2 + M_{uR} b^2 \quad (17-E)$$

$$I'_z = M_{uF} \left[ a^2 + \left( \frac{T_F}{2} \right)^2 \right] + M_{uR} b^2 \quad (17-F)$$

$$I'_z = M_{uF} \left[ a^2 + \left( \frac{T_F}{2} \right)^2 \right] + M_{uR} \left[ b^2 + \left( \frac{T_R}{2} \right)^2 \right] \quad (17-G)$$

$$I'_{xz} = M_{uF} a (z_F + \delta_F) - M_{uR} b (z_R + \delta_R) \quad (18-E)$$

$$I'_{xz} = \frac{M_{uF}}{2} [a (z_F + \delta_1) + a (z_F + \delta_2)] - M_{uR} b (z_R + \delta_R) \quad (18-F)$$

$$I'_{xz} = \frac{M_{uF}}{2} [a (z_F + \delta_1) + a (z_F + \delta_2)] - \frac{M_{uR}}{2} [b (z_R + \delta_3) + b (z_R + \delta_4)] \quad (18-G)$$

$$\gamma_1 = a M_{uF} - b M_{uR} \quad (19)$$

$$\gamma_2 = \gamma_3 = M_{uF} (z_F + \delta_F) + M_{uR} (z_R + \delta_R) \quad (20-E)$$

$$\gamma_2 = \gamma_3 = M_{uF} \left[ z_F + \left( \frac{\delta_1 + \delta_2}{2} \right) \right] + M_{uR} (z_R + \delta_R) \quad (20-F)$$

$$\gamma_2 = \gamma_3 = M_{uF} \left[ z_F + \left( \frac{\delta_1 + \delta_2}{2} \right) \right] + M_{uR} \left[ z_R + \left( \frac{\delta_3 + \delta_4}{2} \right) \right] \quad (20-G)$$

$$\gamma_4 = 0 \quad (21-E)$$

$$\gamma_4 = \frac{M_{uF} T_F}{4} (\delta_1 - \delta_2) \quad (21-F)$$

$$\gamma_4 = \frac{M_{uF} T_F}{4} (\delta_1 - \delta_2) + \frac{M_{uR} T_R}{4} (\delta_3 - \delta_4) \quad (21-G)$$

$$\gamma_5 = M_{uF} a^2 + M_{uR} b^2 \quad (22-E)$$

$$\gamma_5 = M_{uF} \left[ a^2 - \left( \frac{T_F}{2} \right)^2 \right] + M_{uR} b^2 \quad (22-F)$$

$$\gamma_5 = M_{uF} \left[ a^2 - \left( \frac{T_F}{2} \right)^2 \right] + M_{uR} \left[ b^2 - \left( \frac{T_R}{2} \right)^2 \right] \quad (22-G)$$

$$\gamma_6 = 2M_{uF} \dot{\delta}_F + 2M_{uR} \dot{\delta}_R \quad (23-E)$$

$$\gamma_6 = M_{uF} (\dot{\delta}_1 + \dot{\delta}_2) + 2M_{uR} \dot{\delta}_R \quad (23-F)$$

$$\gamma_6 = M_{uF} (\dot{\delta}_1 + \dot{\delta}_2) + M_{uR} (\dot{\delta}_3 + \dot{\delta}_4) \quad (23-G)$$

$$\gamma_7 = 2M_{uF} (z_F + \delta_F) \dot{\delta}_F + 2M_{uR} (z_R + \delta_R) \dot{\delta}_R \quad (24-E)$$

$$\gamma_7 = M_{uF} [z_F (\dot{\delta}_1 + \dot{\delta}_2) + \delta_1 \dot{\delta}_1 + \delta_2 \dot{\delta}_2] + 2M_{uR} (z_R + \delta_R) \dot{\delta}_R \quad (24-F)$$

$$\begin{aligned} \gamma_7 = M_{uF} [z_F (\dot{\delta}_1 + \dot{\delta}_2) + \delta_1 \dot{\delta}_1 + \delta_2 \dot{\delta}_2] \\ + M_{uR} [z_R (\dot{\delta}_3 + \dot{\delta}_4) + \delta_3 \dot{\delta}_3 + \delta_4 \dot{\delta}_4] \end{aligned} \quad (24-G)$$

$$\gamma_8 = 0 \quad (25-E)$$

$$\gamma_8 = \frac{M_{uF} T_F}{2} (\dot{\delta}_1 - \dot{\delta}_2) \quad (25-F)$$

$$\gamma_8 = \frac{M_{uF} T_F}{2} (\dot{\delta}_1 - \dot{\delta}_2) + \frac{M_{uR} T_R}{2} (\dot{\delta}_3 - \dot{\delta}_4) \quad (25-G)$$

$$\gamma_9 = 2M_{uF}^a \dot{\delta}_F - 2M_{uR}^b \dot{\delta}_R \quad (26-E)$$

$$\gamma_9 = M_{uF}^a (\dot{\delta}_1 + \dot{\delta}_2) - 2M_{uR}^b \dot{\delta}_R \quad (26-F)$$

$$\gamma_9 = M_{uF}^a (\dot{\delta}_1 + \dot{\delta}_2) - M_{uR}^b (\dot{\delta}_3 + \dot{\delta}_4) \quad (26-G)$$

### 2.3 Vehicle Attitude and Position

The Euler angles and X, Y, and Z coordinates in fixed space of the sprung mass are computed by the following equations:

$$\phi = \int_0^t [p + (q \sin \phi + r \cos \phi) \tan \theta] dt + \phi_{(0)} \quad (27)$$

$$\theta = \int_0^t (q \cos \phi - r \sin \phi) dt + \theta_{(0)} \quad (28)$$

$$\psi = \int_0^t [q \sin \phi + r \cos \phi) \sec \theta] dt + \psi_{(0)} \quad (29)$$

Let  $a_{ij}$  be the elements of the  $3 \times 3$  transformation matrix [A], from the coordinate system fixed in the vehicle sprung mass to the inertial coordinate system according to the rotational sequence  $\psi$ ,  $\theta$ ,  $\phi$ .

$$a_{11} = \cos \theta \cos \psi \quad (30)$$

$$a_{12} = -\cos \phi \sin \psi + \sin \phi \sin \theta \cos \psi \quad (31)$$

$$a_{13} = \sin \phi \sin \psi + \cos \phi \sin \theta \cos \psi \quad (32)$$

$$a_{21} = \cos \theta \sin \psi \quad (33)$$

$$a_{22} = \cos \phi \cos \psi + \sin \phi \sin \theta \sin \psi \quad (34)$$

$$a_{23} = -\cos \psi \sin \phi + \cos \phi \sin \theta \sin \psi \quad (35)$$

$$a_{31} = -\sin \theta \quad (36)$$

$$a_{32} = \cos \theta \sin \phi \quad (37)$$

$$a_{33} = \cos \theta \cos \phi \quad (38)$$

The position of the sprung mass in inertial space is

$$X = \int_0^t (a_{11} u + a_{12} v + a_{13} w) dt + X_{(0)} \quad (39)$$



$$Y = \int_0^t (a_{21} u + a_{22} v + a_{23} w) dt + Y_{(0)} \quad (40)$$

$$Z = \int_0^t (a_{31} u + a_{32} v + a_{33} w) dt + Z_{(0)} \quad (41)$$

## 2.4 Suspension Force

The suspension force includes the following effects: weight component, coulomb friction, spring force, shock absorber viscous damping, auxiliary roll stiffness, and antipitch and antiroll forces.

2.4.1 Solid Front Axle. The suspension force effective at the front spring location can be expressed as

$$S_i = F_{sWF} - F_{1Fi} - F_{2Fi} - F_{3Fi} + F_{4Fi} + F_{APFi} + F_{ARFi} \quad (42)$$

with  $i = 1, 2$

where the individual contributions are as follows:

Static component of the sprung mass weight:

$$F_{sWF} = \frac{b}{2(a+b)} M_s g \quad (43)$$

Coulomb friction:

$$F_{1Fi} = C'_{Fi} \operatorname{sgn} \dot{\zeta}_i \quad (44)$$

Suspension force due to spring deflection and suspension bump-stop impact:

$$F_{2Fi} = K_{Fi} \zeta_i + F_{BSi} \quad (45)$$

and

$$F_{BSi} = F(\zeta_{Si}), \quad (46)$$

where  $F(\zeta_{Si})$  is a digital function that is the difference between the linear analog value and the actual front spring characteristic.

The suspension deflection measured at the spring location from the position of static equilibrium at no-load condition is

$$\zeta_{Si} = \zeta_i + \zeta_{FIN} \quad (47)$$

Viscous damping force:

$$F_{3Fi} = K_{Si} \dot{\zeta}_i + F_{SABSi} \quad (48)$$

and

$$F_{SABSi} = F(\dot{\zeta}_i), \quad (49)$$

where  $F(\dot{\zeta}_i)$  is a digital function that is the difference between the linear analog value and the actual front shock absorber characteristic.

Suspension force due to auxiliary roll stiffness:

$$F_{4Fi} = (-1)^i \frac{R_F \phi_F}{T_{SF}} \quad (50)$$

Antipitch force:

$$F_{APFi} = (P_{FO} + P_{F1} \zeta'_i + P_{F2} \zeta_i'^2) F_{xui} \quad (51)$$

Antiroll force:

$$F_{ARFi} = (-1)^i (R_{FO} + R_{F1} \zeta'_i + R_{F2} \zeta_i'^2) F_{yui} \quad (52)$$

For these expressions, the suspension deflections relative to the vehicle from the position of static equilibrium, measured at the right ( $i = 1$ ) and left ( $i = 2$ ) spring locations of the front axle, respectively, are evaluated as

$$\zeta_i = \delta_F - (-1)^i \frac{T_{SF}}{2} \phi_F \quad (53)$$

and

$$\dot{\zeta}_i = \dot{\delta}_F - (-1)^i \frac{T_{SF}}{2} \dot{\phi}_F, \quad (54)$$

while the suspension deflection of the center of the front wheel of the front axle is

$$\zeta'_i = \delta_F - (-1)^i \frac{T_F}{2} \phi_F \quad (55)$$

or

$$\zeta'_i = \zeta_i + (-1)^i \frac{T_{SF} - T_F}{2} \phi_F. \quad (56)$$

2.4.2 Solid Rear Axle. For the rear suspension, the suspension force effective at the rear spring location can be written as

$$S_i = F_{sWR} - F_{1Ri} - F_{2Ri} - F_{3Ri} + F_{4Ri} + F_{APRi} + F_{ARRi} \quad (57)$$

with  $i = 3, 4,$

where the individual contributions are as follows:

Static component of the sprung mass weight:

$$F_{sWR} = \frac{a}{2(a+b)} M_s g \quad (58)$$

Coulomb friction:

$$F_{1Ri} = C'_{Ri} \operatorname{sgn} \dot{\zeta}_i \quad (59)$$

Suspension force due to spring deflection and suspension bump-stop impact is

$$F_{2Ri} = K_{Ri} \zeta_i + F_{BSi} \quad (60)$$

and

$$F_{BSi} = F(\zeta_{Si}) , \quad (61)$$

where  $F(\zeta_{Si})$  is a digital function that is the difference between the linear analog value and the actual rear spring characteristic.

The suspension deflection measured at the spring location from the position of static equilibrium at no-load condition is

$$\zeta_{Si} = \zeta_i + \zeta_{RIN} . \quad (62)$$

Viscous damping force:

$$F_{3Ri} = K_{si} \dot{\zeta}_i + F_{SABSi} \quad (63)$$

and

$$F_{SABSi} = F(\dot{\zeta}_i) , \quad (64)$$

where  $F(\dot{\zeta}_i)$  is a digital function that is the difference between the linear analog value and the actual rear shock absorber characteristic.

Suspension force due to auxiliary roll stiffness:

$$F_{4Ri} = (-1)^i \frac{R_R \phi_R}{T_{SR}} \quad (65)$$

Antipitch force:

$$F_{APRi} = (P_{R0} + P_{R1} \zeta_i' + P_{R2} \zeta_i'^2) F_{xui} \quad (66)$$

Antiroll force:

$$F_{ARRi} = (-1)^i (R_{R0} + R_{R1} \zeta_i' + R_{R2} \zeta_i'^2) F_{yui} \quad (67)$$

For these expressions, the suspension deflections relative to the vehicle from the position of static equilibrium, measured at the right ( $i = 3$ ) and left ( $i = 4$ ) spring locations of the rear axle, respectively, are evaluated as

$$\zeta_i = \delta_R - (-1)^i \frac{T_{SR}}{2} \phi_R \quad (68)$$

and

$$\dot{\zeta}_i = \dot{\delta}_R - (-1)^i \frac{T_{SR}}{2} \dot{\phi}_R , \quad (69)$$

while the suspension deflection of the center of the rear wheel of the rear axle is

$$\zeta_i' = \delta_R - (-1)^i \frac{T_R}{2} \phi_R \quad (70)$$

or

$$\zeta'_i = \zeta_i + (-1)^i \frac{T_{SR} - T_R}{2} \phi_R . \quad (71)$$

2.4.3 Independent Front Suspension. The suspension forces  $S_i$  are effective at wheel  $i$ :

$$S_i = F_{sWF} - F_{1Fi} - F_{2Fi} - F_{3Fi} + F_{4Fi} + F_{APFi} + F_{ARFi} \quad (72)$$

with  $i = 1, 2$ .

Static component of the sprung mass weight:

$$F_{sWF} = \frac{b}{2(a + b)} M_s g \quad (73)$$

Coulomb friction:

$$F_{1Fi} = C'_{Fi} \operatorname{sgn} \dot{\delta}_i \quad (74)$$

The suspension force  $F_{2Fi}$  produced by deflection of the spring is

$$F_{2Fi} = K_{Fi} \delta_i + F_{BSi} \quad (75)$$

and

$$F_{BSi} = F(\delta_{Si}) , \quad (76)$$

where  $F(\delta_{Si})$  is a digital function that is the difference between the linear analog value and the actual spring characteristic.

$\delta_{Si}$  denotes the suspension deflection from the position of static equilibrium at no-load condition as

$$\delta_{Si} = \delta_i + \delta_{FIN} \quad (77)$$

Viscous damping force:

$$F_{3Fi} = K_{Si} \dot{\zeta}_i + F_{SABSi} \quad (78)$$

and

$$F_{SABSi} = F(\dot{\zeta}_i) , \quad (79)$$

where  $F(\dot{\zeta}_i)$  is a digital function that is the difference between the linear analog value and the actual front shock absorber characteristic.

Suspension force due to auxiliary roll stiffness:

$$F_{4Fi} = (-1)^i \frac{R_F (\delta_1 - \delta_2)}{T_F^2} \quad (80)$$

Antipitch force:

$$F_{APFi} = (P_{FO} + P_{F1} \delta_i + P_{F2} \delta_i^2) F_{xui} , \quad (81)$$

where  $F_{xui}$  is the component of the tire force on wheel  $i$  in the  $x$  direction in the vehicle axis system.

Antiroll force:

$$F_{ARFi} = (-1)^i (R_{FO} + R_{F1} \delta_i + R_{F2} \delta_i^2) F_{yui} , \quad (82)$$

where  $F_{yui}$  is the component of the tire force on wheel  $i$  along the vehicle  $y$  axis.

2.4.4 Independent Rear Suspension. Similarly, the suspension force effective at wheel  $i$  can be expressed as

$$S_i = F_{sWR} - F_{1Ri} - F_{2Ri} - F_{3Ri} + F_{4Ri} + F_{APRi} + F_{ARRi} \quad (83)$$

with  $i = 3, 4,$

where the individual contributions are as follows:

Static component of the sprung mass weight:

$$F_{sWR} = \frac{a}{2(a+b)} M_s g \quad (84)$$

Coulomb friction:

$$F_{1Ri} = C'_{Ri} \operatorname{sgn} \dot{\delta}_i \quad (85)$$

Suspension force due to spring deflection and suspension bump-stop impact is

$$F_{2Ri} = K_{Ri} \delta_i + F_{BSi} \quad (86)$$

and

$$F_{BSi} = F(\delta_{Si}) , \quad (87)$$

where  $F(\delta_{Si})$  is a digital function that is the difference between the linear analog value and the actual rear spring characteristic.

$\delta_{Si}$  denotes the suspension deflection from the position of static equilibrium at no-load condition as

$$\delta_{Si} = \delta_i + \delta_{RIN} . \quad (88)$$



Viscous damping force:

$$F_{3Ri} = K_{Si} \dot{\zeta}_i + F_{SABSi} \quad (89)$$

and

$$F_{SABSi} = F(\dot{\zeta}_i) \quad , \quad (90)$$

where  $F(\dot{\zeta}_i)$  is a digital function that is the difference between the linear analog value and the actual rear shock absorber characteristic.

Suspension force due to auxiliary roll stiffness:

$$F_{4Ri} = (-1)^i \frac{R_R (\delta_3 - \delta_4)}{T_R^2} \quad (91)$$

Antipitch force:

$$F_{APRi} = (P_{R0} + P_{R1} \delta_i + P_{R2} \delta_i^2) F_{xui} \quad (92)$$

Antiroll force:

$$F_{ARRi} = (-1)^i (R_{R0} + R_{R1} \delta_i + R_{R2} \delta_i^2) F_{yui} \quad (93)$$

## 2.5 Wheel Orientations

The orientations of the wheels with respect to the sprung mass are defined by the following equations:

Camber angles at wheel  $i$ :

$$\phi_1 = \phi_F + \Delta\phi_1 \quad (94-A)$$

$$\phi_2 = \phi_F + \Delta\phi_2 \quad (95-A)$$

$$\phi_3 = \phi_R \quad (96-B)$$

$$\phi_4 = \phi_R \quad (97-B)$$

$$\begin{aligned} \phi_1 = & \sum_{i=0}^5 C_{iF} \delta_{S1}^i + \Delta\phi_1 \operatorname{sgn} F_{S1} - \phi_{SA1} (1 - \cos \psi_1) \\ & + K_{OTF} M_{XF1} \end{aligned} \quad (94-C)$$

$$\begin{aligned} \phi_2 = & - \sum_{i=0}^5 C_{iF} \delta_{S2}^i + \Delta\phi_2 \operatorname{sgn} F_{S2} - \phi_{SA2} (1 - \cos \psi_2) \\ & + K_{OTF} M_{XF2} \end{aligned} \quad (95-C)$$

$$\phi_3 = \sum_{i=0}^5 C_{iR} \delta_{S3}^i + K_{OTR} M_{XR3} \quad (96-D)$$

$$\phi_4 = - \sum_{i=0}^5 C_{iR} \delta_{S4}^i + K_{OTR} M_{XR4} \quad (97-D)$$

Steer angles at wheel  $i$ :

$$\psi_1 = \delta_{FW1} - K_{FS} \phi_F + \Delta\psi_1 \quad (98-A)$$

$$\psi_2 = \delta_{FW2} - K_{FS} \phi_F + \Delta\psi_2 \quad (99-A)$$

$$\psi_3 = K_{RS} \phi_R + K_{SR} M_{ZR3} + K_{LR} F_{S3} \quad (100-B)$$

$$\psi_4 = K_{RS} \phi_R + K_{SR} M_{ZR4} + K_{LR} F_{S4} \quad (101-B)$$

$$\psi_1 = \delta_{FW1} + \sum_{i=0}^5 D_{iF} \delta_{S1}^i + \Delta\psi_1 \quad (98-C)$$

$$\psi_2 = \delta_{FW2} - \sum_{i=0}^5 D_{iF} \delta_{S2}^i + \Delta\psi_2 \quad (99-C)$$

$$\psi_3 = \sum_{i=0}^5 D_{iR} \delta_{S3}^i + K_{SR} M_{ZR3} + K_{LR} F_{S3} \quad (100-D)$$

$$\psi_4 = - \sum_{i=0}^5 D_{iR} \delta_{S4}^i + K_{SR} M_{ZR4} + K_{LR} F_{S4} \quad (101-D)$$

Caster angles of the front wheels:

$$\theta_{S1} = \sum_{i=0}^5 E_{iF} \delta_{S1}^i + \Delta\theta_1 \quad (102)$$

$$\theta_{S2} = \sum_{i=0}^5 E_{iF} \delta_{S2}^i + \Delta\theta_2 \quad (103)$$

## 2.6 Resultant Forces and Moments

The resultant tire and aerodynamic forces and moments required for the equations of motion are given below:

Tire forces:

$$F_{xui} = F_{Rxui} + F_{Cxui} + F_{Sxui} \quad (104)$$

$$F_{yui} = F_{Ryui} + F_{Cyui} + F_{Syui} \quad (105)$$

$$F_{zui} = F_{Rzui} + F_{Czui} + F_{Szui} \quad (106)$$

where

$$F_{Rxui} = -F_{Ri} a_{31} \quad (107)$$

$$F_{Ryui} = -F_{Ri} a_{32} \quad (108)$$

$$F_{Rzui} = -F_{Ri} a_{33} \quad (109)$$

and

$F_{Ri}$  is the tire force normal to the ground.

Furthermore:

$$F_{Cxui} = F_{Ci} (a_{11} \cos \alpha_{ci} + a_{21} \cos \beta_{ci}) \quad (110)$$

$$F_{Cyui} = F_{Ci} (a_{12} \cos \alpha_{ci} + a_{22} \cos \beta_{ci}) \quad (111)$$

$$F_{Czui} = F_{Ci} (a_{13} \cos \alpha_{ci} + a_{23} \cos \beta_{ci}) \quad (112)$$

$$F_{Sxui} = F_{Si} (-a_{11} \cos \beta_{ci} + a_{21} \cos \alpha_{ci}) \quad (113)$$

$$F_{Syui} = F_{Si} (-a_{12} \cos \beta_{ci} + a_{22} \cos \alpha_{ci}) \quad (114)$$

$$F_{Szui} = F_{Si} (-a_{13} \cos \beta_{ci} + a_{23} \cos \alpha_{ci}) \quad (115)$$

Furthermore:

$$\begin{aligned} \cos \alpha_{ywi} &= a_{11} (-\sin \psi_i) + a_{12} (\cos \phi_i \cos \psi_i) \\ &\quad + a_{13} (\sin \phi_i \cos \psi_i) \end{aligned} \quad (116)$$

$$\begin{aligned} \cos \beta_{ywi} &= a_{21} (-\sin \psi_i) + a_{22} (\cos \phi_i \cos \psi_i) \\ &\quad + a_{23} (\sin \phi_i \cos \psi_i) \end{aligned} \quad (117)$$

$$\begin{aligned} \cos \gamma_{ywi} &= a_{31} (-\sin \psi_i) + a_{32} (\cos \phi_i \cos \psi_i) \\ &\quad + a_{33} (\sin \phi_i \cos \psi_i) \end{aligned} \quad (118)$$

and

$$\cos \alpha_{Ci} = \frac{\cos \beta_{ywi}}{\sqrt{\cos^2 \beta_{ywi} + \cos^2 \alpha_{ywi}}} \quad (119)$$

$$\cos \beta_{ci} = \frac{-\cos \alpha_{ywi}}{\sqrt{\cos^2 \beta_{ywi} + \cos^2 \alpha_{ywi}}} \quad (120)$$

$$\Sigma F_{xu} = \sum_{i=1}^4 F_{xui} \quad (121)$$

$$\Sigma F_{yu} = \sum_{i=1}^4 F_{yui} \quad (122)$$

$$\Sigma F_{zu} = \sum_{i=1}^4 F_{zui} \quad (123)$$

Aerodynamic forces:

Cross-wind disturbance:

$$u_r = u - v_{yw} \sin \psi \quad (124)$$

$$v_r = v - v_{yw} \cos \psi \quad (125)$$

$$w_r = w \quad (126)$$

$$\bar{p} = (p - \omega_{xw} \cos \psi + \omega_{zw} \theta) \frac{\ell}{u_r} \quad (127)$$

$$\bar{q} = (q + \omega_{xw} \sin \psi - \omega_{zw} \phi) \frac{\ell}{u_r} \quad (128)$$

$$\bar{r} = (r - \omega_{zw}) \frac{\ell}{u_r} \quad (129)$$

$$V_{CW} = \sqrt{u_r^2 + v_r^2 + w_r^2} \quad (130)$$

$$\alpha = \tan^{-1} \left( \frac{w_r}{u_r} \right) \quad (131)$$

$$\tau = \left| \sin^{-1} \left( \frac{V_r}{V_{CW}} \right) \right| \quad -3.14 \leq \tau \leq 3.14 \quad (132)$$

$$q_a = \frac{1}{2} \rho_a V_{CW}^2 \quad (133)$$

$$\Sigma F_{xS} = (C_X + \Delta C_X) q_a S_f \quad (134)$$

$$\Sigma F_{yS} = (C_Y + C_{y_p} \bar{p} + C_{y_r} \bar{r}) q_a S_f \quad (135)$$

$$\Sigma F_{zS} = (C_Z + C_{z_\alpha} \alpha + C_{z_q} \bar{q}) q_a S_f \quad (136)$$

Tire moments:

$$\begin{aligned} \Sigma N_{\phi u} &= (S_2 - S_1) \frac{T_{SF}}{2} + (S_4 - S_3) \frac{T_{SR}}{2} \\ &\quad - (F_{yu1} + F_{yu2}) (z_F + \delta_F) \\ &\quad - (F_{yu3} + F_{yu4}) (z_R + \delta_R) \end{aligned} \quad (137-E)$$

$$\begin{aligned} \Sigma N_{\phi u} &= (S_2 - S_1) \frac{T_F}{2} + (S_4 - S_3) \frac{T_{SR}}{2} \\ &\quad - F_{yu1} (z_F + \delta_1 + h_1 \cos \gamma_{h1} - H_{FC}) \\ &\quad - F_{yu2} (z_F + \delta_2 + h_2 \cos \gamma_{h2} - H_{FC}) \\ &\quad - (F_{yu3} + F_{yu4}) (z_R + \delta_R) + \sum_{i=1}^2 M_{XF_i} \end{aligned} \quad (137-F)$$

$$\begin{aligned}
\Sigma N_{\phi u} &= (S_2 - S_1) \frac{T_F}{2} + (S_4 - S_3) \frac{T_R}{2} \\
&- F_{yu1} (z_F + \delta_1 + h_1 \cos \gamma_{h1} - H_{FC}) \\
&- F_{yu2} (z_F + \delta_2 + h_2 \cos \gamma_{h2} - H_{FC}) \\
&- F_{yu3} (z_R + \delta_3 + h_3 \cos \gamma_{h3} - H_{RC}) \\
&- F_{yu4} (z_R + \delta_4 + h_4 \cos \gamma_{h4} - H_{RC}) \\
&+ \sum_{i=1}^2 M_{XF_i} + \sum_{i=3}^4 M_{XR_i}
\end{aligned} \tag{137-G}$$

$$\begin{aligned}
\Sigma N_{\theta u} &= (S_1 + S_2)a - (S_3 + S_4)b \\
&+ F_{xu1} (z_F + \delta_F + \frac{T_F}{2} \phi_F + h_1 \cos \gamma_{h1}) \\
&+ F_{xu2} (z_F + \delta_F - \frac{T_F}{2} \phi_F + h_2 \cos \gamma_{h2}) \\
&+ F_{xu3} (z_R + \delta_R + \frac{T_R}{2} \phi_R + h_3 \cos \gamma_{h3}) \\
&+ F_{xu4} (z_R + \delta_R - \frac{T_R}{2} \phi_R + h_4 \cos \gamma_{h4})
\end{aligned} \tag{138-E}$$

$$\Sigma N_{\theta u} = (S_1 + S_2)a - (S_3 + S_4)b + F_{xu1} (z_F + \delta_1 + h_1 \cos \gamma_{h1})$$



$$\begin{aligned}
& + F_{xu2} (z_F + \delta_2 + h_2 \cos \gamma_{h2}) \\
& + F_{xu3} (z_R + \delta_R + \frac{T_R}{2} \phi_F + h_3 \cos \gamma_{h3}) \\
& + F_{xu4} (z_R + \delta_R - \frac{T_R}{2} \phi_F + h_4 \cos \gamma_{h4}) \tag{138-F}
\end{aligned}$$

$$\begin{aligned}
\Sigma N_{\theta u} & = (S_1 + S_2)a - (S_3 + S_4)b + F_{xu1} (z_F + \delta_1 + h_1 \cos \gamma_{h1}) \\
& + F_{xu2} (z_F + \delta_2 + h_2 \cos \gamma_{h2}) + F_{xu3} (z_R + \delta_3 + h_3 \cos \gamma_{h3}) \\
& + F_{xu4} (z_R + \delta_4 + h_4 \cos \gamma_{h4}) \tag{138-G}
\end{aligned}$$

$$\begin{aligned}
\Sigma N_{\phi F} & = F_{zu1} (\frac{T_F}{2} + h_1 \cos \beta_{h1}) - F_{zu2} (\frac{T_F}{2} - h_2 \cos \beta_{h2}) \\
& - F_{yu1} (\frac{T_F}{2} \phi_F + h_1 \cos \gamma_{h1}) - F_{yu2} (-\frac{T_F}{2} \phi_F + h_2 \cos \gamma_{h2}) \\
& + (S_1 - S_2) \frac{T_{SF}}{2} + \sum_{i=1}^2 M_{XF_i} \tag{139-A}
\end{aligned}$$

$$\begin{aligned}
\Sigma N_{\phi R} & = F_{zu3} (\frac{T_R}{2} + h_3 \cos \beta_{h3}) - F_{zu4} (\frac{T_R}{2} - h_4 \cos \beta_{h4}) \\
& - F_{yu3} (\frac{T_R}{2} \phi_R + h_3 \cos \gamma_{h3}) - F_{yu4} (-\frac{T_R}{2} \phi_R + h_4 \cos \gamma_{h4}) \\
& + (S_3 - S_4) \frac{T_{SR}}{2} + \sum_{i=3}^4 M_{XR_i} \tag{140-B}
\end{aligned}$$

$$\begin{aligned}
\Sigma N_{\psi u} = & F_{yu1} (a + h_1 \cos \alpha_{h1}) + F_{yu2} (a + h_2 \cos \alpha_{h2}) \\
& - F_{yu3} (b - h_3 \cos \alpha_{h3}) - F_{yu4} (b - h_4 \cos \alpha_{h4}) \\
& + F_{xu2} \left( \frac{T_F}{2} - h_2 \cos \beta_{h2} \right) - F_{xu1} \left( \frac{T_F}{2} + h_1 \cos \beta_{h1} \right) \\
& + F_{xu4} \left( \frac{T_R}{2} - h_4 \cos \beta_{h4} \right) - F_{xu3} \left( \frac{T_R}{2} + h_3 \cos \beta_{h3} \right) \\
& + \sum_{i=1}^2 M_{ZF_i} + \sum_{i=3}^4 M_{ZR_i}
\end{aligned} \tag{141}$$

where

$$\cos \alpha_{hi} = a_{11} \cos \alpha_{Ri} + a_{21} \cos \beta_{Ri} + a_{31} \cos \gamma_{Ri} \tag{142}$$

$$\cos \beta_{hi} = a_{12} \cos \alpha_{Ri} + a_{22} \cos \beta_{Ri} + a_{32} \cos \gamma_{Ri} \tag{143}$$

$$\cos \gamma_{hi} = a_{13} \cos \alpha_{Ri} + a_{23} \cos \beta_{Ri} + a_{33} \cos \gamma_{Ri} \tag{144}$$

and

$$\cos \alpha_{Ri} = \frac{-\cos \gamma_{ywi} \cos \alpha_{ywi}}{\sqrt{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}}} \tag{145}$$

$$\cos \beta_{Ri} = \frac{-\cos \gamma_{ywi} \cos \beta_{ywi}}{\sqrt{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}}} \tag{146}$$

$$\cos \gamma_{Ri} = \frac{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}}{\sqrt{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}}} \tag{147}$$

Aerodynamic moments:

$$d_{CG} = a - \frac{\ell}{2} \quad (148)$$

$$C'_L = \frac{\ell_v}{\ell} C_L + \frac{Z(0)}{\ell} C_Y \quad (149)$$

$$C'_M = \frac{\ell_v}{\ell} C_M - \frac{d_{CG}}{\ell} C_Z - \frac{Z(0)}{\ell} C_X \quad (150)$$

$$C'_N = \frac{\ell_v}{\ell} C_N + \frac{d_{CG}}{\ell} C_Y \quad (151)$$

$$\Sigma N_{\phi_s} = (C'_L + C_{\ell_p} \bar{p} + C_{\ell_r} \bar{r}) q_a S_f \ell \quad (152)$$

$$\Sigma N_{\theta_s} = (C'_M + C_{m_\alpha} \alpha + C_{m_q} \bar{q}) q_a S_f \ell \quad (153)$$

$$\Sigma N_{\psi_s} = (C'_N + C_{n_p} \bar{p} + C_{n_r} \bar{r}) q_a S_f \ell \quad (154)$$

## 2.7 Radial Tire Force and Rolling Radius

The radial tire forces and the rolling radii of the tires are computed by the following equations:

$$F'_{Ri} = K_{Ti} (R_w - h_i) \quad (155)$$

where

$$h_i = \Delta_i \text{ for } h_i \leq R_w \quad (156)$$

$$h_i = R_w \text{ for } h_i > R_w \quad (157)$$

and

$$\Delta_i = \frac{\sqrt{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}}}{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}} (Z_{Si} - Z_i) \quad (158)$$

$$Z_1 = Z + a_{31} a + a_{32} \frac{T_F}{2} + a_{33} (z_F + \frac{T_F}{2} \phi_F + \delta_F) \quad (159-A)$$

$$Z_2 = Z + a_{31} a - a_{32} \frac{T_F}{2} + a_{33} (z_F - \frac{T_F}{2} \phi_F + \delta_F) \quad (160-A)$$

$$Z_3 = Z - a_{31} b + a_{32} \frac{T_R}{2} + a_{33} (z_R + \frac{T_R}{2} \phi_R + \delta_R) \quad (161-B)$$

$$Z_4 = Z - a_{31} b - a_{32} \frac{T_R}{2} + a_{33} (z_R - \frac{T_R}{2} \phi_R + \delta_R) \quad (162-B)$$

$$Z_1 = Z + a_{31} a + a_{32} \frac{T_F}{2} + a_{33} (z_F + \delta_1) \quad (159-C)$$

$$Z_2 = Z + a_{31} a - a_{32} \frac{T_F}{2} + a_{33} (z_F + \delta_2) \quad (160-C)$$

$$Z_3 = Z - a_{31} b + a_{32} \frac{T_R}{2} + a_{33} (z_R + \delta_3) \quad (161-D)$$

$$Z_4 = Z - a_{31} b - a_{32} \frac{T_R}{2} + a_{33} (z_R + \delta_4) \quad (162-D)$$

and the initial tire loading and orientation are as shown below:

$$\theta_{(0)} = \frac{[h_1(0) - h_3(0)] + [z_F - z_R]}{(a + b)} \quad (163)$$

$$h_1(0) = h_2(0) = R_w - \frac{g}{2K_{T1}} \left[ M_{UF} + \left( \frac{b}{a+b} \right) M_S \right] \quad (164)$$

$$h_3(0) = h_4(0) = R_w - \frac{g}{2K_{T3}} \left[ M_{UR} + \left( \frac{b}{a+b} \right) M_S \right] \quad (165)$$

$$z_{(0)} = - \frac{b[h_1(0) + z_F] + a[h_3(0) + z_R]}{(a+b)} + z_{bias} . \quad (166)$$

Wheel lift-off indication is provided by

$$z_{MXi} = (R_w - h_i) \quad i = 1, 2, 3, 4 \quad (167)$$

where

$$z_{MXi} > 0 \quad \text{wheel } i \text{ in contact with tire-terrain patch,}$$

$$z_{MXi} \leq 0 \quad \text{wheel } i \text{ not in contact with tire-terrain patch.}$$

## 2.8 Tire Circumferential Force

The circumferential tire forces for both driving and braking are defined by the following equation:

$$F_{Ci} = - \mu'_i F_{Ri} \quad (168)$$

where

$$F_{Ri} = F'_{Ri} \left( \frac{1}{\cos \phi_{cGi}} \right) - F_{Si} \tan \phi_{cGi} . \quad (169)$$

## 2.9 Circumferential Friction Coefficients

The circumferential friction coefficient equations are shown below:

$$\begin{aligned}\mu'_i &= m_{2i} (\text{SLIP})_i + \mu_{0i} \text{ for } (\text{SLIP})_i > \text{SI}_i \\ &= m_{1i} (\text{SLIP})_i \text{ for } (\text{SLIP})_i \leq \text{SI}_i.\end{aligned}\quad (170)$$

Computation of the slopes for the  $\mu'_i$  curve is performed by the following equations:

Front wheels:

$$\mu'_{\text{SF}} = (\mu_{\text{SF}} + S_{1\text{F}} F_{\text{Ri}}) |\cos(\beta_i)| \quad i = 1, 2 \quad (171)$$

$$\mu_{\text{PF}} = P_{\text{BF1}} + P_{\text{BF2}} F_{\text{Ri}} \quad (172)$$

$$\text{SN}_i = (\text{SN})_{\text{S0}} / (\text{SN})_{\text{T}} \quad (173)$$

$$\begin{aligned}m_{1i} &= \left( \frac{\mu_{\text{PF}}}{\text{SI}_i} \right) (1.0 - 57.3 B_c |\beta_i + \beta'_i|) \text{SN}_i \quad \text{for } m_{1i} \geq \frac{\mu'_{\text{SF}}}{\text{SI}_i} \text{SN}_i \\ &= \left( \frac{\mu'_{\text{SF}}}{\text{SI}_i} \right) \text{SN}_i \quad \text{for } m_{1i} < \frac{\mu'_{\text{SF}}}{\text{SI}_i} \text{SN}_i\end{aligned}\quad (174)$$

$$\begin{aligned}m_{2i} &= \left[ \frac{\mu'_{\text{SF}} - \mu_{\text{PF}} (1.0 - 57.3 B_c |\beta_i + \beta'_i|)}{(1.0 - \text{SI}_i)} \right] \text{SN}_i \quad \text{for } m_{1i} \geq \frac{\mu'_{\text{SF}}}{\text{SI}_i} \text{SN}_i \\ &= 0.0 \quad \text{for } m_{1i} < \frac{\mu'_{\text{SF}}}{\text{SI}_i} \text{SN}_i\end{aligned}\quad (175)$$

$$\mu_{1i} = \mu'_{SF} SN_i \quad (176)$$

$$\mu_{0i} = \mu_{1i} - m_{2i} \quad (177)$$

Rear wheels:

$$\mu'_{SR} = (\mu_{SR} + S_{1R} F_{Ri}) |\cos(\beta_i)| \quad i = 3, 4 \quad (178)$$

$$\mu_{PR} = P_{BR1} + P_{BR2} F_{Ri} \quad (179)$$

$$SN_i = (SN)_{S0} / (SN)_T \quad (180)$$

$$m_{1i} = \left( \frac{\mu_{PR}}{SI_i} \right) (1.0 - 57.3 B_c |\beta_i + \beta'_i|) SN_i \quad \text{for } m_{1i} \geq \frac{\mu'_{SR}}{SI_i} SN_i$$

$$= \left( \frac{\mu'_{SR}}{SI_i} \right) SN_i \quad \text{for } m_{1i} < \frac{\mu'_{SR}}{SI_i} SN_i \quad (181)$$

$$m_{2i} = \left[ \frac{\mu'_{SR} - \mu_{PR} (1.0 - 57.3 B_c |\beta_i + \beta'_i|)}{(1.0 - SI_i)} \right] SN_i \quad \text{for } m_{1i} \geq \frac{\mu'_{SR}}{SI_i} SN_i$$

$$= 0.0 \quad \text{for } m_{1i} < \frac{\mu'_{SR}}{SI_i} SN_i \quad (182)$$

$$\mu_{1i} = \mu'_{SR} SN_i \quad (183)$$

$$\mu_{0i} = \mu_{1i} - m_{2i} \quad (184)$$

### 1.11 Wheel Slip

Computation of nonuniform wheel slip is performed by the following equations:

$$\begin{aligned} \text{Slip } s_{ij} &= 1 & \text{for } \sigma_{ij} > 1 \\ &= \sigma_{ij} & \text{for } -1 \leq \sigma_{ij} \leq 1 \\ &= -1 & \text{for } \sigma_{ij} < -1 \end{aligned} \quad (13)$$

where

$$\sigma_{ij} = 1 - \frac{v_{ij} r_{ij}}{v_{\text{ref}} r_{\text{ref}} \cos \theta_{ij} + v_{\text{ref}} r_{\text{ref}} \sin \theta_{ij}} \quad (14)$$



### 1.11 Wheel Rotational Equations (4 degrees of freedom)

The wheel rotational equations required to compute wheel slip are presented below:

$$\left( \overline{I}_{WF} + \frac{1}{4} \overline{I}_{DR} \left( \frac{\overline{AR}_F}{r} \right)^2 \right) \dot{\omega}_1 + \left( \frac{1}{4} \overline{I}_{DF} \left( \frac{\overline{AR}_F}{r} \right)^2 \right) \dot{\omega}_1 = - F_{G1} h_1 + \overline{EQ}_1 \quad (137)$$

$$\left( \overline{I}_{WF} + \frac{1}{4} \overline{I}_{DF} \left( \frac{\overline{AR}_F}{r} \right)^2 \right) \dot{\omega}_2 + \left( \frac{1}{4} \overline{I}_{DF} \left( \frac{\overline{AR}_F}{r} \right)^2 \right) \dot{\omega}_1 = - F_{G2} h_1 + \overline{EQ}_2 \quad (138)$$

$$\left( \overline{I}_{WR} + \frac{1}{4} \overline{I}_{DR} \left( \frac{\overline{AR}_R}{r} \right)^2 \right) \dot{\omega}_3 + \left( \frac{1}{4} \overline{I}_{DR} \left( \frac{\overline{AR}_R}{r} \right)^2 \right) \dot{\omega}_4 = - F_{G3} h_3 + \overline{EQ}_3 \quad (139)$$

$$\left( \overline{I}_{WR} + \frac{1}{4} \overline{I}_{DR} \left( \frac{\overline{AR}_R}{r} \right)^2 \right) \dot{\omega}_4 + \left( \frac{1}{4} \overline{I}_{DR} \left( \frac{\overline{AR}_R}{r} \right)^2 \right) \dot{\omega}_3 = - F_{G4} h_4 + \overline{EQ}_4 \quad (140)$$

where

$$\omega_{\pm} = \omega_{\pm}(t) + \int_0^t \dot{\omega}_{\pm} dt \quad (141)$$

For:  $(\text{SLIP})_{\pm} = 0$  at  $t = 0$ ,

$$\omega_{\pm}(0) = \frac{u_{\pm}(0) \cos \psi_{\pm}(0) + v_{\pm}(0) \sin \psi_{\pm}(0)}{h_{\pm}(0)} \quad (142)$$

$$\overline{EQ}_1 = (1 - \lambda_D) \left( \frac{\overline{AR}_F}{r} \right) \overline{EQ}_{DF} + \lambda_{B1} \overline{EQ}_{B1} \quad (143)$$

$$\overline{EQ}_2 = (1 - \lambda_D) \left( \frac{\overline{AR}_F}{r} \right) \overline{EQ}_{DF} + \lambda_{B2} \overline{EQ}_{B2} \quad (144)$$

$$\overline{EQ}_3 = \lambda_D \left( \frac{\overline{AR}_R}{r} \right) \overline{EQ}_{DR} + \lambda_{B3} \overline{EQ}_{B3} \quad (145)$$

$$\overline{TQ}_4 = \lambda_D \left( \frac{\overline{AR}_R}{2} \right) \overline{TQ}_{DR} + \lambda_{B4} \overline{TQ}_{B4} \quad (196)$$

### 2.12 Brake and Drive Torques

The drive torques generated to maintain a constant velocity are computed by

$$\begin{aligned} \overline{TQ}_D &= K_{TQ} (V_C - u), \quad \text{for } \overline{TQ}_D \leq TQ_{D_{\max}} \\ &= TQ_{D_{\max}}, \quad \text{otherwise,} \end{aligned} \quad (197)$$

where  $V_C$  is the desired velocity.

Values of 1000 lb-in./in./s and 6000 lb-in. were assigned to  $K_{TQ}$  and  $TQ_{D_{\max}}$ , respectively. When braking is investigated, the drive torque<sup>max</sup> is 0 and the brake torque magnitudes are determined from input data functions.

$$\overline{TQ}_{B1} = \overline{TQ}_{B2} = FF(PFL), \text{ lb-in.} \quad (198)$$

$$\overline{TQ}_{B3} = \overline{TQ}_{B4} = FR(PFL), \text{ lb-in.} \quad (199)$$

where PFL is an input value for brake-line pressure.

### 2.13 Tire Side Force

The nonlinear tire side forces are computed using the following equations:

$$\begin{aligned} F_{Si} &= F_{Ri} \left\{ \left| \mu_{yi} g(\overline{\beta}_i) \right| \right. & i = 1, 2 \\ &\quad \left. - \left[ \left| \mu_{yi} g(\overline{\beta}_i) \right| - \mu_{SF} \left| \sin(\beta_i) \right| SN_i \right] F_i \right\} \text{sgn } g(\overline{\beta}_i) \end{aligned} \quad (200)$$

$$F_{Si} = F_{Ri} \left\{ \begin{aligned} &|\mu_{yi} \operatorname{sgn}(\bar{\beta}_i)| && i = 3, 4 \\ &- \left[ |\mu_{yi} \operatorname{sgn}(\bar{\beta}_i)| - \mu_{SR} |\sin(\beta_i)| SN_i \right] F_i \end{aligned} \right\} \operatorname{sgn} \operatorname{sgn}(\bar{\beta}_i) \quad (201)$$

#### 2.14 Tire Side Force Friction Coefficient

The side force coefficient of friction is defined below:

$$\mu_{yi} = (B_{1F} F_{Ri} + B_{2F} C_{vi} + B_{3F} + B_{4F} F_{Ri}^2) SN_i \quad i = 1, 2 \quad (202)$$

$$\mu_{yi} = (B_{1R} F_{Ri} + B_{2R} C_{vi} + B_{3R} + B_{4R} F_{Ri}^2) SN_i \quad i = 3, 4 \quad (203)$$

and

$$C_{vi} = \sqrt{u_{Gi}^2 + v_{Gi}^2} \quad (204)$$

#### 2.15 Velocities of the Tire Contact Points

The velocities of the tire contact points along the vehicle axes are computed by the following equations:

$$u_1 = u - \frac{T_F}{2} r + (z_F + \delta_F + \frac{T_F}{2} \phi_F) q \quad (205-A)$$

$$u_2 = u + \frac{T_F}{2} r + (z_F + \delta_F - \frac{T_F}{2} \phi_F) q \quad (206-A)$$

$$u_3 = u - \frac{T_R}{2} r + (z_R + \delta_R + \frac{T_R}{2} \phi_R) q \quad (207-B)$$

$$u_4 = u + \frac{T_R}{2} r + (z_R + \delta_R - \frac{T_R}{2} \phi_R) q \quad (208-B)$$

$$u_1 = u - \frac{T_F}{2} r + (z_F + \delta_1) q \quad (205-C)$$

$$u_2 = u + \frac{T_F}{2} r + (z_F + \delta_2) q \quad (206-C)$$

$$u_3 = u - \frac{T_R}{2} r + (z_R + \delta_3) q \quad (207-D)$$

$$u_4 = u + \frac{T_R}{2} r + (z_R + \delta_4) q \quad (208-D)$$

$$v_1 = v + ar - (z_F + \delta_F)p - \left(\frac{T_F}{2} \phi_F + h_1 \cos \gamma_{h1}\right)(p + \dot{\phi}_F) \quad (209-A)$$

$$v_2 = v + ar - (z_F + \delta_F)p - \left(-\frac{T_F}{2} \phi_F + h_2 \cos \gamma_{h2}\right)(p + \dot{\phi}_F) \quad (210-A)$$

$$v_3 = v - br - (z_R + \delta_R)p - \left(\frac{T_R}{2} \phi_R + h_3 \cos \gamma_{h3}\right)(p + \dot{\phi}_R) \quad (211-B)$$

$$v_4 = v - br - (z_R + \delta_R)p - \left(-\frac{T_R}{2} \phi_R + h_4 \cos \gamma_{h4}\right)(p + \dot{\phi}_R) \quad (212-B)$$

$$v_1 = v + ar - (z_F + \delta_1 + h_1 \cos \gamma_{h1}) p \quad (209-C)$$

$$v_2 = v + ar - (z_F + \delta_2 + h_2 \cos \gamma_{h2}) p \quad (210-C)$$

$$v_3 = v - br - (z_R + \delta_3 + h_3 \cos \gamma_{h3}) p \quad (211-D)$$

$$v_4 = v - br - (z_R + \delta_4 + h_4 \cos \gamma_{h4}) p \quad (212-D)$$

$$w_1 = w + \dot{\delta}_F - aq - \left(-\frac{T_F}{2} - h_1 \cos \beta_{h1}\right)(p + \dot{\phi}_F) \quad (213-A)$$

$$w_2 = w + \dot{\delta}_F - aq - \left(\frac{T_F}{2} - h_2 \cos \beta_{h2}\right)(p + \dot{\phi}_F) \quad (214-A)$$

$$w_3 = w + \dot{\delta}_R + bq - \left(-\frac{T_R}{2} - h_3 \cos \beta_{h3}\right)(p + \dot{\phi}_R) \quad (215-B)$$

$$w_4 = w + \dot{\delta}_R + bq - \left(\frac{T_R}{2} - h_4 \cos \beta_{h4}\right)(p + \dot{\phi}_R) \quad (216-B)$$

$$w_1 = w - aq + \left(\frac{T_F}{2} + h_1 \cos \beta_{h1}\right)p + \dot{\delta}_1 \quad (213-C)$$

$$w_2 = w - aq - \left(\frac{T_F}{2} - h_2 \cos \beta_{h2}\right)p + \dot{\delta}_2 \quad (214-C)$$

$$w_3 = w + bq + \left(\frac{T_R}{2} + h_3 \cos \beta_{h3}\right)p + \dot{\delta}_3 \quad (215-D)$$

$$w_4 = w + bq - \left(\frac{T_R}{2} - h_4 \cos \beta_{h4}\right)p + \dot{\delta}_4 \quad (216-D)$$

The wheel velocities in the ground plane are computed by

$$u_{Gi} = u_i \cos \theta_{XGi} - w_i \sin \theta_{XGi} \quad (217)$$

$$v_{Gi} = v_i \cos \phi - w_i \sin \phi \quad i = 1, 2, 3, 4 \quad (218)$$

where

$$\cos \theta_{XGi} = \frac{\cos \theta \cos \phi}{\sqrt{\cos^2 \phi + \sin^2 \phi \sin^2 \theta}} \quad (219)$$

$$\sin \theta_{XGi} = \frac{-\sin \theta}{\sqrt{\cos^2 \phi + \sin^2 \phi \sin^2 \theta}} \quad (220)$$

## 2.16 Combined Slip Angle and Camber Shaping Function

The dimensionless side force shaping function for slip angle and camber is as follows:

$$\begin{aligned}
 g(\bar{\beta}_i) &= \bar{\beta}_i - \frac{1}{3} \bar{\beta}_i |\bar{\beta}_i| + \frac{1}{27} \bar{\beta}_i^3 \quad \text{if } |\bar{\beta}_i| < 3 \\
 &= \frac{\bar{\beta}_i}{|\bar{\beta}_i|} \quad \text{if } |\bar{\beta}_i| \geq 3 \quad i = 1, 2, 3, 4.
 \end{aligned} \tag{221}$$

For  $F_{Ri} \leq A\Omega_{TF} A_{2F}$ ,  $i = 1, 2$

$$\bar{\beta}_i = \frac{A_{1F} F_{Ri} (F_{Ri} - A_{2F}) - A_{OF} A_{2F}}{A_{2F} \mu_{yi} F_{Ri}} (\beta_i + \beta'_i) \tag{222}$$

$$\beta'_i = \frac{A_{2F} A_{3F} (A_{4F} - F_{Ri}) F_{Ri} \phi_{CGi}}{A_{4F} [A_{1F} F_{Ri} (F_{Ri} - A_{2F}) - A_{OF} A_{2F}]} . \tag{223}$$

If  $F_{Ri} > A\Omega_{TF} A_{2F}$ ,  $i = 1, 2$

$$\bar{\beta}_i = \frac{A_{1F} A_{2F} A\Omega_{TF} (A\Omega_{TF} - 1) - A_{OF}}{\mu_{yi} F_{Ri}} (\beta_i + \beta'_i) \tag{224}$$

$$\beta'_i = \frac{A_{2F} A_{3F} A\Omega_{TF} (A_{4F} - A\Omega_{TF} A_{2F}) \phi_{CGi}}{A_{4F} [A_{1F} A_{2F} A\Omega_{TF} (A\Omega_{TF} - 1) - A_{OF}]} . \tag{225}$$

For  $F_{Ri} \leq A\Omega_{TR} A_{2R}$ ,  $i = 3, 4$

$$\bar{\beta}_i = \frac{A_{1R} F_{Ri} (F_{Ri} - A_{2R}) - A_{OR} A_{2R}}{A_{2R} \mu_{yi} F_{Ri}} (\beta_i + \beta'_i) \tag{226}$$

$$\beta'_i = \frac{A_{2R} A_{3R} (A_{4R} - F_{Ri}) F_{Ri} \phi_{CGi}}{A_{4R} [A_{1R} F_{Ri} (F_{Ri} - A_{2R}) - A_{OR} A_{2R}]} . \tag{227}$$

If  $F_{Ri} > A_{\Omega_{TR}} A_{2R}$ ,  $i = 3, 4$

$$\bar{\beta}_i = \frac{A_{1R} A_{2R} A_{\Omega_{TR}} (A_{\Omega_{TR}} - 1) - A_{OR}}{u_{yi} F_{Ri}} (\beta_i + \beta'_i) \quad (228)$$

$$\beta'_i = \frac{A_{2R} A_{3R} A_{\Omega_{TR}} (A_{4R} - A_{\Omega_{TR}} A_{2R}) \phi_{CGi}}{A_{4R} [A_{1R} A_{2R} A_{\Omega_{TR}} (A_{\Omega_{TR}} - 1) - A_{OR}]} \quad (229)$$

### 2.17 Wheel Slip Angle

$$\beta_i = \tan^{-1} \left( \frac{v_{Gi}}{|u_{Gi}|} \right) - \psi'_i \operatorname{sgn} \left( u_{Gi} \right) \quad (230)$$

where

$$\psi'_i = \sin^{-1} \left[ \frac{-(a_{11} \cos \alpha_{ywi} + a_{21} \cos \beta_{ywi})}{\cos \theta \sqrt{\cos^2 \alpha_{ywi} + \cos^2 \beta_{ywi}}} \right] \quad (231)$$

### 2.18 Wheel Camber with Respect to the Road

The camber angles of the wheels measured with respect to the road are given by

$$\phi_{CGi} = \sin^{-1} (\cos \gamma_{ywi}) + K_{CF} F_{Si} + \Delta\phi_i \quad i = 1, 2 \quad (232-A)$$

$$\phi_{CGi} = \sin^{-1} (\cos \gamma_{ywi}) + K_{CF} F_{Si} \quad i = 1, 2 \quad (232-C)$$

$$\phi_{CGi} = \sin^{-1} (\cos \gamma_{ywi}) + K_{CR} F_{Si} \quad i = 3, 4 \quad (233-B,D)$$

## 2.19 Wheel Slip Shaping Function

The dimensionless side force shaping function for circumferential slip is empirically derived.

$$F_i \left[ (\text{SLIP})_i \right] = \text{input table} \quad (234)$$

$F_i$	$(\text{SLIP})_i$ (%)
0.00	00.0
0.01	05.0
0.03	10.0
0.07	15.0
0.17	20.0
0.35	30.0
0.54	40.0
0.81	60.0
0.93	80.0
1.00	100.0

## 2.20 Tire Moments

The tire-road reaction moments acting about the kingpins are computed by the following equations:

$$\begin{aligned}
 M_{Ti} = & - (y_{SAi} - h_i \phi_{SOi}) \left[ (F_{xui} - F_{zui} \theta_{Si}) \cos \psi_i \right. \\
 & \left. + (F_{yui} + F_{zui} \phi_{SAi}) \sin \psi_i \right] \\
 & - \overline{PT}_i \cos \psi_i \left[ (F_{yui} + F_{zui} \phi_{SAi}) \cos \psi_i \right. \\
 & \left. - (F_{xui} - F_{zui} \theta_{Si}) \sin \psi_i \right] \quad i = 1, 2 \quad (235)
 \end{aligned}$$



where

$$\phi_{SA1} = \phi_{SA01} + \sum_{i=1}^5 C_{iF} \delta_{S1}^i \quad (236)$$

$$\phi_{SA2} = \phi_{SA02} - \sum_{i=1}^5 C_{iF} \delta_{S2}^i \quad (237)$$

The tire aligning torques are defined as

$$M_{ZF_i} = (A_{F1} F_{Ri} + A_{F2} |F_{Si}|) F_{Si} + A_{F3} F_{Ri} (|\phi_{CGi}|)^{\frac{1}{2}} \text{sgn } \phi_{CGi} \quad (238)$$

$i = 1, 2$

$$M_{ZR_i} = (A_{R1} F_{Ri} + A_{R2} |F_{Si}|) F_{Si} + A_{R3} F_{Ri} (|\phi_{CGi}|)^{\frac{1}{2}} \text{sgn } \phi_{CGi} \quad (239)$$

$i = 3, 4$

The tire overturning moments are defined as

$$M_{XF_i} = O_{F0} + (O_{F1} + O_{F2} |\phi_{CGi}|) F_{Si} F_{Ri} + O_{F3} \phi_{CGi} F_{Ri} \quad (240)$$

$i = 1, 2$

$$M_{XR_i} = O_{R0} + (O_{R1} + O_{R2} |\phi_{CGi}|) F_{Si} F_{Ri} + O_{R3} \phi_{CGi} F_{Ri} \quad (241)$$

$i = 3, 4$

## 2.21 Steering Equations (3 degrees of freedom)

The steering equations are presented on the next page.

$$(\dot{r} + \ddot{\delta}_{FWi}) I_{FW} = -H_i \dot{\delta}_{FWi} + M_{Ti} - M_{SSi} + M_{ZFi} \quad (242)$$

$$i = 1, 2$$

$$M_{CR} \ddot{y}_{CR} = -C_{FCR} - C_{CR} \dot{y}_{CR} + \frac{T_P}{a_p} + \frac{M_{SS1}}{a_{L1}} + \frac{M_{SS2}}{a_{L2}} \quad (243)$$

where  $C_{FCR} = f(\dot{y}_{CR})$ .

Conditions:

$$T_P = N_G \left\{ K_{SC} \left[ \left( \delta_{SW} - N_G \frac{y_{CR}}{a_p} \right) - \frac{\epsilon_{SP}}{2} \operatorname{sgn} \left( \delta_{SW} - N_G \frac{y_{CR}}{a_p} \right) \right] \right\}, \quad (244)$$

$$\text{if } \left| \delta_{SW} - N_G \frac{y_{CR}}{a_p} \right| > \frac{\epsilon_{SP}}{2};$$

$$\text{otherwise } T_P = 0. \quad (245)$$

$$M_{SSi} = K_{SLi} \left[ \left( \delta_{FWi} - \frac{y_{CR}}{a_{Li}} \right) - \frac{\epsilon_{pi}}{2} \operatorname{sgn} \left( \delta_{FWi} - \frac{y_{CR}}{a_{Li}} \right) \right] \quad (246)$$

$$\text{if } \left| \delta_{FWi} - \frac{y_{CR}}{a_{Li}} \right| > \frac{\epsilon_{pi}}{2};$$

$$\text{otherwise } M_{SSi} = 0. \quad (247)$$

## 2.22 Longitudinal and Lateral Acceleration

The longitudinal and lateral accelerations of the sprung mass are computed by the following equations:

$$A_x = (\dot{u} - vr + wq)/g \quad (248)$$

$$A_y = (\dot{v} + ru - wp)/g. \quad (249)$$

## 2.23 Dual Tires on Solid Rear Axle

### 2.23.1 Equations of Motion

$$\begin{aligned}
 M_{uR} \dot{w} + b M_{uR} \dot{q} + M_{uR} \ddot{\delta}_R \\
 = M_{uR} [uq - vp + bpr + (z_R + \delta_R)(p^2 + q^2) \\
 + g \cos \theta \cos \phi] + 2 (F_{zu3} + F_{zu4}) + S_3 + S_4
 \end{aligned} \tag{250-H}$$

and

$$\begin{aligned}
 (F'_{R3} + F'_{R4}) = K_{T3} (R_w + Z_{3DE}) \\
 + K_{T4} (R_w + Z_{4DE})
 \end{aligned} \tag{251}$$

### 2.23.2 Suspension Forces

$$\begin{aligned}
 F_{APRi} = (P_{R0} + P_{R1} \zeta'_i + P_{R2} \zeta'^2_i) (F_{xui} + F_{xu(i+2)}) \\
 i = 3, 4
 \end{aligned} \tag{252}$$

$$\begin{aligned}
 F_{ARRi} = (R_{R0} + R_{R1} \zeta'_i + R_{R2} \zeta'^2_i) (F_{yui} + F_{yu(i+2)}) \\
 i = 3, 4
 \end{aligned} \tag{253}$$

$$\begin{aligned}
 \zeta'_i = \delta_R - (-1)^i \left( \frac{T_{IR} + T_{OR}}{2} \right) \phi_R \\
 i = 3, 4
 \end{aligned} \tag{254}$$

### 2.23.3 Wheel Orientation

$$\psi_3 = K_{RS} \phi_R + K_{SR} \frac{M_{ZR3}}{2} + K_{LR} F_{S3} \tag{255}$$

$$\psi_4 = K_{RS} \phi_R + K_{SR} \frac{M_{ZR4}}{2} + K_{LR} F_{S4} \tag{256}$$

#### 2.23.4 Resultant Forces and Moments

Tire forces:

$$F_{yui} = -F_{iRID} \phi + F_{CiID} \sin \psi_i + F_{SiID} \cos \psi_i \quad (257)$$

$$i = 3, 4$$

$$F_{yui} = -F_{iROD} \phi + F_{CiOD} \sin \psi_{(i-2)} + F_{SiOD} \cos \psi_{(i-2)} \quad (258)$$

$$i = 5, 6$$

$$F_{xui} = F_{iRID} \theta + F_{CiID} \cos \psi_i - F_{SiID} \sin \psi_i \quad (259)$$

$$i = 3, 4$$

$$F_{xui} = F_{iROD} \theta + F_{CiOD} \cos \psi_{(i-2)} - F_{SiOD} \sin \psi_{(i-2)} \quad (260)$$

$$i = 5, 6$$

Aligning moments:

$$\begin{aligned} M_{ZiRID} &= (A_{R1} F_{iRID} + A_{R2} |F_{SiID}|) F_{SiID} \\ &+ A_{R3} F_{iRID} (|\phi_{CGi}|)^{\frac{1}{2}} \quad i = 3, 4 \end{aligned} \quad (261)$$

$$\begin{aligned} M_{ZiROD} &= (A_{R1} F_{iROD} + A_{R2} |F_{SiOD}|) F_{SiOD} \\ &+ A_{R3} F_{iROD} (|\phi_{CG(i-2)}|)^{\frac{1}{2}} \quad i = 5, 6 \end{aligned} \quad (262)$$

$$M_{ZRi} = M_{ZiRID} + M_{Z(i+2)ROD} \quad i = 3, 4 \quad (263)$$

Overturning moments:

$$\begin{aligned}
 M_{XiRID} &= (O_{R1} + O_{R2} |\phi_{CGi}|) F_{SiID} F_{iRID} \\
 &+ O_{R3} \phi_{CGi} F_{iRID} \\
 & \qquad \qquad \qquad i = 3, 4 \qquad (264)
 \end{aligned}$$

$$\begin{aligned}
 M_{XiROD} &= (O_{R1} + O_{R2} |\phi_{CG(i-2)}|) F_{SiID} F_{iRID} \\
 &+ O_{R3} \phi_{CG(i-2)} F_{iRID} \\
 & \qquad \qquad \qquad i = 5, 6 \qquad (265)
 \end{aligned}$$

$$\begin{aligned}
 M_{XRi} &= M_{XiRID} + M_{X(i+2)ROD} \\
 & \qquad \qquad \qquad i = 3, 4 \qquad (266)
 \end{aligned}$$

Suspension and tire moments:

$$\begin{aligned}
 \Sigma N_{\psi u} &= F_{yu1} (a + h_1 \cos \alpha_{h1}) + F_{yu2} (a + h_2 \cos \alpha_{h2}) \\
 &- (F_{yu3} + F_{yu5}) (b - h_3 \cos \alpha_{h3}) \\
 &- (F_{yu4} + F_{yu6}) (b - h_4 \cos \alpha_{h4}) \\
 &+ F_{xu2} \left( \frac{T_F}{2} - h_2 \cos \beta_{h2} \right) - F_{xu1} \left( \frac{T_F}{2} + h_1 \cos \beta_{h1} \right) \\
 &+ F_{xu4} \left( \frac{T_{IR}}{2} - h_4 \cos \beta_{h4} \right) - F_{xu3} \left( \frac{T_{IR}}{2} + h_3 \cos \beta_{h3} \right) \\
 &+ F_{xu6} \left( \frac{T_{OR}}{2} - h_4 \cos \beta_{h4} \right) - F_{xu5} \left( \frac{T_{OR}}{2} + h_3 \cos \beta_{h3} \right) \\
 &+ \sum_{i=1}^2 M_{ZFi} + \sum_{i=3}^4 M_{ZRi} \qquad (267)
 \end{aligned}$$

$$\begin{aligned}
\Sigma N_{\phi u} = & (S_2 - S_1) \frac{T_F}{2} + (S_4 - S_3) \frac{T_{SR}}{2} \\
& - F_{yu1} (z_F + \delta_1 + h_1 \cos \gamma_{h1} - H_{FC}) \\
& - F_{yu2} (z_F + \delta_2 + h_2 \cos \gamma_{h2} - H_{FC}) \\
& - (F_{yu3} + F_{yu4} + F_{yu5} + F_{yu6}) (z_R + \delta_R) \\
& + \sum_{i=1}^2 M_{XF_i}
\end{aligned} \tag{268-H}$$

$$\begin{aligned}
\Sigma N_{\theta u} = & (S_1 + S_2) a - (S_3 + S_4) b \\
& + F_{xu1} (z_F + \delta_1 + h_1 \cos \gamma_{h1}) \\
& + F_{xu2} (z_F + \delta_2 + h_2 \cos \gamma_{h2}) \\
& + F_{xu3} (z_R + \delta_R - Z_{3ID} + \frac{T_{IR}}{2} \phi_R) \\
& + F_{xu4} (z_R + \delta_R - Z_{4ID} - \frac{T_{IR}}{2} \phi_R) \\
& + F_{xu5} (z_R + \delta_R - Z_{5OD} + \frac{T_{OR}}{2} \phi_R) \\
& + F_{xu6} (z_R + \delta_R - Z_{6OD} - \frac{T_{OR}}{2} \phi_R)
\end{aligned} \tag{269-H}$$

$$\begin{aligned}
\Sigma N_{\phi_R} = & (S_3 - S_4) \frac{T_{SR}}{2} + 2 F_{zu3} (T_{OIR} + Z_{3DE} \phi_R) \\
& - 2 F_{zu4} (T_{OIR} - Z_{4DE} \phi_R) - F_{yu3} (-Z_{3ID} + \frac{T_{IR}}{2} \phi_R) \\
& - F_{yu4} (-Z_{4ID} - \frac{T_{IR}}{2} \phi_R) \\
& - F_{yu5} (-Z_{5OD} + \frac{T_{OR}}{2} \phi_R) \\
& - F_{yu6} (-Z_{6OD} - \frac{T_{OR}}{2} \phi_R) \\
& + \sum_{i=3}^4 M_{XRi}
\end{aligned} \tag{270}$$

### 2.23.5 Radial Tire Force and Rolling Radius

$$\begin{aligned}
F_{3RID} &= K_{T3} (R_w + Z_{3ID}) & (R_w + Z_{3ID}) > 0 \\
&= 0 & (R_w + Z_{3ID}) \leq 0
\end{aligned} \tag{271}$$

$$\begin{aligned}
F_{4RID} &= K_{T4} (R_w + Z_{4ID}) & (R_w + Z_{4ID}) > 0 \\
&= 0 & (R_w + Z_{4ID}) \leq 0
\end{aligned} \tag{272}$$

$$\begin{aligned}
F_{5ROD} &= K_{T3} (R_w + Z_{5OD}) & (R_w + Z_{5OD}) > 0 \\
&= 0 & (R_w + Z_{5OD}) \leq 0
\end{aligned} \tag{273}$$

$$\begin{aligned}
F_{6ROD} &= K_{T4} (R_w + Z_{6OD}) & (R_w + Z_{6OD}) > 0 \\
&= 0 & (R_w + Z_{6OD}) \leq 0
\end{aligned} \tag{274}$$

$$T_{OIR} = \frac{T_{IR} + T_{OR}}{4} \tag{275}$$

$$T_{IOR} = \frac{T_{IR} - T_{OR}}{4} \tag{276}$$

$$Z_{3DE} = Z - a_{31} b + a_{32} T_{OIR} + a_{33} (z_R + T_{OIR} \phi_R + \delta_R) \tag{277}$$

$$Z_{4DE} = Z - a_{31} b - a_{32} T_{OIR} + a_{33} (z_R - T_{OIR} \phi_R + \delta_R) \tag{278}$$

$$Z_{3ID} = Z_{3DE} + T_{IOR} (\phi + \phi_R) \tag{279}$$

$$Z_{4ID} = Z_{4DE} - T_{IOR} (\phi + \phi_R) \tag{280}$$

$$Z_{5OD} = Z_{3DE} - T_{IOR} (\phi + \phi_R) \tag{281}$$

$$Z_{6OD} = Z_{4DE} + T_{IOR} (\phi + \phi_R) \tag{282}$$

where

$$h_{3(0)} = h_{4(0)} = R_w - \frac{g}{4K_{T3}} [M_{ur} + (\frac{a}{a+b}) M_S] \tag{283}$$

#### 2.23.6 Tire Circumferential Force

$$F_{CiID} = -\mu'_{iID} F_{iRID} \quad i = 3, 4 \tag{284}$$

$$F_{CiOD} = -\mu'_{iOD} F_{iROD} \quad i = 5, 6 \tag{285}$$



### 2.23.7 Circumferential Friction Coefficient

$$\begin{aligned}
 \mu'_{iID} &= m_{1i} S_{iID} && \text{for } S_{iID} \leq SI_i \\
 &= m_{2i} S_{iID} + \mu_{0i} && \text{for } S_{iID} > SI_i
 \end{aligned} \tag{286}$$

$i = 3, 4$

$$\begin{aligned}
 \mu'_{iOD} &= m_{1(i-2)} S_{iID} && \text{for } S_{iID} \leq SI_{(i-2)} \\
 &= m_{2(i-2)} S_{iID} + \mu_{0(i-2)} && \text{for } S_{iID} > SI_{(i-2)}
 \end{aligned} \tag{287}$$

$i = 5, 6$

$$\begin{aligned}
 \mu_{yiID} &= (B_{1R} F_{iRID} + B_{2R} C_{vi} + B_{3R} \\
 &\quad + B_{4R} F_{iRID}^2) SN_i
 \end{aligned} \tag{288}$$

$i = 3, 4$

$$\begin{aligned}
 \mu_{yiOD} &= (B_{1R} F_{iROD} + B_{2R} C_{v(i-2)} + B_{3R} \\
 &\quad + B_{4R} F_{iROD}^2) SN_{(i-2)}
 \end{aligned} \tag{289}$$

$i = 5, 6$

### 2.23.8 Wheel Slip

$$\begin{aligned}
 (SLIP)_i &= 1 && \text{for } \xi_i > 1 \\
 &= \xi_i && \text{for } -1 \leq \xi_i \leq 1 \\
 &= -1 && \text{for } \xi_i < -1
 \end{aligned} \tag{290}$$

where

$$\xi_i = 1 + \frac{\omega_i Z_{iDE}}{u_{Gi} \cos \psi_i + v_{Gi} \sin \psi_i} \quad (291)$$

$$i = 3, 4$$

$$\begin{aligned} S_{iID} &= 1 && \text{for } \xi_i > 1 \\ &= \xi_i && \text{for } -1 \leq \xi_i \leq 1 \\ &= -1 && \text{for } \xi_i < -1 \end{aligned} \quad (292)$$

$$\xi_i = 1 + \frac{\omega_i Z_{iID}}{u_{GiID} \cos \psi_i + v_{GiID} \sin \psi_i} \quad (293)$$

$$i = 3, 4$$

$$\begin{aligned} S_{iOD} &= 1 && \text{for } \xi_i > 1 \\ &= \xi_i && \text{for } -1 \leq \xi_i \leq 1 \\ &= -1 && \text{for } \xi_i < -1 \end{aligned} \quad (294)$$

$$\xi_i = 1 + \frac{\omega_{(i-2)} Z_{iOD}}{u_{GiOD} \cos \psi_{(i-2)} + v_{GiOD} \sin \psi_{(i-2)}} \quad (295)$$

$$i = 5, 6$$

$$u_{G3ID} = u_{3ID} + \theta_w 3ID \quad (296)$$

$$u_{G4ID} = u_{4ID} + \theta_w 4ID \quad (297)$$

$$u_{G50D} = u_{50D} + \theta w_{50D} \quad (298)$$

$$u_{G60D} = u_{60D} + \theta w_{60D} \quad (299)$$

$$v_{G3ID} = v_{3ID} - \phi w_{3ID} \quad (300)$$

$$v_{G4ID} = v_{4ID} - \phi w_{4ID} \quad (301)$$

$$v_{G50D} = v_{50D} - \phi w_{50D} \quad (302)$$

$$v_{G60D} = v_{60D} - \phi w_{60D} \quad (303)$$

$$u_{3ID} = u_3 - T_{IOR} r \quad (304)$$

$$u_{4ID} = u_4 + T_{IOR} r \quad (305)$$

$$u_{50D} = u_3 + T_{IOR} r \quad (306)$$

$$u_{60D} = u_4 - T_{IOR} r \quad (307)$$

$$v_{3ID} = v - br - z_R p + Z_{3ID} (p + \dot{\phi}_R) \quad (308)$$

$$v_{4ID} = v - br - z_R p + Z_{4ID} (p + \dot{\phi}_R) \quad (309)$$

$$v_{50D} = v - br - z_R p + Z_{50D} (p + \dot{\phi}_R) \quad (310)$$

$$v_{60D} = v - br - z_R p + Z_{60D} (p + \dot{\phi}_R) \quad (311)$$

$$w_{3ID} = w_3 + T_{IOR} (p + \dot{\phi}_R) \quad (312)$$

$$w_{4ID} = w_4 - T_{IOR} (p + \dot{\phi}_R) \quad (313)$$

$$w_{50D} = w_3 - T_{IOR} (p + \dot{\phi}_R) \quad (314)$$

$$w_{60D} = w_4 + T_{IOR} (p + \dot{\phi}_R) \quad (315)$$

### 2.23.9 Wheel Rotational Equations

Analog:

$$\begin{aligned} & (I_{WR} + \frac{1}{4} I_{DR} \overline{AR}_R^2) \dot{\omega}_3 + (\frac{1}{4} I_{DR} \overline{AR}_R^2) \dot{\omega}_4 \\ & = 2(F_{C3} Z_{3DE}) + \overline{TQ}_3 \end{aligned} \quad (316)$$

$$\begin{aligned} & (I_{WR} + \frac{1}{4} I_{DR} \overline{AR}_R^2) \dot{\omega}_4 + (\frac{1}{4} I_{DR} \overline{AR}_R^2) \dot{\omega}_3 \\ & = 2(F_{C4} Z_{4DE}) + \overline{TQ}_4 \end{aligned} \quad (317)$$

$$F_{C3} = -\mu'_3 F_{R3} \quad (318)$$

$$F_{C4} = -\mu'_4 F_{R4} \quad (319)$$

### 2.23.10 Tire Side Force

$$\begin{aligned} F_{SiID} = F_{iRID} \{ & [|\mu_{yiID} g(\overline{\beta}_i)| - [|\mu_{yiID} g(\overline{\beta}_i)| \\ & - \mu_{SR} |\sin(\beta_i)| SN_i] F_i \} \operatorname{sgn} g(\overline{\beta}_i) \end{aligned} \quad (320)$$

$$i = 3, 4$$

$$\begin{aligned} F_{SiOD} = F_{iROD} \{ & [|\mu_{yiOD} g(\overline{\beta}_{(i-2)})| - [|\mu_{yiOD} g(\overline{\beta}_{(i-2)})| \\ & - \mu_{SR} |\sin(\beta_{(i-2)})| SN_{(i-2)}] F_{i-2} \} \operatorname{sgn} g(\overline{\beta}_{(i-2)}) \end{aligned} \quad (321)$$

### 2.23.11 Velocities of Tire Contact Points

$$u_3 = u - T_{OIR} r + z_R q \quad (322)$$

$$u_4 = u + T_{OIR} r + z_R q \quad (323)$$

$$u_5 = u - T_{OIR} r + z_R q \quad (324)$$

$$u_6 = u + T_{OIR} r + z_R q \quad (325_)$$

$$v_3 = v - br - [z_R - Z_{3DE}] p + Z_{3DE} \dot{\phi}_R \quad (326)$$

$$v_4 = v - br - [z_R - Z_{4DE}] p + Z_{4DE} \dot{\phi}_R \quad (327)$$

$$v_5 = v - br - [z_R - Z_{3DE}] p + Z_{3DE} \dot{\phi}_R \quad (328)$$

$$v_6 = v - br - [z_R - Z_{4DE}] p + Z_{4DE} \dot{\phi}_R \quad (329)$$

$$w_3 = w + bq + \dot{\delta}_R + (p + \dot{\phi}_R) T_{OIR} \quad (330)$$

$$w_4 = w + bq + \dot{\delta}_R - (p + \dot{\phi}_R) T_{OIR} \quad (331)$$

$$w_5 = w + bq + \dot{\delta}_R + (p + \dot{\phi}_R) T_{OIR} \quad (332)$$

$$w_6 = w + bq + \dot{\delta}_R - (p + \dot{\phi}_R) T_{OIR} \quad (333)$$

Wheel velocities in the ground plane:

$$u_{Gi} = u_i + \theta w_i \quad (334)$$

$$v_{Gi} = v_i - \phi w_i \quad i = 3, 4, 5, 6 \quad (335)$$

2.24 Resultant Moments of Solid Front Axle and Dual Tires on Solid Rear Axle

$$\begin{aligned} \Sigma N_{\phi u} = & (S_2 - S_1) \frac{T_{SF}}{2} + (S_4 - S_3) \frac{T_{SR}}{2} \\ & - (F_{yu1} + F_{yu2}) (z_F + \delta_F) \\ & - (F_{yu3} + F_{yu4} + F_{yu5} + F_{yu6}) (z_R + \delta_R) \end{aligned} \quad (336-I)$$

$$\begin{aligned} \Sigma N_{\theta u} = & (S_1 + S_2) a - (S_3 + S_4) b \\ & + F_{xu1} (z_F + \delta_F + \frac{T_F}{2} \phi_F + h_1 \cos \gamma_{h1}) \\ & + F_{xu2} (z_F + \delta_F - \frac{T_F}{2} \phi_F + h_2 \cos \gamma_{h2}) \\ & + F_{xu3} (z_R + \delta_R + \frac{T_{IR}}{2} \phi_R - Z_{3ID}) \\ & + F_{xu4} (z_R + \delta_R - \frac{T_{IR}}{2} \phi_R - Z_{4ID}) \\ & + F_{xu5} (z_R + \delta_R + \frac{T_{OR}}{2} \phi_R - z_{5ID}) \\ & + F_{xu6} (z_R + \delta_R - \frac{T_{OR}}{2} \phi_R - Z_{6ID}) \end{aligned} \quad (337-I)$$

3. NOTATION AND LIST OF SYMBOLS

3.1 Notation

The time derivative of a variable is indicated by a dot over the symbol for the variable, e.g.,

$$\dot{\alpha} = d\alpha/dt, \quad \ddot{\alpha} = d^2\alpha/dt^2 .$$

Special symbols for mathematical operations are

$|\alpha|$  = absolute value of  $\alpha$

$\text{sgn } \alpha$  = algebraic sign of  $\alpha$  .

The following subscript notation is used:

$i$  = wheel identification number; 1 = right front,  
2 = left front, 3 = right rear, 4 = left rear,  
5 = right rear outside, 6 = left rear outside

$j$  = identification of vehicle end;  $j = F, R$  for the  
front and the rear, respectively.

$s$  = sprung mass

$u$  = unsprung mass

$F$  = front, or front axle

$R$  = rear, or rear axle

The technical dimension system is employed with the fundamental units of lb (force), in. (length), and s (time).

## 3.2 List of Symbols

### 3.2.1 Variables

$A_x, A_y$  = Longitudinal and lateral accelerations,  
respectively, of the sprung mass (g)

$a_{ij}$  = Elements of the 3 x 3 transformation  
matrix relating the orientation of the  
vehicle fixed axis system to the inertial  
frame of reference.

$C_L, C_M, C_N$  = Aerodynamic moment coefficients, given  
as tabular functions of  $\tau$  for  $\alpha = 0$

$C_{vi}$  = Resultant velocity of the contact  
point of wheel  $i$  in the ground plane,  
(in./s)

$C_X, C_Y, C_Z$  = Aerodynamic force coefficients, given  
as tabular functions of  $\tau$  for  $\alpha = 0$

- $d_{CG}$  = Horizontal distance between aerodynamic center and sprung mass center of gravity (in.)
- $F_{1Fi}$ ,  $F_{1Ri}$  = Coulomb damping force in front and rear suspensions, respectively (lb)
- $F_{2Fi}$ ,  $F_{2Ri}$  = Suspension force produced by deflection of springs and bump stops in front and rear suspensions, respectively (lb)
- $F_{3Fi}$ ,  $F_{3Ri}$  = Viscous damping force in front and rear suspensions, respectively (lb)
- $F_{4Fi}$ ,  $F_{4Ri}$  = Suspension force produced by auxiliary roll stiffness in front and rear suspensions, respectively (lb)
- $F_{APFi}$ ,  $F_{APRi}$  = Antipitch force in front and rear suspensions, respectively (lb)
- $F_{ARFi}$ ,  $F_{ARRi}$  = Antiroll force in front and rear suspensions, respectively (lb)
- $F_{BSi}$  = Suspension force component which is the difference between analog value and actual spring characteristic at wheel  $i$  (lb)
- $F_{Ci}$  = Tire circumferential force at wheel  $i$  (lb)
- $F_{CiID}$ ,  $F_{CiOD}$  = Dual tire circumferential force at rear inside and outside wheels, respectively (lb)
- $F_{Cxui}$ ,  $F_{Cyui}$ ,  $F_{Czui}$  = Components of the circumferential force for tire  $i$  resolved along the vehicle axes (lb)
- $FF$ ,  $FR$  = Front and rear brake torque curves that are input as functions of brake line pressure (lb-in.)
- $F_i[(SLIP)_i]$  = Nondimensional tire side-force shaping function versus longitudinal slip at wheel  $i$



$F_{iRID}, F_{iROD}$  = Dual tire radial force at rear inside and outside wheel, respectively (lb)

$F_{Ri}$  = Tire normal force to ground at wheel  $i$  (lb)

$F'_{Ri}$  = Tire radial force at wheel  $i$  (lb)

$F_{Rxui}, F_{Ryui}, F_{Rzui}$  = Components of the radial force for tire  $i$  resolved along the vehicle axes (lb)

$F_{SABSi}$  = Suspension force component which is the difference between analog value and actual shock absorber characteristic at wheel  $i$  (lb)

$F_{Si}$  = Tire side force at wheel  $i$  (lb)

$F_{SiID}, F_{SiOD}$  = Dual tire side force at rear inside and outside wheels, respectively (lb)

$F_{SWF}, F_{SWR}$  = Front and rear static force component of the sprung mass (lb)

$F_{Sxui}, F_{Syui}, F_{Szui}$  = Components of the side force for tire  $i$  resolved along the vehicle axes (lb)

$F_{xui}, F_{yui}, F_{zui}$  = Tire force components at wheel  $i$  along the sprung mass  $x$ ,  $y$ , and  $z$  axes, respectively (lb)

$\Sigma F_{xs}, \Sigma F_{ys}, \Sigma F_{zs}$  = Components of the resultant of aerodynamic forces that act directly on the sprung mass, along the sprung mass  $x$ ,  $y$ , and  $z$  axes, respectively (lb)

$\Sigma F_{xu}, \Sigma F_{yu}, \Sigma F_{zu}$  = Components of the resultant of forces that act on the unsprung masses, along the sprung mass  $x$ ,  $y$ , and  $z$  axes, respectively (lb)

$g(\bar{\beta}_i)$  = Nondimensional tire side force shaping function for combined slip angle and camber angle at wheel  $i$

$h_i$  = Rolling radius of wheel  $i$  (in.)

$I'_x, I'_y, I'_z$  = Moment of inertia of unsprung mass (lb-in.-s<sup>2</sup>)

- $I'_{xz}$  = Product of inertia of unsprung mass  
 (lb-in.-s<sup>2</sup>)
- $m_{1i}, m_{2i}$  = Slope of straight-line segments approximating circumferential friction coefficient at wheel  $i$
- $M_{SSi}$  = Torque applied to front wheel  $i$  by the steering system connecting rod (lb-in.)
- $M_{Ti}$  = Moment acting at front wheel  $i$  about the kingpin axis due to tire-road contact forces (lb-in.)
- $M_{XF_i}, M_{XR_i}$  = Tire overturning moment at wheel  $i$ , front and rear wheels, respectively (lb-in.)
- $M_{XiRID}, M_{XiROD}$  = Dual tire overturning moment at rear inside and outside wheel, respectively (lb-in.)
- $M_{ZFi}, M_{ZR_i}$  = Tire aligning moment at wheel  $i$ , front and rear wheels, respectively (lb-in.)
- $M_{ZiRID}, M_{ZiROD}$  = Dual tire aligning moment at rear inside and outside wheel, respectively (lb-in.)
- $\Sigma N_{\phi F}, \Sigma N_{\phi R}$  = Rolling moment acting on the front and rear axles, respectively (lb-in.)
- $\Sigma N_{\phi S}, \Sigma N_{\theta S}, \Sigma N_{\psi S}$  = Components of the resultant moment of aerodynamic forces that act directly on the sprung mass, about the sprung mass  $x$ ,  $y$ , and  $z$  axes, respectively (lb-in.)
- $\Sigma N_{\phi u}, \Sigma N_{\theta u}, \Sigma N_{\psi u}$  = Components of the resultant moment of forces that act on the unsprung masses, about the sprung mass  $x$ ,  $y$ , and  $z$  axes, respectively (lb-in.)
- $\dot{p}, \dot{q}, \dot{r}, p, q, r$  = Scalar components of angular acceleration and velocity of the sprung mass, taken about the sprung mass  $x$ ,  $y$ , and  $z$  axes, respectively (rad/s<sup>2</sup>, rad/s)

- $\bar{p}, \bar{q}, \bar{r}$  = Dimensionless components of angular velocity of vehicle relative to wind in vehicle-fixed axes
- $P_{FL}$  = Brake line pressure (lb/in.<sup>2</sup>)
- $q_a$  = Dynamic pressure (lb/in.<sup>2</sup>)
- $S_i$  = Total suspension force at wheel  $i$ , effective at the wheel for independent suspensions and at the spring location for the solid front/rear axle (lb)
- $(SLIP)_i$  = Longitudinal slip ratio at wheel  $i$
- $S_{iID}, S_{iOD}$  = Longitudinal slip ratio at dual rear inside and outside wheel, respectively
- $T_P$  = Pitman torque at the steering gear box (lb-in.)
- $\overline{TQ}_{Bi}$  = Brake torque at wheel  $i$  (lb-in.)
- $\overline{TQ}_D$  = Drive torque (lb-in.)
- $\overline{TQ}_{DMAX}$  = Maximum drive torque (lb-in)
- $\dot{u}, \dot{v}, \dot{w}, u, v, w$  = Scaler components of linear acceleration and velocity of the sprung mass, taken along the sprung mass  $x, y,$  and  $z$  axes, respectively (in./s<sup>2</sup>, in./s)
- $u_i, v_i, w_i$  = Velocity components of the contact point of wheel  $i$  along the vehicle-fixed axes (in./s)
- $u_{iID}, u_{iOD}$  = Forward velocity component of the contact point of dual rear inside and outside wheel, respectively, along the vehicle-fixed axes (in./s)
- $u_r, v_r, w_r$  = Components of vehicle velocity relative to wind in vehicle-fixed axes (in./s)
- $u_{Gi}$  = Forward velocity of the contact point of wheel  $i$  in the ground plane (in./s)

$u_{GiID}, u_{GiOD}$  = Forward velocity of the contact point of dual rear inside and outside wheel, respectively, in the ground plane (in./s)

$V_{CW}$  = Magnitude of vehicle velocity relative to wind (in./s)

$v_{Gi}$  = Lateral velocity of the contact point of wheel  $i$  in the ground plane (in./s)

$v_{GiID}, v_{GiOD}$  = Lateral velocity of the contact point of dual rear inside and outside wheel, respectively, in the ground plane (in./s)

$v_{iID}, v_{iOD}$  = Lateral velocity component of the contact point of dual rear inside and outside wheel, respectively, along the vehicle-fixed axes (in./s)

$w_{iID}, w_{iOD}$  = Downward velocity component of the contact point of dual rear inside and outside wheel, respectively, along the vehicle-fixed axes (in./s)

$x, y, z$  = Coordinates of a point relative to the vehicle-fixed coordinate axis system (in.)

$X, Y, Z$  = Coordinates of the center of gravity of the sprung mass relative to the space-fixed coordinate axis system (in.)

$\ddot{y}_{CR}, \dot{y}_{CR}, y_{CR}$  = Linear acceleration, velocity, and displacement of the steering system connecting rod (in./s<sup>2</sup>, in./s, in.)

$Z_i$  = Coordinate of individual wheel center above the road surface (in.)

$Z_{iID}, Z_{iOD}$  = Inertial position of the rear dual inside and outside wheel center, respectively (in.)

$Z_{MXi}$  = Wheel contact/lift-off indicator

$Z_{si}$  = Input function to wheel center  $i$  which represents elevation change in reference surface (initially equal to zero) (in.)

$Z_{3DE}, Z_{4DE}$  = Inertial position of a single equivalent wheel center replacing the right and left pair of rear dual wheel centers, respectively (in.)

$\cos \alpha_{ci}, \cos \beta_{ci}, \cos \gamma_{ci}$  = Direction cosines of the line of intersection of the wheel plane  $i$  and the ground plane (Note:  $\cos \gamma_{ci} = 0$  since the ground plane is assumed horizontal)

$\cos \alpha_{hi}, \cos \beta_{hi}, \cos \gamma_{hi}$  = Direction cosines of the tire radial force relative to the vehicle axis system

$\cos \alpha_{Ri}, \cos \beta_{Ri}, \cos \gamma_{Ri}$  = Direction cosines of the tire radial force relative to the inertial reference

$\cos \alpha_{ywi}, \cos \beta_{ywi}, \cos \gamma_{ywi}$  = Direction cosines of a line perpendicular to tire  $i$  in the inertial reference

$\alpha$  = Aerodynamic angle of attack (rad)

$\beta$  = Vehicle body angle of sideslip (rad)

$\beta_i$  = Slip angle at wheel  $i$  (rad)

$\beta'_i$  = "Equivalent" slip angle produced by camber effects at wheel  $i$  (rad)

$\bar{\beta}_i$  = Nondimensional slip angle variable for wheel  $i$

$\gamma_{i,i=1, 9}$  = Inertial terms used in the equations of motion

$\ddot{\delta}_i, \dot{\delta}_i, \delta_i$  = Suspension acceleration, velocity, and deflection relative to the vehicle from the position of static equilibrium, measured at the center of wheel  $i$  (in./s<sup>2</sup>, in./s, in.)

$\ddot{\delta}_{FWi}, \dot{\delta}_{FWi}, \delta_{FWi}$  = Angular acceleration, velocity, and displacement of front wheel  $i$  produced by the steering system (rad/s<sup>2</sup>, rad/s, rad)

$\ddot{\delta}_F, \dot{\delta}_F, \delta_F$  = Suspension acceleration, velocity, and deflection relative to the vehicle from the position of static equilibrium at the center of the solid front axle (in./s<sup>2</sup>, in./s, in.)

$\ddot{\delta}_R, \dot{\delta}_R, \delta_R$  = Suspension acceleration, velocity, and deflection relative to the vehicle from the position of static equilibrium at the center of the solid rear axle (in./s<sup>2</sup>, in./s, in.)

$\delta_{Si}$  = Suspension deflection relative to the vehicle, measured at the center of wheel  $i$  from the position of static equilibrium at curb (no-load) condition (in.)

$\delta_{SW}$  = Steering wheel displacement (rad)

$\Delta C_X$  = Aerodynamic increment in axial force coefficient, given as tabular function of  $\alpha$

$\Delta_i$  = Distance between the wheel center and ground contact point (in.)

$\dot{\zeta}_i, \zeta_i$  = Suspension velocity and deflection relative to the vehicle from the position of static equilibrium, measured at the spring location  $i$  (in./s, in.)

$\zeta_{Si}$  = Suspension deflection relative to the vehicle, measured at the spring location from the position of static equilibrium at curb (no-load) condition (in.)

$\zeta'_i$  = Deflection of the center of wheel  $i$  (solid front/rear axle) relative to the vehicle from the position of static equilibrium (in.)

- $\theta_{Si}$  = Caster angle of front wheel  $i$  relative to the vehicle-fixed coordinate axis system, positive for rearward inclination of the steering axis in the upward direction (rad)
- $\theta_{XGi}$  = Angle between the vehicle  $x$  axis and ground plane at wheel  $i$  (rad)
- $\mu'_{iID}, \mu'_{iOD}$  = Circumferential friction coefficient at dual rear inside and outside wheels, respectively
- $\mu_{yiID}, \mu_{yiOD}$  = Lateral friction coefficient at dual rear inside and outside wheels, respectively
- $\mu_{0i}, \mu_{1i}$  = Circumferential friction coefficient at braking slip equal to 0 and 1, respectively
- $\mu_{PF}, \mu_{PR}$  = Peak braking friction coefficient, front and rear wheels, respectively
- $\mu_{yi}, \mu'_i$  = Lateral and circumferential friction coefficients, respectively, at wheel  $i$
- $\tau$  = Aerodynamic angle of sideslip (rad)
- $\phi, \theta, \psi$  = Euler angular coordinates (roll, pitch, and yaw angles) of the sprung mass relative to the space-fixed coordinate axis system (rad)
- $\phi_i$  = Camber angle of wheel  $i$  relative to the vehicle-fixed coordinate axis system, positive when clockwise as viewed from the rear (rad)
- $\phi_{CGi}$  = Camber angle of wheel  $i$  relative to the ground plane (rad)
- $\ddot{\phi}_F, \dot{\phi}_F, \phi_F$  = Angular acceleration, velocity, and displacement of the front axle relative to the vehicle about a line parallel to the  $x$  axis through the front axle center of gravity, positive when counterclockwise as viewed from the front ( $\text{rad/s}^2, \text{rad/s}, \text{rad}$ )

$\ddot{\phi}_R, \dot{\phi}_R, \phi_R$  = Angular acceleration, velocity, and displacement of the rear axle relative to the vehicle about a line parallel to the x axis through the rear axle center of gravity, positive when clockwise as viewed from the rear (rad/s<sup>2</sup>, rad/s, rad)

$\phi_{SAi}$  = Kingpin inclination angle at front wheel i (rad)

$\psi_i$  = Steer angle of wheel i relative to the vehicle-fixed coordinate axis system, positive for clockwise steer as viewed from above vehicle (rad)

$\psi'_i$  = Steer angle of wheel i in the ground plane (rad)

$\dot{\omega}_i, \omega_i$  = Rotational acceleration and velocity of wheel i (rad/s<sup>2</sup>, rad/s)

### 3.2.2 Parameters

a, b = Distance in the x direction between the center of gravity of the sprung mass and the centerline of the front and rear wheels, respectively (in.)

$a_{Li}$  = Length of steering linkage arm at front wheel i (in.)

$a_p$  = Length of Pitman arm (in.)

$A_{0F}, A_{1F}, A_{2F}, A_{0R}, A_{1R}, A_{2R}$  = Coefficients of 2nd degree curves fitted to small-angle cornering stiffness, front and rear wheels, respectively

$A_{3F}, A_{4F}, A_{3R}, A_{4R}$  = Coefficients of 2nd degree curves fitted to small-angle camber stiffness, front and rear wheels, respectively

$A_{F1}, A_{F2}, A_{F3}, A_{R1}, A_{R2}, A_{R3}$  = Coefficients of functions fitted to tire aligning torque, front and rear wheels, respectively

$\overline{AR}_F, \overline{AR}_R$  = Drive axle ratio for the front and the rear, respectively, (i.e., propeller shaft speed to wheel speed)



$A_{TF}^{\Omega}, A_{TR}^{\Omega}$  = Proportionality factor defining limits of small-angle cornering and camber stiffness variation with tire loading, front and rear wheels, respectively

$B_{1F}, B_{2F}, B_{3F}, B_{4F}, B_{1R}, B_{2R}, B_{3R}, B_{4R}$  = Coefficients of curves fitted to lateral friction coefficient, front and rear wheels, respectively

$C_{iF}, C_{iR}$  = Coefficients of 5th degree polynomials ( $i = 0$  to 5) fitted to wheel camber angle versus suspension deflection, front and rear wheels, respectively

$C_{CR}$  = Viscous damping in steering gear, effective at the steering system connecting rod (lb-s/in.)

$C_{FCR}$  = Coulomb friction in steering gear, effective at the steering system connecting rod (lb)

$C'_{Fi}, C'_{Ri}$  = Coulomb damping for a single wheel, effective at the wheel for independent suspension and at the spring location for the solid front/rear axle, front and rear wheels, respectively

$C_{y_p}, C_{y_r}, C_{z_{\alpha}}, C_{z_q}, C_{\ell_p}, C_{\ell_r}, C_{m_{\alpha}}, C_{m_q}, C_{n_p}, C_{n_r}$  = Aerodynamic stability derivatives

$D_{iF}, D_{iR}$  = Coefficients of 5th degree polynomials ( $i = 0$  to 5) fitted to wheel toe angle versus suspension deflection, front and rear wheels, respectively

$E_{iF}$  = Coefficients of 5th degree polynomials ( $i = 0$  to 5) fitted to front wheel caster angle versus suspension deflection

$g$  = Acceleration due to gravity = 386.4 in./s<sup>2</sup>

$h_{FC}, h_{RC}$  = Distance between the ground and the static roll center of the independent front and rear suspension, respectively (in.)

- $H_i$  = Viscous damping derivative at front wheel  $i$  (lb-in.-s/rad)
- $I_{DF}, I_{DR}$  = Drive-line moment of inertia for front and rear wheel drives, respectively (lb-in.-s<sup>2</sup>)
- $I_F, I_R$  = Moment of inertia of solid front and rear axles, respectively, about a line through its center of gravity and parallel to the  $x$  axis (lb-in.-s<sup>2</sup>)
- $I_{FW}$  = Moment of inertia of individual front wheel about the kingpin axis (lb-in.-s<sup>2</sup>)
- $I_{WF}, I_{WR}$  = Moment of inertia of individual wheel about its spin axis, front and rear wheels, respectively (lb-in.-s<sup>2</sup>)
- $I_x, I_y, I_z$  = Moment of inertia of sprung mass about the  $x, y,$  and  $z$  axes, respectively (lb-in.-s<sup>2</sup>)
- $I_{xz}$  = Product of inertia of sprung mass with respect to the  $x$  and  $z$  axes (lb-in.-s<sup>2</sup>)
- $K_{CF}, K_{CR}$  = Lateral force compliance camber coefficient, front and rear wheels, respectively (rad/lb)
- $K_{Fi}, K_{Ri}$  = Suspension load-deflection rate for a single wheel in the quasi-linear range about the position of static equilibrium, effective at the spring location for the solid front/rear axle, and at the front/rear wheel for independent rear suspension (lb/in.)
- $K_{FS}, K_{RS}$  = Roll steer coefficient of the solid front and rear axles, respectively, positive for roll understeer (rad/rad)
- $K_{LR}$  = Rear lateral force compliance steer (rad/lb)
- $K_{OTF}, K_{OTR}$  = Front and rear overturning moment compliance camber (independent suspension) (rad/lb-in.)

- $K_{SC}$  = Flexibility in steering column and steering gear box (lb-in./rad)
- $K_{Si}$  = Suspension viscous damping rate for a single wheel in the quasi-linear range about the position of static equilibrium, effective at the spring location for the solid axle and at the wheel for independent suspension (lb-s/in.)
- $K_{SLi}$  = Flexibility in steering linkage at front wheel  $i$  (lb-in./rad)
- $K_{SR}$  = Aligning torque compliance steer coefficient at the rear wheels (rad/(lb-in.))
- $K_{Ti}$  = Tire load-deflection rate in the quasi-linear range for a single tire at wheel  $i$  (lb/in.)
- $K_{TQ}$  = Gain in drive torque (lb-s)
- $\ell$  = Wheelbase length of vehicle (in.)
- $\ell_v$  = Characteristic vehicle length upon which aerodynamic moment coefficients are referenced (in.)
- $M_{CR}$  = Effective mass of the steering system connecting rod (lb-s<sup>2</sup>/in.)
- $M_S$  = Total sprung mass (lb-s<sup>2</sup>/in.)
- $M_{uF}, M_{uR}$  = Total front and rear unsprung mass, respectively (lb-s<sup>2</sup>/in.)
- $\Sigma M$  = Total vehicle mass (lb-s<sup>2</sup>/in.)
- $N_G$  = Gear ratio of the steering gear box
- $O_{F0}, O_{F1}, O_{F2}, O_{F3}, O_{R0}, O_{R1}, O_{R2}, O_{R3}$  = Coefficients of functions fitted to tire overturning moment, front and rear wheels, respectively
- $P_{BF1}, P_{BF2}, P_{BR1}, P_{BR2}$  = Coefficients of curves fitted to peak braking friction coefficient, front and rear wheels, respectively

$P_{FO}, P_{F1}, P_{F2}, P_{RO}, P_{R1}, P_{R2}$  = Coefficients of curves fitted to anti-pitch coefficients, front and rear wheels, respectively

$\overline{PT}$  = Front wheel caster offset (in.)

$R_F, R_R$  = Auxiliary roll stiffness at front and rear suspensions, respectively (lb-in./rad)

$R_{FO}, R_{F1}, R_{F2}, R_{RO}, R_{R1}, R_{R2}$  = Coefficients of curves fitted to anti-roll coefficients, front and rear wheels, respectively

$R_w$  = Undelected wheel radius (in.)

$S_f$  = Projected frontal area of vehicle (in.<sup>2</sup>)

$S_{Ii}$  = Longitudinal slip at wheel  $i$  at which peak braking friction occurs

$(SN)_{S0}$  = Skid number of simulated surface

$(SN)_T$  = Skid number of surface on which tire data were obtained

$SN_i$  = Skid number ratio of simulated surface to tire data surface

$S_{1F}, S_{1R}$  = Front and rear tire linear coefficient of sliding friction, respectively (1/lb)

$T_F, T_R$  = Wheel tread width at the front and rear, respectively (in.)

$T_{IR}, T_{OR}$  = Distance between the centers of inside and outside tires, respectively, in the  $y$  direction for solid rear axle with dual tires (in.)

$T_{SF}, T_{SR}$  = Distance in the  $y$  direction between the spring centers for solid front and rear axles, respectively (in.)

$V_c$  = Desired constant vehicle velocity (in./s)

$v_{yw}$  = Velocity of cross wind in space-fixed axes, measured at sprung mass center of gravity (in./s)

- $y_{SAi}$  = Distance between the kingpin axis and wheel centerline, measured along the wheel spin axis at front wheel  $i$  (in.)
- $Z_{bias}$  = Bias constant to vertically shift the vehicle center-of-gravity position (in.)
- $z_F, z_R$  = Static distance in the  $z$  direction between the center of gravity of the sprung mass and center of gravities of the front and rear unsprung masses, respectively (in.)
- $\delta_{FIN}, \delta_{RIN}$  = Static displacement of the independent front/rear suspension from the position of static equilibrium due to loading condition (in.)
- $\Delta\phi_i$  = Magnitude of camber play at front wheel  $i$  (rad)
- $\Delta\phi_i$  = Static caster angle bias at front wheel  $i$  (rad)
- $\Delta\psi_i$  = Static toe angle bias at front wheel  $i$  (rad)
- $\epsilon_{pi}$  = Free play in steer of front wheel  $i$  (rad)
- $\epsilon_{sp}$  = Free play in steering gear box (rad)
- $\zeta_{FIN}, \zeta_{RIN}$  = Static displacement of the front/rear suspension (solid front/rear axle) from the position of static equilibrium due to loading condition (in.)
- $\lambda_{Bi}$  = Brake torque multiplier at wheel  $i$
- $\lambda_D$  = Drive torque distribution factor
- $\mu_{SF}, \mu_{SR}$  = Coefficient of sliding friction, front and rear wheels, respectively
- $\rho_a$  = Air density (lb-s<sup>2</sup>/in.<sup>4</sup>)

$\phi_{SA0i}$  = Right and left front wheel kingpin  
inclination angle at equilibrium  
suspension position (rad)

$\omega_{xw}, \omega_{zw}$  = Angular velocity of wind in space-  
fixed axes (rad/s)

Appendix B

DESCRIPTION OF THE HYBRID COMPUTER SIMULATION LABORATORY

Figure B-1 is a diagram of the APL/JHU hybrid computer system. The primary units are the analog and digital computers, the hybrid control and data interface, the hybrid operator control console, and the remote batch station. Two types of analog computers manufactured by Electronic Associates, Inc. (EAI), are located in the hybrid laboratory, and the portion of the model programmed on the analog computer is divided between them. The entire steering system is contained on an EAI 231-R and the rotational wheel dynamics, circumferential friction coefficient calculation, tire deflection, and suspension dynamics are contained on an EAI 680.

The hybrid data and control interface permits control of the analog computer by the digital computer and exchange of data between the analog and digital computers. Data communication with the digital computer is provided by 24 multiplying digital-to-analog converters (MDAC's), 24 nonmultiplying DAC's, and 48 channels of

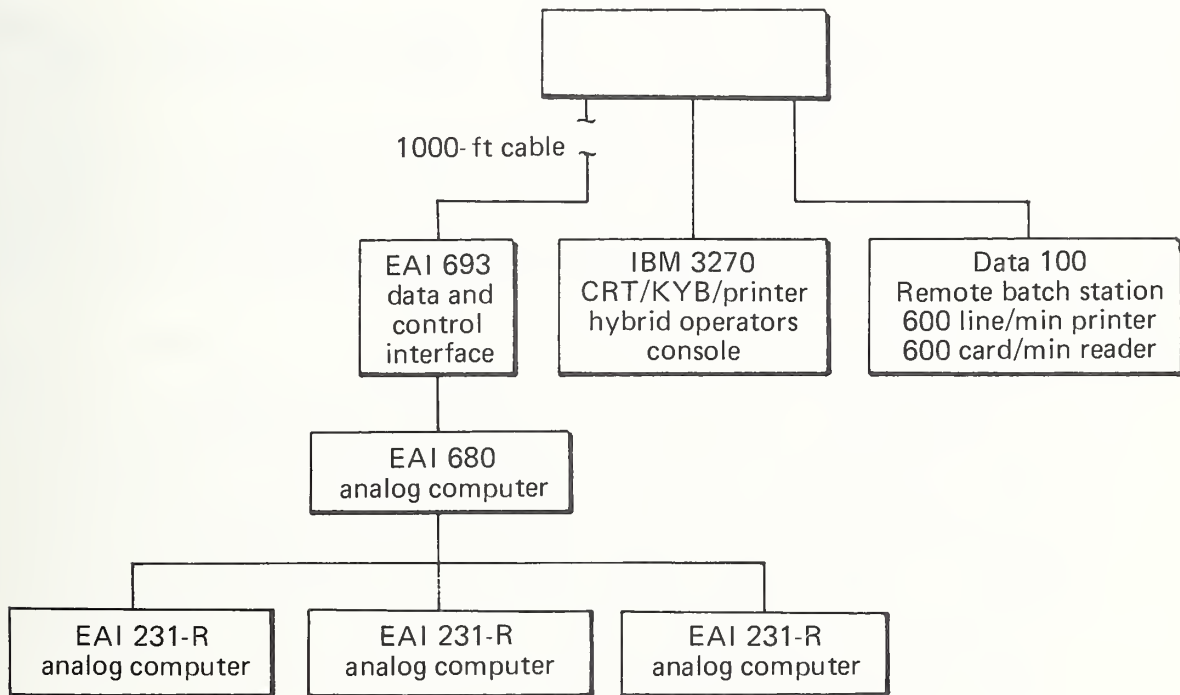


Fig. B-1 APL/JHU Hybrid Computer System Block Diagram

analog-to-digital conversion (ADC's). The system contains a control interface that allows complete control of the 680 analog computer and data interface via Fortran IV callable subroutines, by the digital computer, which is remotely located 1000 feet from the hybrid laboratory. A detailed description of the APL/JHU hybrid facility is presented in Appendix C of Ref. 10.

The digital computer is an IBM 360/91, one of the largest and fastest computers built by IBM, and is characterized by the following:

- Third generation hardware
- 4 million bytes of main core storage
- 4 billion bytes of random access storage
- Minimum instruction execution time of 60 ns
- Use of the Operating System Multiprogramming with a Variable Number of Tasks (OS/MVT)

All vehicle model calculations not assigned to the analog computers are performed digitally. Simulation coding is performed in the Fortran IV language.

Since the hybrid computing facility is remotely located from the digital computer, a remote batch terminal is required for program deck submission and the printing of digital output. The terminal in the hybrid laboratory is a Data 100 and contains a 600 card/min reader and a 600 line/min printer.

The hybrid operator control console is an IBM 3270 display system consisting of a CRT, a keyboard, and a printer. All simulation control is exercised at this station. Simulation directives, user information input via the keyboard, and simulation output appear on the CRT. The printer is used to ghost print everything that appears on the CRT so that user/computer transactions are not lost. A very powerful and flexible set of communication routines, designed for simulation use, is available to the user at the hybrid operator console. The software that services the control console is applicable to terminals other than the IBM 3270. Therefore, the simulation can be operated via a dial-up typewriter of a CRT type terminal from a remote location.



## Appendix C

### INTERACTIVE SUBROUTINES

#### 1. INTRODUCTION

A set of generalized user communication subroutines has been added to the Improved Hybrid Computer Vehicle Handling Program (IHVHP) to enhance its operation by engineers. A subset of these routines directly aimed at the engineering user expedites the simulation functions of changing parameters, selecting variables for output, performing parametric runs, and general simulation control. Another subset, directed toward the simulation designer, allows tasks such as reassigning and rescaling analog-to-digital and digital-to-analog converters (ADC's and DAC's), printing the current values of all digital variables, and printing selected members of arrays. The use of these routines has allowed easy configuration of the IHVHP to perform the Vehicle Handling Test Procedures (VHTP) and to calculate the vehicle performance comparison variables.

#### 2. SUBROUTINE USE

All simulation control occurs at the hybrid computer operator's station, which consists of a telecommunications device (teletypewriter or a CRT with keyboard). Once the simulation is active, the user controls simulation activity with input responses to the OPTION cue. Each input selects an interactive routine. Once a routine has been selected, the user is queried for information necessary to perform the task of the selected routine. When the routine is completed, the readiness of the simulation for the next routine is indicated by the reappearance of the OPTION cue. Table C-1 lists the names of the currently available interactive subroutines.

In general, the routines either alter simulation data, provide simulation control, or provide for output of simulation data. For output, the information may be directed to the hybrid operator station (T), the system line printer (L), or both (B). Also, the output can be specified as immediate (XEQ), at the end of a single-run execution (S), or at the end of each run in a multiple-run execution (M). These output selections and their codes are shown in Table C-2.

Table C-1  
Interactive Subroutine List

X	Execute single simulation run	TABLE	Set up end-of-run output
XM	Execute multirun series	TRACK	Set up during-run data collection
IC	Initialize simulation	LA	List array values
F	Read or alter real variables	REMOVE	Suspend output
I	Read or alter integer variables	T+D	Output time and data
DACA	Alter DAC array	STD	Standard output
ADCA	Alter ADC array	DUMP	Output all variables
MULTI	Set up multiple runs	DACL	List DAC array
TEST	Test runs or ABEND	ADCL	List ADC array
MES	Send message to line printer	PLOT	Variable cross-plot
		TERM	Terminate program

Table C-2  
Data Output Selections

Unit	Mode
T = CRT	S = Single runs only
L = System line printer	M = Multiruns only
B = Both T and L	A = Both S and M
	XEQ = Immediately

### 3. INTERACTIVE VARIABLES

To be effective, the routines must access, by name, the Fortran variables within a simulation. The variables of interest, termed interactive variables, need only appear in a Fortran named COMMON to be accessed. Once selected, a variable can be given any number of aliases. The alias capability is particularly important when an interactive variable is an array member. For instance, the current value of input brake line pressure, which is stored in element 121 of the PARAM array, has been given the alias PFL. Also, the PARAM array has been given the shorter alias PRM. A maximum of 400 interactive variables can be selected. However, it is important to note that the PARAM array, which has 295 elements, uses only one interactive variable allocation. Nearly all variables associated with wheel computation (side force, FSI; normal force, FRI; ground patch velocity, CVI; etc.) can be addressed as arrays and use only one interactive variable allocation. Currently, 300 interactive names have been used that permit the interrogation or alteration of more than 900 Fortran variables.

### 4. SUBROUTINE DESCRIPTIONS

Each subroutine is discussed, including all required inputs, and actual user examples are presented. In the examples, \*\*\*\* indicates user input, the remainder is computer output. Although they are not presented, the routines have extensive error handling facilities that alert a user when errors are made.

#### 4.1 X (Execute Single Simulation Run)

Purpose: To perform a single simulation run. The simulation is automatically initialized (IC) and a run performed.

OPTION when the run is completed and all output has been printed.

Example:

```
OPTION
**** X
JUNE      20 1974
TIME 10:18:17.09
RUN 5 HAS STARTED
OUTPUT BELOW
AXAV= 0.0  DECL TIME= 0.000  AVCUR= 0.118  BTDMAX= 0.023  BTMAX= 0.007  DELBT= 0.008
AYMAX= 0.154  PHIMAX= 1.502  RMAX= 0.088  LANE CHNG DEL= 0.0  DELPSI= 0.0  MAX STEER= 27.927
FTRQMAX= 0.0  RTRQMAX= 0.0
OPTION
```

#### 4.2 XM (Execute Multirun Series)

Purpose: Perform a series of parametric runs. The simulation is automatically initialized (IC) prior to performing each run in the series.

Input requested: None. Control is returned to OPTION when the run series is completed and all output has been printed.

Example:

```
OPTION
***** XM
JUNE      20  1974
TIME 10:24: 7.18
RUN 10 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR4..( 1) BETAMX( 1) BETDMX( 1) CUVRAT( 1)
  1    10      28.0      0.674E-02      0.237E-01      0.111
  2    11      56.0      0.141E-01      0.465E-01      0.209
  3    12      84.0      0.254E-01      0.655E-01      0.306
  4    13     112.      0.416E-01      0.903E-01      0.394
```

#### 4.3 IC (Initialize Simulation [do not execute])

Purpose: Resets variables back to their initial conditions. Sets potentiometers and DAC's, then returns control to OPTION.

Internal input requested: None

Example:

```
OPTION
***** IC
OPTION
```

#### 4.4 F (Read or Alter Real Variables)

Purpose: Read current values of parameters, initial conditions, and variables which are declared REAL to Fortran. Alter current values of REAL parameters and initial conditions.

Input requested: Interactive variable only for readout, interactive variable followed by new value for altering data.

Variation: Array Readout: (a) Interactive variable followed by range of array to be output, (b) interactive variable followed by the letters AM, allowing addressing array elements by number.

Examples:

```

OPTION
***** F
ENTER
***** VHTPNO
  0.0
***** VHTPNO 5.
***** FRI 1 4
  1==> 1073.          2==> 1073.          3==> 887.7          4==> 887.7
***** PRM 285 287
 285==> 3.900          286==> 0.0          287==> 1.000
***** PRM 1 23
  1==> 12.33          2==> 0.5100          3==> 0.8200          4==> 11.30
  5==> 11.30          6==> 49.30          7==> 68.70          8==> 59.80
  9==> 61.80          10==> 47.00          11==> 3758.          12==> 0.2305E 05
 13==> 0.2333E 05     14==> 530.0          15==> 550.0          16==> 0.0
 17==> 0.4040E 05     18==> 40.00          19==> 105.0          20==> 2.000
 21==> -2.400          22==> 2.100          23==> 0.0
***** FRI AM
***** 1
 1073.
***** 2
 1073.
***** 3
 887.7
***** 4
 887.7
***** PRM AM
***** 285
 3.900
***** 285 4.4
***** 285
 4.400
*****

```

#### 4.5 I (Read or Alter Integer Variables)

Purpose: Read current values of parameters, initial conditions, and variables that are declared INTEGER to Fortran. Alter current values of INTEGER parameters and initial conditions.

Input requested: Interactive variable only for readout, interactive variable followed by new value for altering data.

Example:

```
OPTION
**** I
ENTER
**** IPOT
      283
****
```

#### 4.6 DACA (Alter DAC Array)

Purpose: To change DAC variable assignment and/or scaling.

Inputs requested:

1. ENTER DAC NUM OR NAME
  - a. Purpose: To select DAC to be altered.
  - b. Input requested: The name of any interactive variable that is assigned to a DAC or a number from 1 to 48.
2. ENTER NAME
  - a. Purpose: To reassign a new variable to the DAC.
  - b. Input requested: Any interactive variable. Depressing the carriage return will retain the old assignment.
3. SCALE FACTOR
  - a. Purpose: To enter scale factor.
  - b. Input requested: Any number.

**Example:**

```
OPTION
****  \ DACA
TO RETURN TO OPTIONS  HIT CR
ENTER DAC ARRAY NUM OR NAME
****  1
DACD( 1) = 10UT..( 1) /      1.0000
ENTER NAME
****  AYMAX
SCALE FACTOR
****  1.
ENTER DAC ARRAY NUM OR NAME
****
OPTION
```

#### 4.7 ADCA (Alter ADC Array)

Identical to DAC routine with the exception that the interactive variable is assigned to an ADC, not a DAC, and the number must be from 1 to 28.

**Example:**

```
OPTION
****  ADCA
TO RETURN TO OPTIONS  HIT CR
ENTER ADC ARRAY NUM OR NAME
****  20
QUANZ.( 1) = ADCD(20) *      1.0000
ENTER NAME
****  SLIPI(2)
SCALE FACTOR
****  1.
ENTER ADC ARRAY NUM OR NAME
****
```

#### 4.8 MULTI (Set Up Multiple Runs)

**Purpose:** To automatically execute a series of runs. Parameters (interactive variables) may be incremented from run to run by this routine. Parameters retain their incremented value at the end of the multiple run.

Inputs requested:

1. NUMBER OF LOOPS, VARS

- a. Purpose: To specify the total number of runs to be made and the number of interactive variables to be incremented.
- b. Input requested: LOOPS, a number less than 100; VARS, a number less than 50.

2. VAR

- a. Purpose: To specify the interactive variables to be incremented. The variables are incremented at the end of each run in the multiloop. If 0 is entered, control is returned to OPTION.
- b. Input requested: Any interactive variable.

3. LOOP, VAL, INC

- a. Purpose: To specify the run number, initial value, and increment per run.
- b. Input requested: A value can be specified for each run with a 0 increment or a series can be set up by the input of an increment. The incrementing is halted at each new LOOP input or when runs equal to the total number of LOOPS have been completed.

Example:

```
OPTION
***** MULTI
NUM OF LOOPS, VARS
***** 12 2
VAR
***** STR4
LOOP, VAL, INC
***** 1 28. 28.
***** 7 28. 28.
*****
VAR
***** UIN
LOOP, VAL, INC
***** 1 50. 0.
***** 7 60.
***** 7 60. 0.
*****
OPTION
```



#### 4.9 TEST (Test Runs or ABEND)

Purpose: To run the problem without real-time service or produce an abnormal termination (ABEND), thus giving a program dump.

Input requested:

1. ENTER: RTIME, NO RTIME, ABEND
  - a. Purpose: To indicate that a command is desired.
  - b. Input requested: One of three commands:
    - (1) NO RTIME: This will remove the real-time calls.
    - (2) RTIME: This will replace the real-time calls.
    - (3) ABEND: Will produce a program dump.

Example:

```
OPTION
***** TEST
ENTER: RTIME,NO RTIME,ABEND
***** RTIME
```

#### 4.10 MES (Send Message to Line Printer)

Purpose: To send a message to the line printer that will document analog programming changes (experimental or permanent), indicate the state of analog computer, or log simulation information.

Input requested: A message that is less than 80 characters per line long.

Example:

```
OPTION
***** MES
TO RETURN TO OPTIONS HIT CR TWICE
***** THIS OPTION IS USEFUL FOR
***** DOCUMENTING SIMULATION RUNNING
***** AND KEEPING SIMULATION NOTES
*****
```

#### 4.11 TABLE (Set up End-of-Run Output)

Purpose: To output data for a series of runs in tabular form. Designed for use in the multirun cases. This routine is called automatically whenever a multirun case is in affect, unless it is deselected.

Input requested: Up to nine interactive variables.

Example:

```
OFTION
***** TABLE
UNIT,MODE
***** T M
ENTER UP TO 9 NAMES
***** STR4 BETAMX BETDMX CUVRAT
*****
```

#### 4.12 TRACK (Set up During-Run Data Collection)

Purpose: To collect and output simulation data as a function of time.

Inputs requested:

##### 1. TIME ON

- a. Purpose: To state the time in seconds that the routine will turn on.
- b. Input requested: Any positive number.

##### 2. TIME OFF

- a. Purpose: To state the time in seconds that the routine will turn off.
- b. Input requested: Any positive number  $\geq$  TIME ON.

##### 3. TIME STEP

- a. Purpose: To state the time between samples. If this sample interval is too small, the program will automatically compensate for it.
- b. Input requested: Any positive number.

#### 4. VARIABLES

a. Purpose: To enter the interactive variables to be tracked. Entering the word RETAIN will retain the previous variable list.

b. Inputs requested: Up to 50 variables.

Example:

```
OPTION
**** TRACK
UNIT,MODE
**** T A
ENTER TIME ON,OFF,STEP
**** .5 1.1 1
TYPE RETAIN OR ENTER NEW ARRAY
**** PSIDT PHIDT PHI ZIMX(1) ZIMX(3)
****
```

TIME	PSIDT.( 1)	PHIDT.( 1)	PHI...( 1)	ZIMX..( 1)	ZIMX..( 3)
0.50	0.43077	0.77597E-02	-0.11728	0.29986E-01	0.10125
0.60	0.35703	0.29683	-0.10414	0.29986E-01	0.10125
0.70	0.28586	0.49151	-0.59047E-01	0.29986E-01	0.10125
0.80	0.28740	0.32454	-0.16426E-01	0.29986E-01	0.10125
0.90	0.30123	0.14344E-02	-0.12279E-03	0.29986E-01	0.10125
1.00	0.28316	-0.14820	-0.90558E-02	0.29986E-01	0.10125
1.10	0.29048	-0.38197	-0.30314E-01	0.29986E-01	0.10125

OPTION

#### 4.13 LA (List Array Values)

Purpose: To output the values of variables that are array members.

Inputs requested: Any interactive variable that is an array, followed by the range of the array desired.

Example:

```
OPTION
**** LA
UNIT,MODE
**** T XEQ
ENTER NAME,INDEX1,INDEX2
**** FRI 1 4
**** FSI 1 4
**** PRM 11 14
**** PARAM 11 14
****
FRI.....
  1==) 1073.          2==) 1073.          3==) 887.7          4==) 887.7
FSI.....
  1==) -10.51         2==) 10.51          3==) 0.0            4==) 0.0
PRM.....
  11==) 3832.         12==) 0.2400E 05    13==) 0.2431E 05    14==) 530.0
PARAM...
  11==) 3832.         12==) 0.2400E 05    13==) 0.2431E 05    14==) 530.0
```

#### 4.14 REMOVE (Suspend Output)

Purpose: To cancel the execution of a selected interactive subroutine.

Input requested: Any interactive subroutine name.

Example:

```
OPTION
**** REMOVE
WHAT
**** TRACK
```

#### 4.15 T+D (Output Time and Date)

Purpose: To display the time and date.

Example:

```
OPTION
**** T+D
UNIT,MODE
**** T XEQ
JUNE      21  1974
TIME  14:30:40.67
```

#### 4.16 STD (Standard Output)

Purpose: Select standard end-of-run data.

Example:

```
OPTION
**** STD
UNIT,MODE
**** T XEQ
  AXAV=  0.0  DECL TIME=  0.0  AVCUR=  0.0  RTDMAX=  0.0  RTMAX=  0.0  DELRT=  0.0
AYMAX=  0.000 PHIMAX=  0.0  RMAX=  0.0  LANE CHNG DEL=  0.0  DELPSI=  0.0  MAX STEER=  0.0
FTRGMAX=  0.0  RTRGMAX=  0.0
```

#### 4.17 DUMP (Output All Variables)

Purpose: To display the value of each interactive variable at the time the dump is selected to execute.

Example:

OPTION

\*\*\*\* DUMP

UNIT/MODE

\*\*\*\* I XEQ

ABBTV.= 0.0	DEL1DT= 0.0	OTM...= 63.28	S3P...= -38.00
ARI...= 0.1962E-01	DEL2DA= 0.0	F.....= 0.0	S4P...= -38.00
AFA...= 1.000	DEL2DT= 0.0	PARAM.= 0.430	TBCR3.= 2.923
AIXBR.= 3928.	DEL3DA= 0.0	FRF...= 0.0	TBCR4.= 2.923
AIXP...= 169.8	DEL3DT= 0.0	FBR...= 0.0	TBSR3.= 1.038
AIXZBR.= 177.5	DLIS...= -.8000	FD1...= -.3097E-03	TBSR4.= 0.9047
AIXZF.= -352.5	DLYTB.= -.2453E-54	PE1...= 1090.	IFRDAC= -.5388E 09
AIYBR.= 0.2322E 05	DSWMAX= 0.0	PHI...= 0.0	TF02...= 29.90
AIYP...= 169.8	DT.....= 0.1000E-01	PHICGI= -.5630E-02	THE...= -.1215E-02
AIZBR.= 0.2944E 05	D1.....= 0.0	PHIDMX= 0.0	THEDT.= 0.0
AKK1...= 1.000	D2.....= -1.209	PHID1.= 0.0	THEFNT= 0.7500
AKK2...= 1.000	D3.....= 0.0	PHIFNT= -.3800	THEO...= -.1215E-02
ALFL...= -.2262E 08	D4.....= 0.1146E-68	PHI1...= -.6405E-02	THERR.= 0.0
ALTR...= -46.06	ETAL...= -.1133E-05	PHIMAX= 0.0	THRD...= 0.3333
AM11...= 25.85	ETAX...= -.2176E-03	PHIO...= 0.0	THS1...= 0.1309E-01
AM12...= -25.85	EXTAB.= -.1278E-56	PHIRD.= 0.0	THS2...= 0.1309E-01
AMUI...= 0.9657	E1.....= 0.1156E 09	PHIRDA= 0.0	THBMP.= 0.0
AM1I...= 5.018	E2.....= -.4480E 06	PHIRR.= 0.0	TIMDEC= 0.0
AM2I...= -.2466	E3.....= 0.1252E 06	PO....= 0.0	TIME...= 0.0
ANGNL.= 0.1180E 09	FBS1...= 0.0	PRM...= 0.430	TIME10= 0.0
ANGNLO= 0.8392E-04	FBS2...= 0.0	PSI...= 0.0	TIME25= 0.0
ANTI1.= 1.734	FBS3...= 0.0	PSIDT.= 0.0	TIMIN5= 0.0
ANTI2.= 1.734	FBS4...= 0.0	PSIFNT= -.2700	TMAX1.= 0.9942E 28
ANTI3.= -.1425	FCI...= 0.0	PSII...= -.1558E-02	TMAX2.= 0.1991E 06
ANTI4.= -.1425	FCIMAX= 892.9	PSIMAX= 0.0	TMAX3.= -.4879E-49
AP1...= 0.1381	FI.....= 1.000	PSIO...= 0.0	TMP...= 0.0
AP2...= 0.1381	FOIM...= -1.218	PSIOUT= 0.0	TQBF...= 0.0
AP3...= -.1425	FRI...= 1047.	PSIRR.= 0.0	TQBR...= 0.0
AP4...= -.1425	FRIBR.= 1047.	PSI3S.= 0.0	TQFMAX= 0.0
ARPS1.= 56.79	FSI...= -19.70	PSI4S.= 0.0	TQRMAX= 0.0
ARPS2.= 56.97	FXL1...= 0.0	PSI5...= 0.0	TRCR3.= 1.315
AR1...= 1.596	FXL2...= 0.0	PSR3...= 0.0	TRCR4.= 1.315
AR2...= 1.596	FXUI...= -1.302	PSK4...= 0.0	TRC2...= 30.90
AR3...= 0.0	FYUI...= -19.70	Q.....= 0.0	TRSR3.= 0.4669
AR4...= 0.0	G.....= 386.4	QDT...= 0.5060E-01	TRSR4.= 0.4069
AXAVE.= 0.0	GAMF...= 0.0	QO....= 0.0	T302...= 23.50
AXI...= 0.0	GAM1...= -31.19	QUAN1.= 0.0	TSTEP.= 0.1000E-01
AYMAX.= 0.1133E-05	GAM2...= 15.03	QUAN2.= 0.0	TWN7...= 0.3704E-01
A1....= 1.540	GAM3...= 15.03	QUAN3.= 0.0	U.....= 880.0
A12...= -1543.	GBI...= -.1949E-01	QUAN4.= 0.0	UDT...= -.8422E-01
A2....= 1545.	GETDL.= 0.0	R.....= 0.0	UGT...= 880.0
A2T...= 1900.	GI.....= -.1882E-01	RDT...= -.2380E-05	UGIF...= 880.0
BAMI...= 0.2221E-02	GP1...= 0.2864E 06	RMAX...= 0.0	UL....= 880.0
BETAI.= 0.1558E-02	GP2...= 2202.	RMI...= 1011.	UIN...= 50.00
BETAMX= 0.0	GR1...= 2202.	RO....= 0.0	UO....= 880.0
BETDMX= 0.0	GR2...= 0.3811E 05	ROTM...= 0.0	UOUT...= 880.0
BETIBR.= -.1962E-01	GV1...= 0.4480E 06	ROUT...= 0.0	UOI...= 0.8966
BETIF.= 0.6625E-03	GV2...= 0.1252E 06	RTAB...= -.8457E-53	U1T...= 0.6500
BMPN...= 0.0	IAX...= 0.5148E-84	RWZI...= 0.7219	U1P...= 0.0
BRMFS...= 0.0	IDACK.= 0.0	RZF...= 24.50	U2P...= 0.0
BRKOFF= 1.020	IENDR.= -14.24	RZR...= 24.50	U3P...= 0.0
BRKON.= 0.5200	IERDAC= -14.24	SALTQ.= 0.0	U4P...= 0.0
BSLOPE= 0.5000E-01	IN....= -.2014E-02	SAMI...= 0.1272	V.....= 0.0
BTV...= 0.0	INA...= 0.2523E 09	SCR3...= 0.3551	VDT...= -.4844E-03
BTVDT.= -.4975E-06	IOR...= 0.8236E-83	SCR4...= 0.3095	VGI...= 0.0

```

CA20..= 0.6842E 07 IOUT..= 0.7892E-04 SFIN..= -100.0      VHTFNO= 6.000
CA23..= 3293.      IOUTA.= 0.2031E 38 SFOUT..= 1.000      VI....= 0.0
CIP...= 4105.      IFOT..= 0.1524E-01 SFXU..= -4.643      VO....= 0.0
CIVF..= 2046.      IFOTAD= 0.1524E-01 SFYU..= 0.0      VOUT..= 0.0
EQSFSI= 1.000      IFRT..= 0.0      SINFSI= -1.1550E-02 W.....= 0.0
CPSR3.= 1.000      ISW1..= 0.0      SLIFI.= 0.0      WCTH1.= -1.7869
CPSR4.= 1.000      ISW7..= 0.0      SM....= 9.760      WCTH2.= -1.9782
CURTBP= 0.0      ITMF..= 0.7892E-04 SN....= 0.0      WDI...= 18.51
CURVAV= 0.0      IVHTF.= 0.3089E-03 SNI...= 1.000      WI....= 0.0
CUVRAT= 0.0      JJTIME= 0.0      SNPHIU= -1.218      WO....= 0.0
CVI...= 50.00      JUMP..= 0.0      SNPSIU= 0.0      WSTH1.= 0.6163
DACO...= 0.7892E-04 MUF...= 0.8563      SNTHIU= 1166.      WSTH2.= 0.2056
DEL...= 0.0      NCAM..= 0.5432E 09 SPSR3.= 0.3551      X.....= 0.0
DELBET= 0.0      NCAS..= -1.7418E-67 SPSR4.= 0.3095      XDT...= 880.0
DELFW1= 0.0      NFA...= 0.5148E-03 STR1..= 0.0      XO....= 0.0
DELFW2= 0.0      NTF...= 0.1030E-03 STR2..= 0.0      Y.....= 0.0
DELFHI= -1.7662E 55 NTR...= 0.1030E-03 STR3..= 0.0      YDT...= 0.0
DELFSI= 0.0      N1....= 0.1519E-01 STR4..= 0.0      YO....= 0.0
DELSTR= 0.0      N2....= 0.6126E-02 STR5..= 223.4      Z.....= -23.84
DELTA.= 0.1118E 10 ONEOA.= -1.6480E-03 STR6..= 223.4      ZDT...= 1.069
DELTHE= -1.1079E-49 ONEOD.= 0.8947E-09 S1P...= -40.00      ZI....= -12.48
DELIDA= 0.0      ONER..= -1.5653E-09 S2P...= -40.00      ZIMX..= 0.7219
OPTION

```

#### 4.18 DACL (List DAC Array)

Purpose: To list the DAC assignments and scale factors.

Example:

```

OPTION
**** DACL
UNIT,MODE
**** I XEQ
DACO( 1) = IOUT..( 1)/ 1.0000
DACO( 2) = IOUT..( 2)/ 1.0000
DACO( 3) = IOUT..( 3)/ 1.0000
DACO( 4) = IOUT..( 4)/ 1.0000
DACO( 5) = IOUT..( 5)/ 1.0000
DACO( 6) = IOUT..( 6)/ 1.0000
DACO( 7) = IOUT..( 7)/ 1.0000
DACO( 8) = IOUT..( 8)/ 1.0000
DACO( 9) = IOUT..( 9)/ 1.0000
DACO(10) = IOUT..(10)/ 1.0000
DACO(11) = IOUT..(11)/ 1.0000
DACO(12) = IOUT..(12)/ 1.0000
DACO(13) = IOUT..(13)/ 1.0000
DACO(14) = IOUT..(14)/ 1.0000
DACO(15) = IOUT..(15)/ 1.0000
DACO(16) = IOUT..(16)/ 1.0000
DACO(17) = IOUT..(17)/ 1.0000
DACO(18) = IOUT..(18)/ 1.0000
DACO(19) = IOUT..(19)/ 1.0000
DACO(20) = IOUT..(20)/ 1.0000
DACO(21) = IOUT..(21)/ 1.0000
DACO(22) = IOUT..(22)/ 1.0000
DACO(23) = IOUT..(23)/ 1.0000
DACO(24) = IOUT..(24)/ 1.0000
DACO(25) = IOUT..(25)/ 1.0000
DACO(26) = IOUT..(26)/ 1.0000
DACO(27) = IOUT..(27)/ 1.0000
DACO(28) = IOUT..(28)/ 1.0000

```

```

DAC0(29) = IOUT..( 24)/ 1.0000
DAC0(30) = IOUT..( 30)/ 1.0000
DAC0(31) = IOUT..( 22)/ 1.0000
DAC0(32) = IOUT..( 21)/ 1.0000
DAC0(33) = IOUT..( 33)/ 1.0000
DAC0(34) = IOUT..( 34)/ 1.0000
DAC0(35) = IOUT..( 35)/ 1.0000
DAC0(36) = IOUT..( 36)/ 1.0000
DAC0(37) = IOUT..( 37)/ 1.0000
DAC0(38) = ANTI1.( 1)/ 10000.
DAC0(39) = ANTI2.( 1)/ 10000.
DAC0(40) = ANTI3.( 1)/ 10000.
DAC0(41) = ANTI4.( 1)/ 10000.
DAC0(42) = ETAX..( 1)/ 1.4000
DAC0(43) = ETAL..( 1)/ 1.4000
DAC0(44) = ROUT..( 1)/ 1.0000
DAC0(45) = UOUT..( 1)/ 1200.0
DAC0(46) = VOUT..( 1)/ 1200.0
DAC0(47) = BTV... ( 1)/ 3.1400
DAC0(48) = ONER..( 1)/ 0.41700E-02

```

#### 4.19 ADCL (List ADC Array)

Purpose: To list the ADC assignments and scale factors.

Example:

```

OPTION
**** ADCL
UNIT/MODE
**** T XEQ
DEL1DT( 1) = ADC0( 1)* -100.00
DEL2DT( 1) = ADC0( 2)* -100.00
DEL3DT( 1) = ADC0( 3)* -100.00
DEL1DA( 1) = ADC0( 4)* 10.000
DEL2DA( 1) = ADC0( 5)* 10.000
DEL3DA( 1) = ADC0( 6)* 10.000
PHIRD.( 1) = ADC0( 7)* 1.0000
PHIRDA( 1) = ADC0( 8)* 0.25000
DELFW1( 1) = ADC0( 9)* 0.50000
DELFW2( 1) = ADC0(10)* 0.50000
U1F... ( 1) = ADC0(11)* 2.0000
U2F... ( 1) = ADC0(12)* 2.0000
U3F... ( 1) = ADC0(13)* 2.0000
U4F... ( 1) = ADC0(14)* 2.0000
S1F... ( 1) = ADC0(15)* 1000.0
S2F... ( 1) = ADC0(16)* 1000.0
S3F... ( 1) = ADC0(17)* 1000.0
S4F... ( 1) = ADC0(18)* 1000.0
QUAN1.( 1) = ADC0(19)* 1.0000
QUAN2.( 1) = ADC0(20)* 1.0000
QUAN3.( 1) = ADC0(21)* 1.0000
QUAN4.( 1) = ADC0(22)* 1.0000
ARPS1.( 1) = ADC0(23)* 100.00
ARPS2.( 1) = ADC0(24)* 100.00
WSTH1.( 1) = ADC0(25)* 1.0000

```

```
WCTH1.( 1) = ADCO(26)* 1.0000
WSTH2.( 1) = ADCO(27)* 1.0000
WCTH2.( 1) = ADCO(28)* 1.0000
OPTION
```

#### 4.20 PLOT (Variable Cross-Plot)

Purpose: To provide X-Y printer plot of any two variables which are included in TRACK option.

Example:

```
OPTION
**** PLOT
UNIT,MODE
**** L XEQ
ENTER NUMBER OF PLOTS
**** 1
ENTER DEPENDENT AND INDEPENDENT PLOT VARIABLES
**** Y X
****
OPTION
```

#### 4.21 TERM (Terminate Program)

Purpose: To terminate program.

Example:

```
OPTION
**** TERM
JUNE 21 1974
TIME 17: 5:36.72
PROGRAM TERMINATED
```



Appendix D

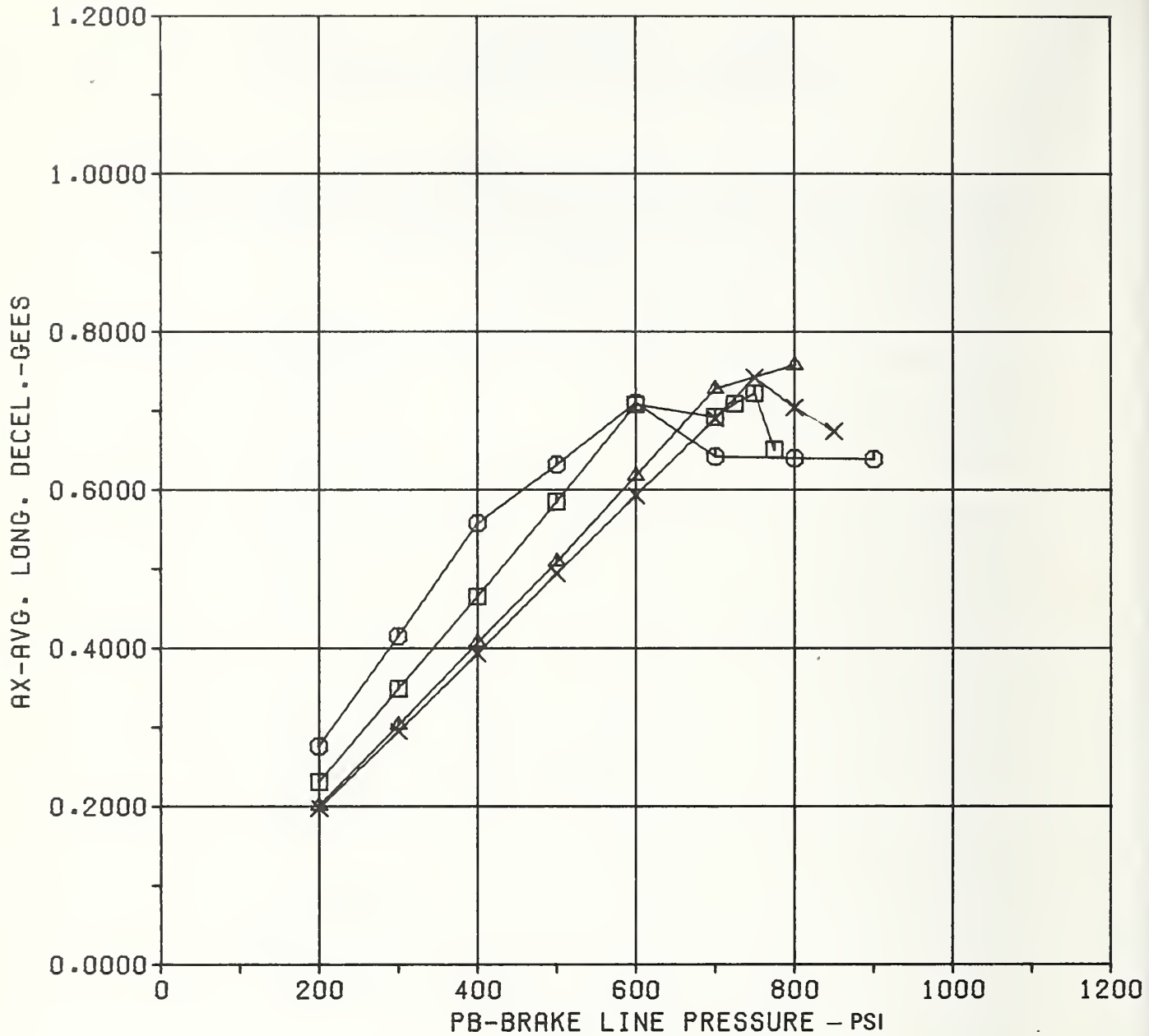
PERFORMANCE COMPARISON VARIABLE GRAPHS

This appendix contains the performance comparison variable (PVC) graphs for six Vehicle Handling Test Procedures (VHTP's) for four vehicles.

1. VHTP No. 1: Straight Line Braking

$A_x$  - Average longitudinal deceleration from 35 mph to 10 mph (g)

$P_B$  - Brake line pressure (psi)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- × - VW SUPERBEETLE

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Fig. D-1 VHTP 1, Straight Line Braking: Average Longitudinal Deceleration from 35 to 10 mph versus Brake Line Pressure (Calspan, O.E. tires)

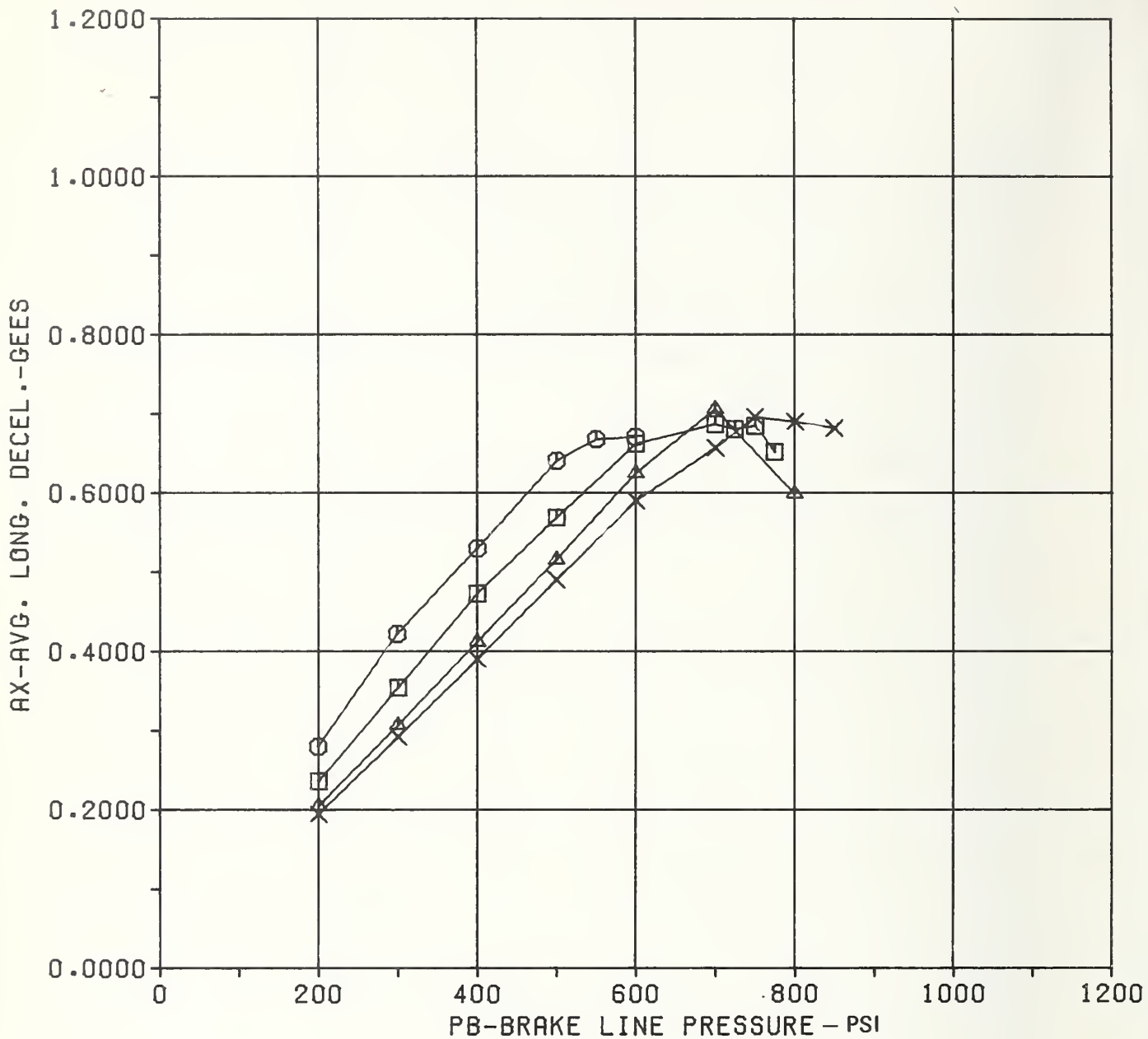
2. VHTP No. 2: Braking in a Turn

$A_x$  -- Average longitudinal deceleration from 35 mph to 10 mph (g)

$P_B$  -- Brake line pressure (psi)

BETADOT -- Peak vehicle sideslip angle rate (rad/s)

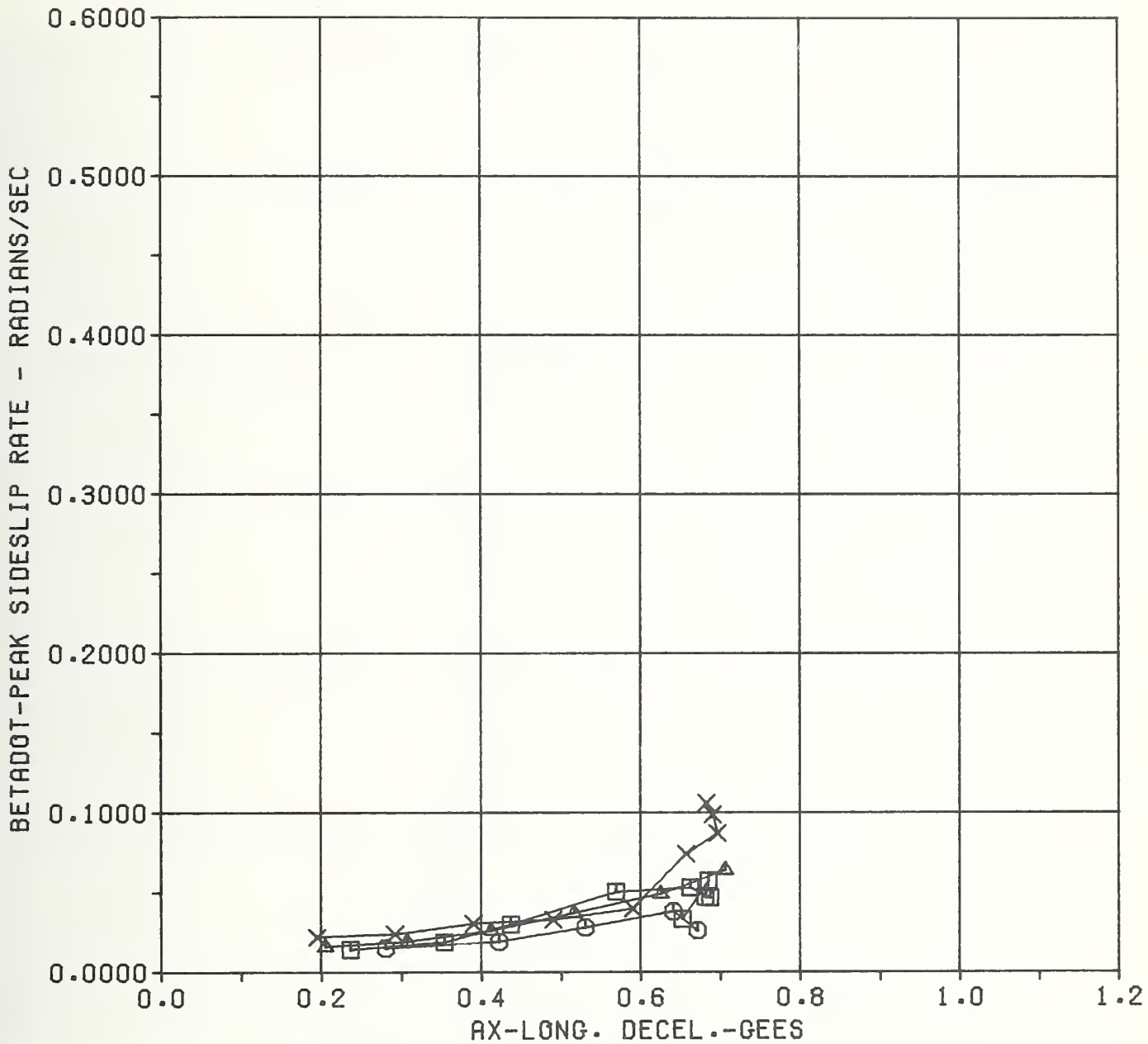
$R_0(1/R)$  -- Average path curvature ratio relative to initial turn



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- × - VW SUPERBEETLE

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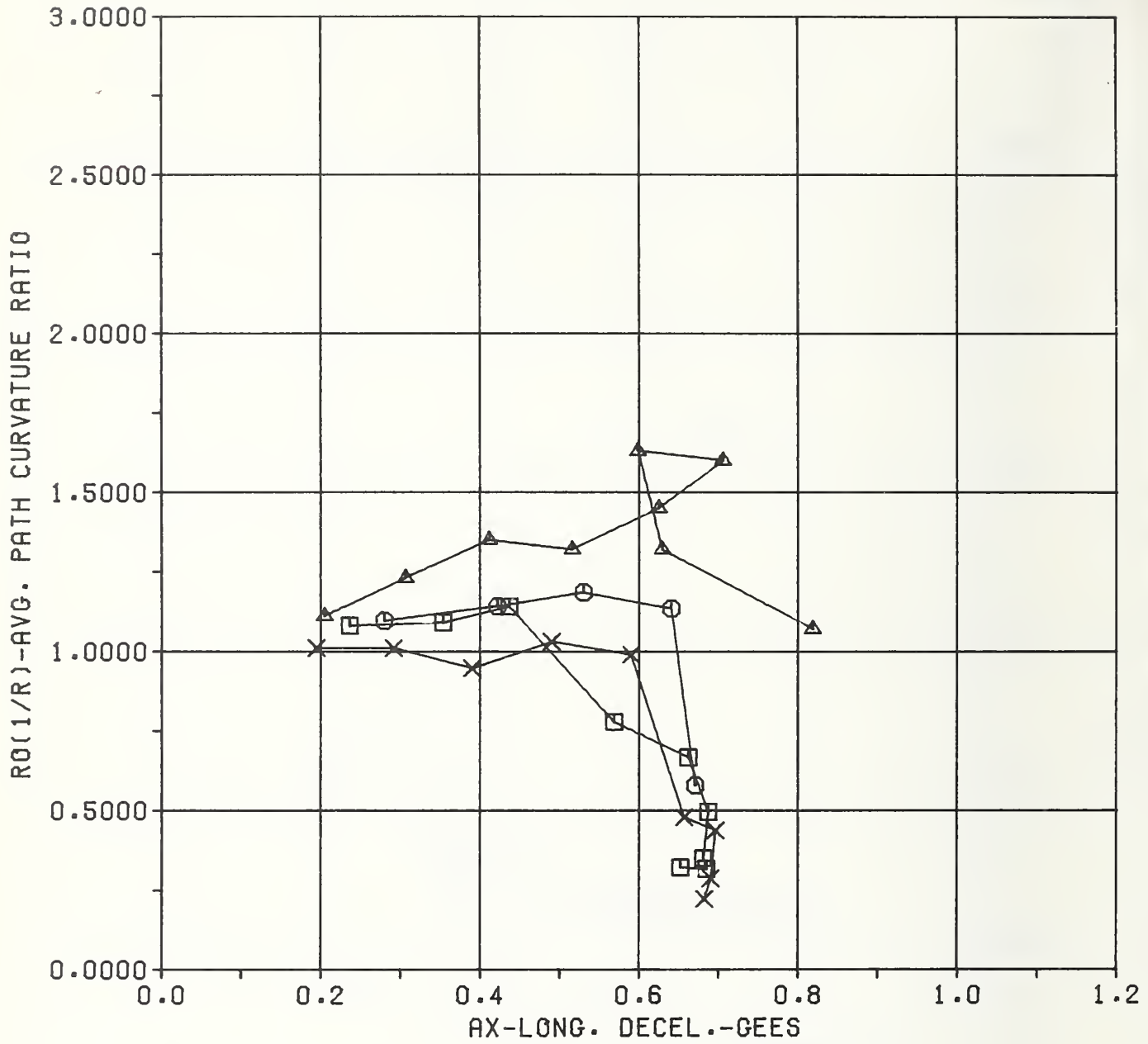
Fig. D-2 VHTP 2, Braking in a Turn: Average Longitudinal Deceleration from 35 to 10 mph versus Brake Line Pressure (Calspan, O.E. tires)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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Fig. D-3 VHTP 2, Braking in a Turn: Sideslip Rate versus Average Longitudinal Deceleration from 35 to 10 mph (Calspan, O. E. tires).



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- × - VW SUPERBEETLE

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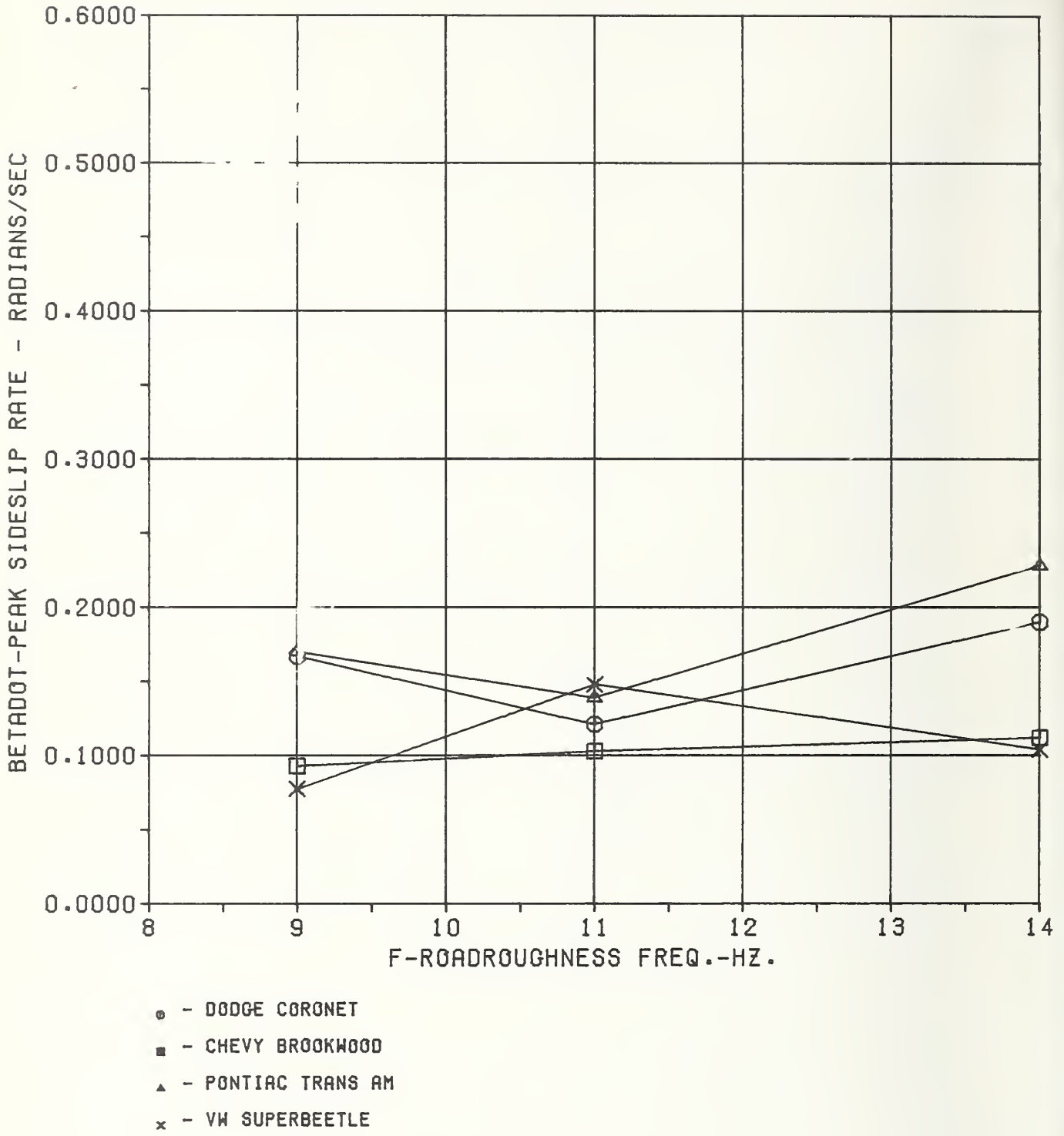
Fig. D-4 VHTP 2, Braking in a Turn: Average Path Curvature Ratio versus Average Longitudinal Deceleration from 35 to 10 mph (Calspan, O. E. tires)

3. VHTP No. 3: Turning on a Rough Road

$f$  — Roadroughness fundamental frequency, determined by spacing of the disturbance elements in each grid (Hz)

BETADOT — Peak vehicle sideslip angle rate (rad/s)

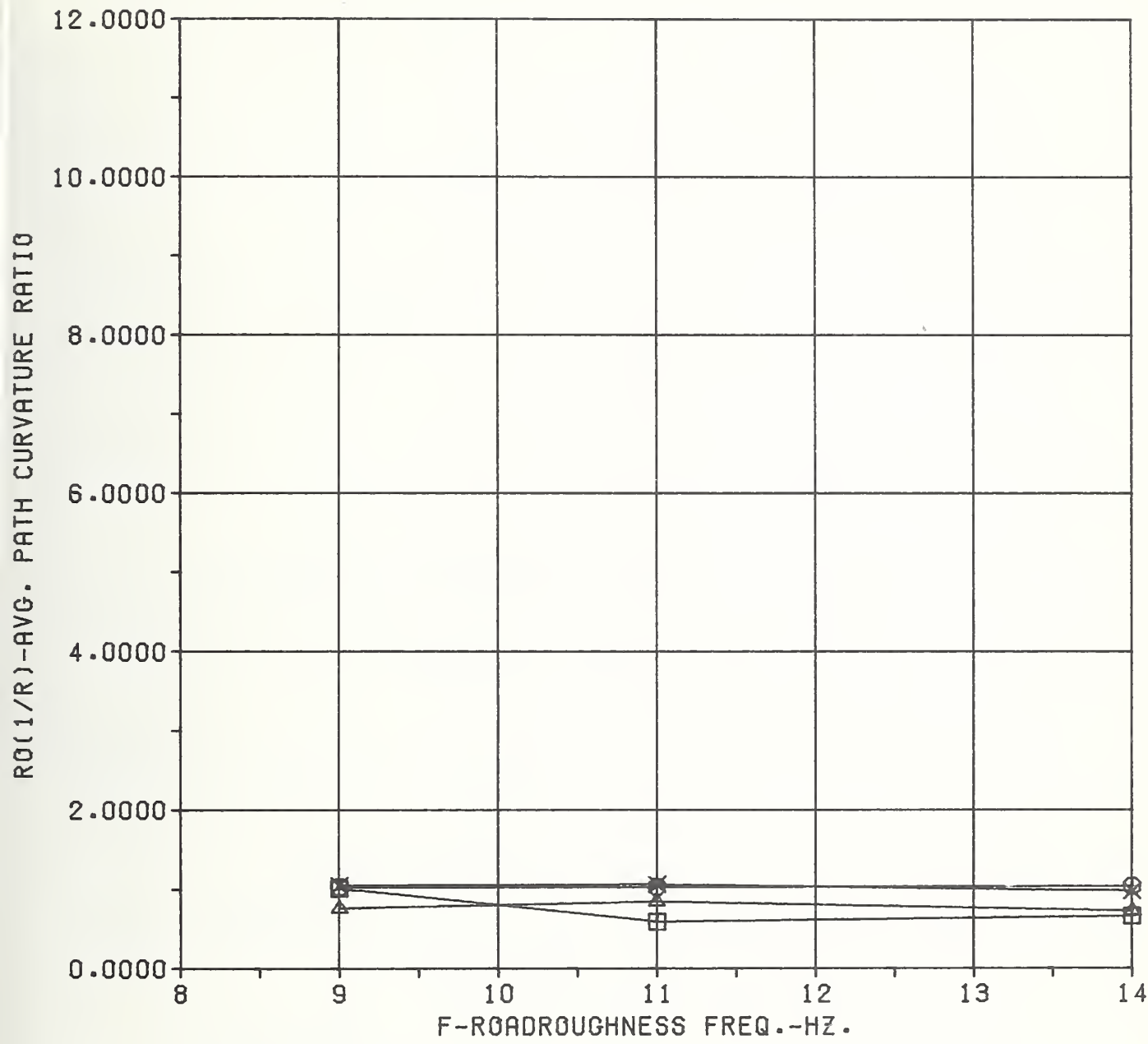
$R_0(1/R)$  — Average path curvature ratio relative to the initial turn



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Fig. D-5 VHTP 3, Turning on a Rough Road: Sideslip Rate versus Road Roughness Frequency (Calspan, O.E. tires).





- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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Fig. D-6 VHTP 3, Turning on a Rough Road: Average Path Curvature Ratio versus Road Roughness Frequency (Calspan, O.E. tires)

4. VHTP No. 4: Trapezoidal Steer

$A_y$  — Peak lateral acceleration (g)

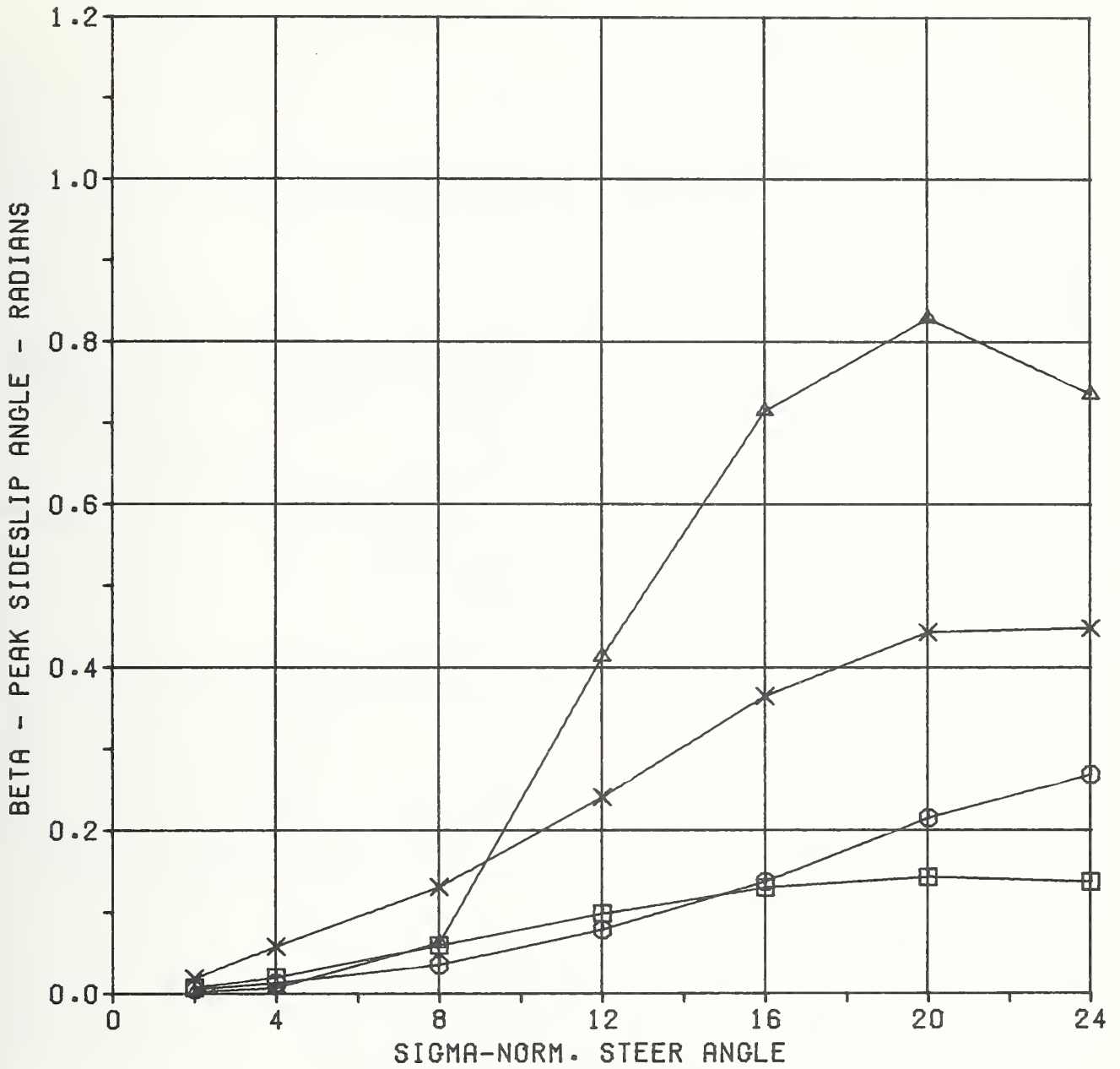
SIGMA — Normalized steer angle (deg)

R — Peak yaw rate (rad/s)

$R_s (1/R)$  — Path curvature response averaged over 2 s and ratioed to  
a reference path curvature deriving from a steady turn  
of 40 mph and  $1.0g A_y$

BETADOT — Peak vehicle sideslip angle rate (rad/s)

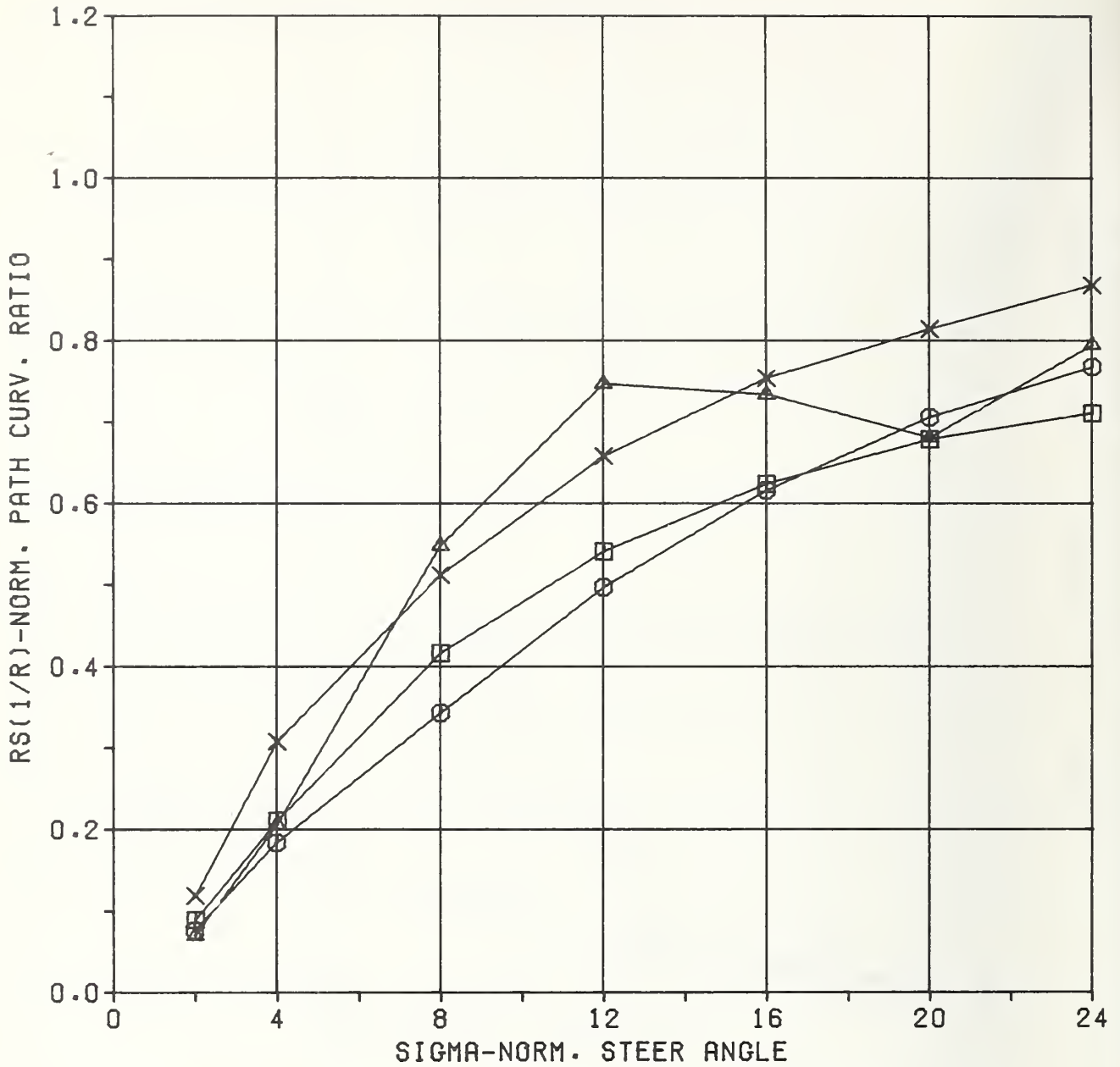
BETA — Peak vehicle sideslip angle (rad)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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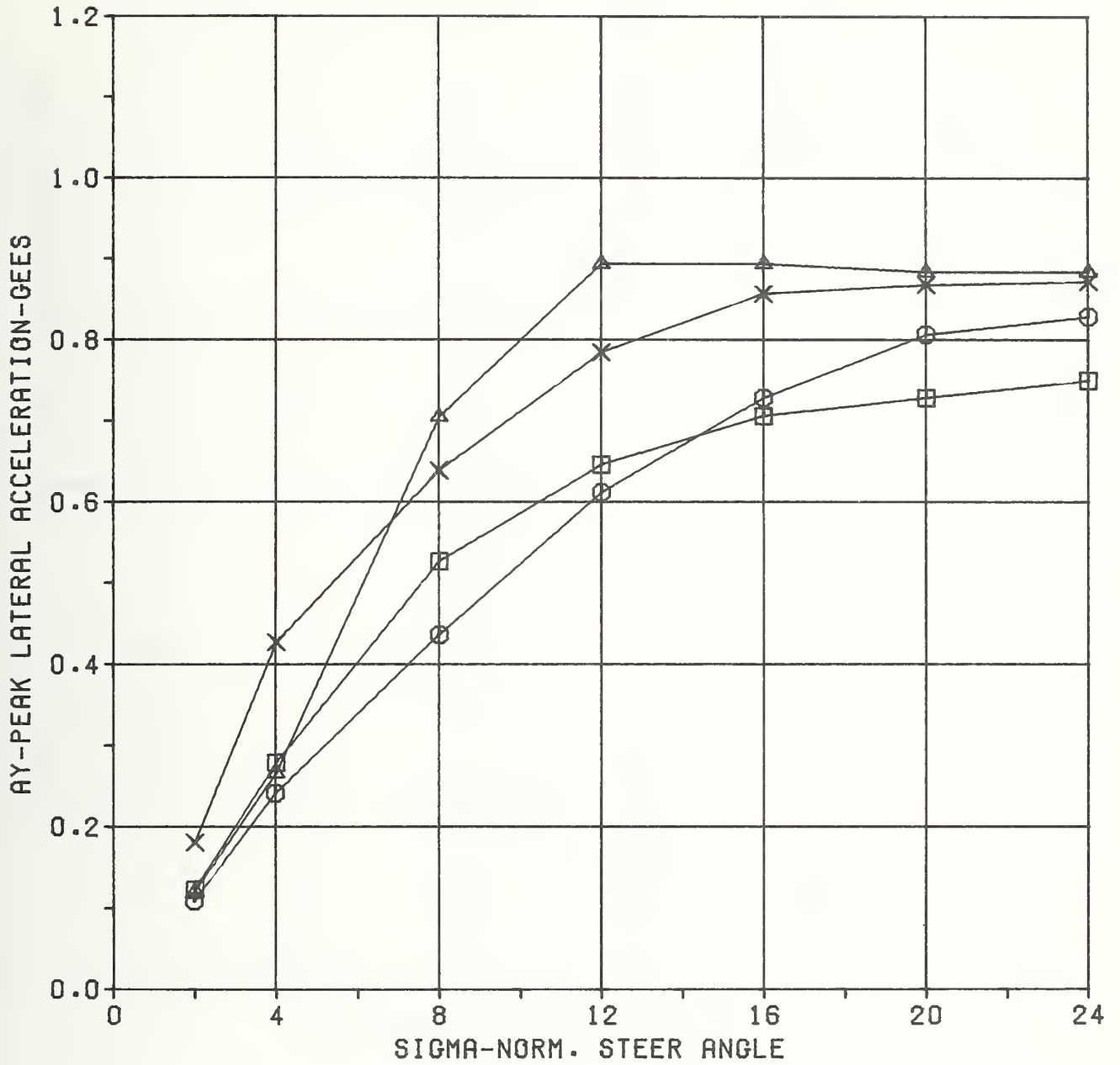
Fig. D-7 VHTP 4, Trapezoidal Steer: Sideslip Angle versus Normalized Steer Angle (Calspan, O.E. tires)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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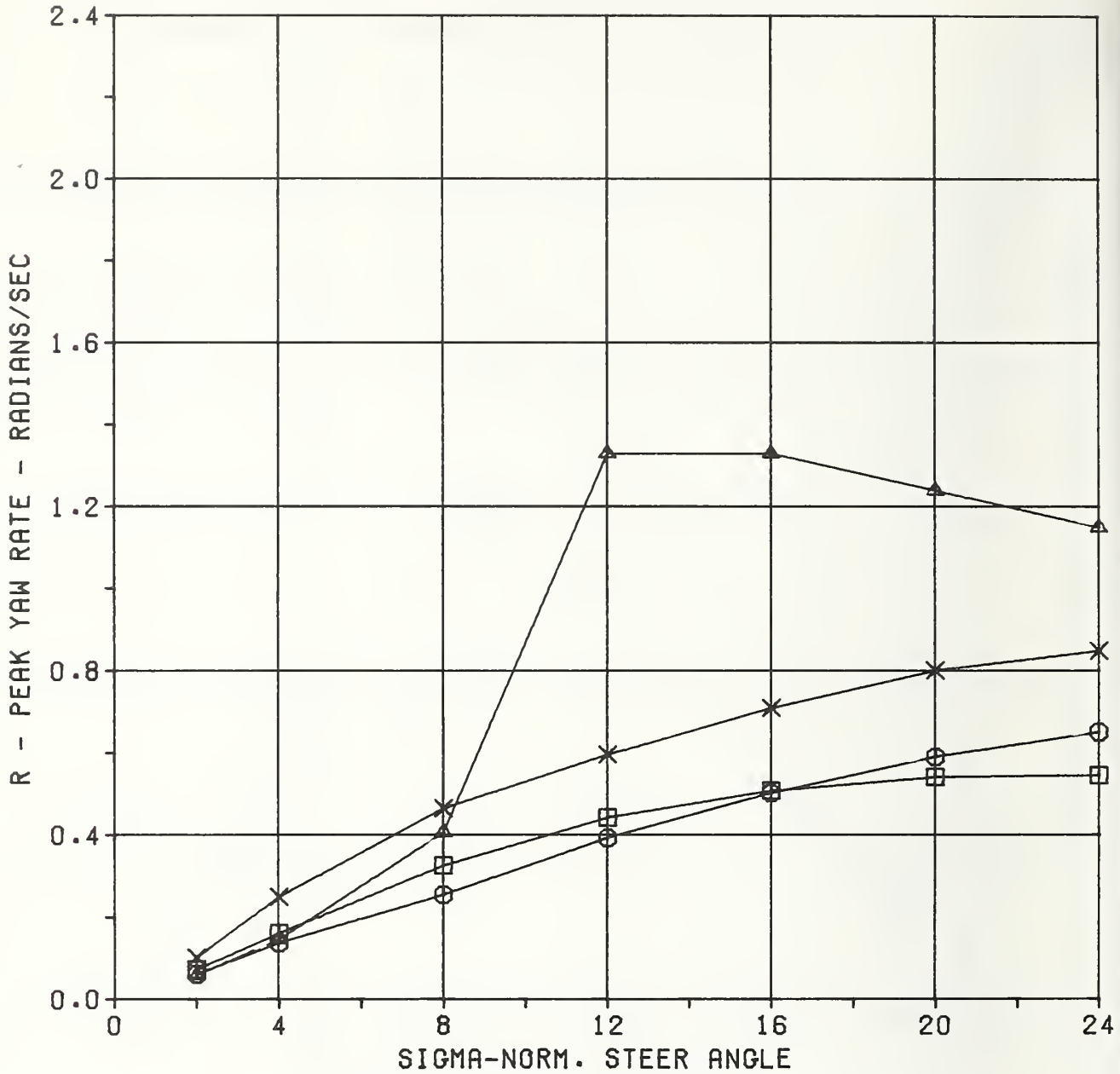
Fig. D-8 VHTP 4, Trapezoidal Steer: Normalized Curvature Ratio versus Normalized Steer Angle (Calspan, O.E. tires)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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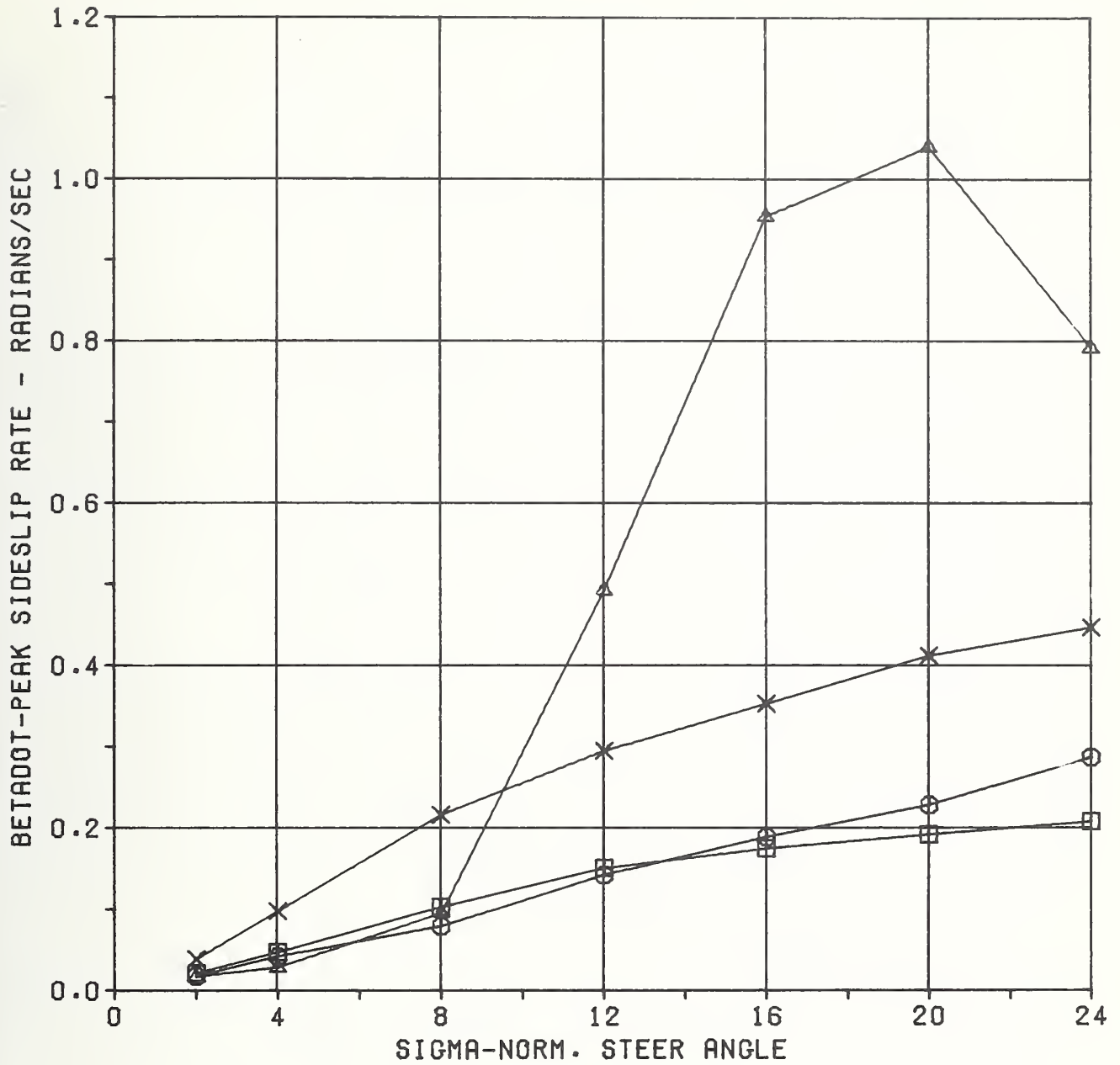
Fig. D-9 VHTP 4, Trapezoidal Steer: Lateral Acceleration versus Normalized Steer Angle (Calspan, O.E. tires)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- × - VW SUPERBEETLE

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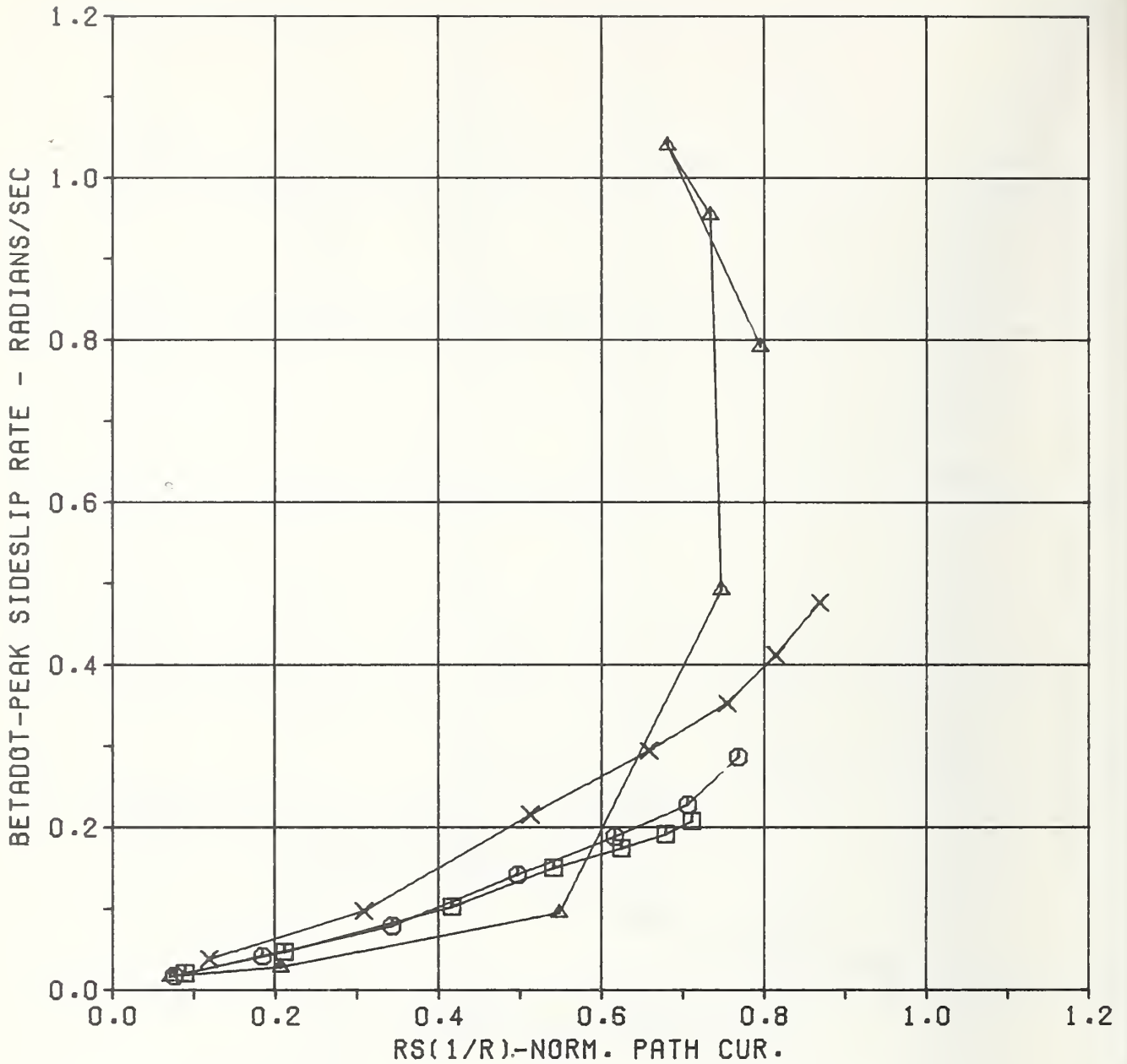
Fig. D-10 VHTP 4, Trapezoidal Steer: Yaw Rate versus Normalized Steer Angle (Calspan, O.E. tires)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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Fig. D-11 VHTP 4, Trapezoidal Steer: Sideslip Rate versus Normalized Steer Angle (Calspan, O.E. tires)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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Fig. D-12 VHTP 4, Trapezoidal Steer: Sideslip Rate versus Normalized Path Curvature Ratio (Calspan, O.E. tires)



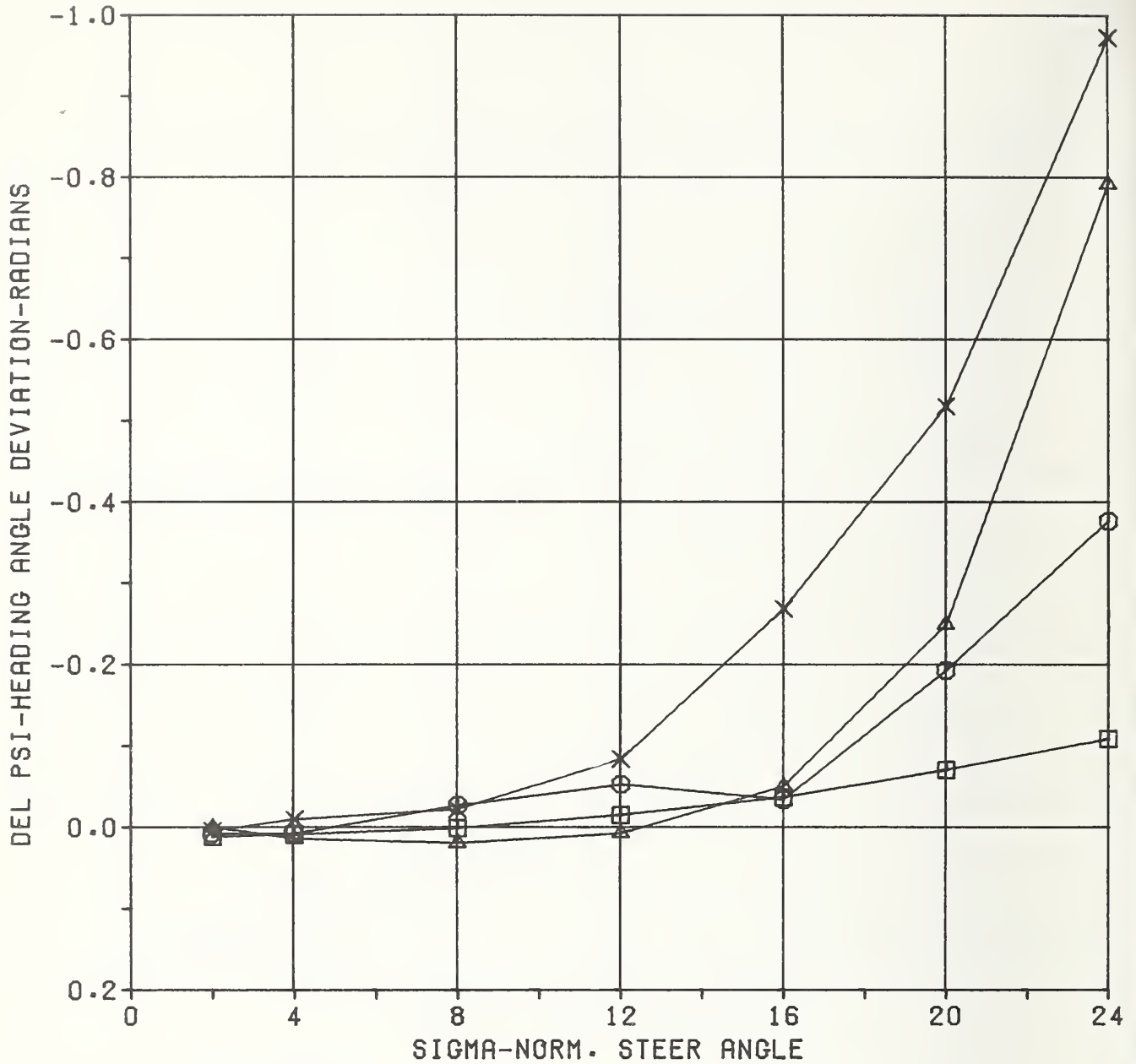
5. VHPT No. 5: Sinusoidal Steer

DEL PSI — Vehicle heading angle deviation after 3.4 s (rad)

SIGMA — Normalized steer angle (deg)

DEL — Lane change deviation from "IDEAL" lane change displacement (ft)

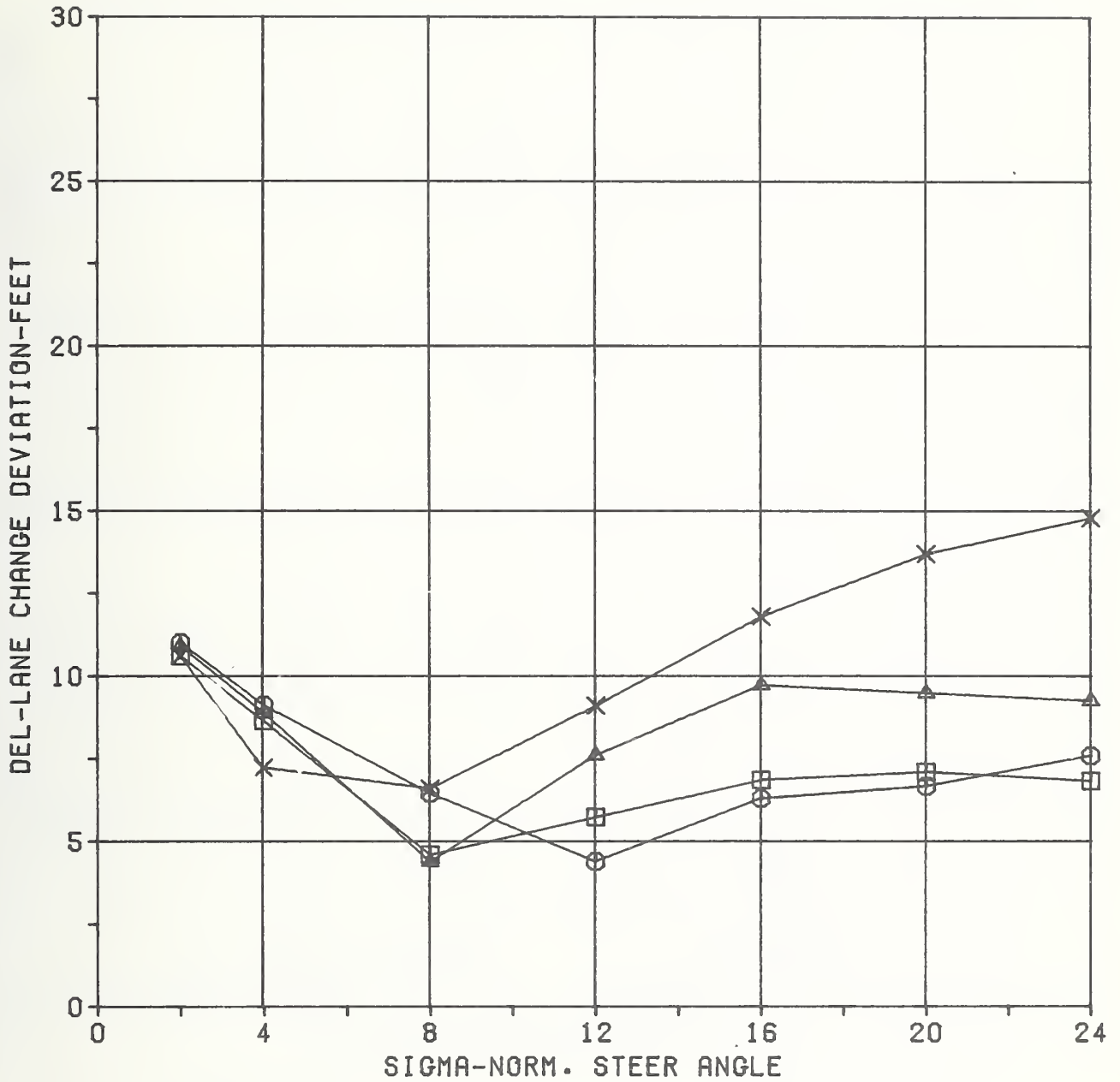
BETA — Peak vehicle sideslip angle (rad)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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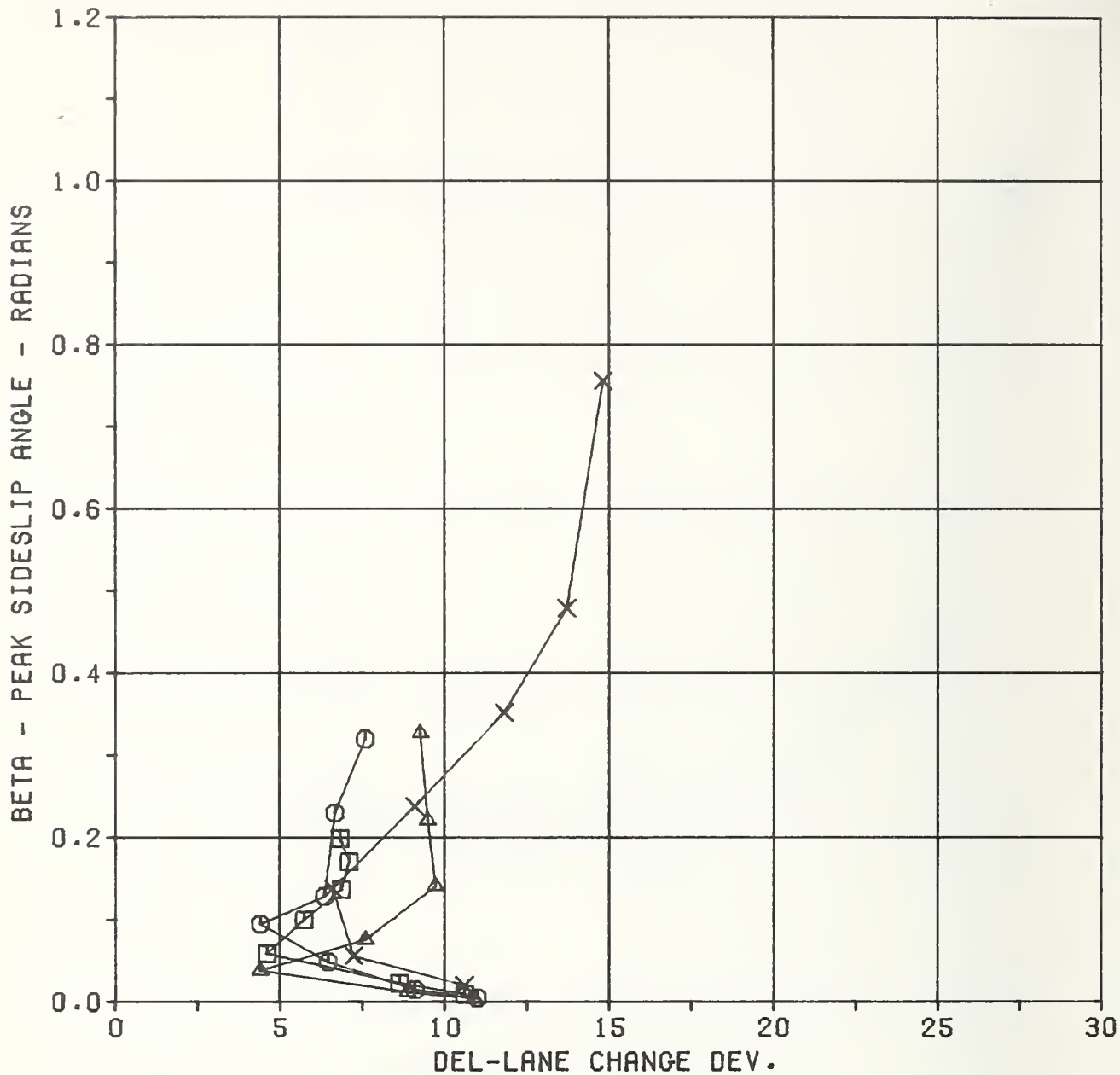
Fig. D-13 VHTP 5, Sinusoidal Steer, 45 mph: Heading Angle Deviation versus Normalized Steer Angle (Calspan, O.E. tires)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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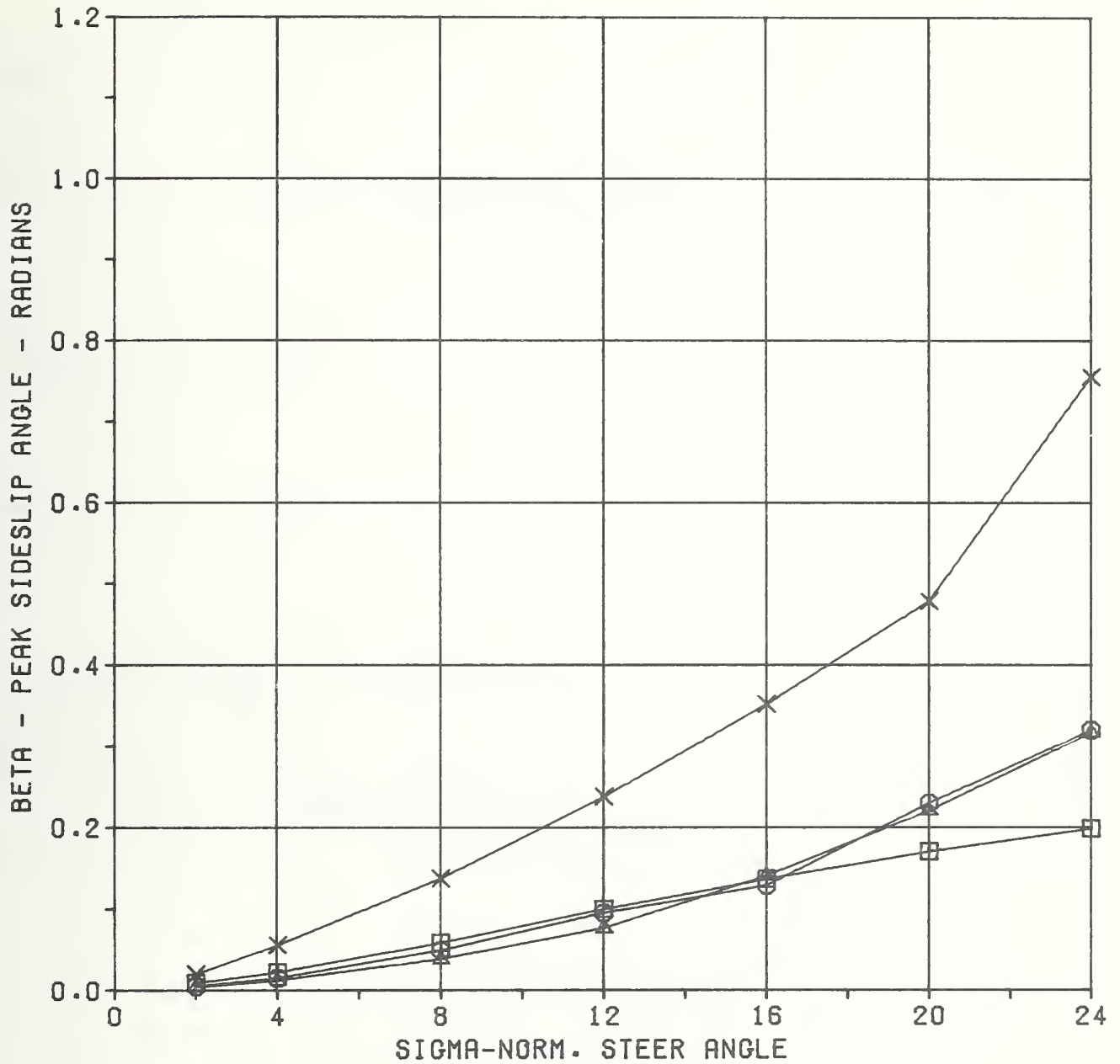
Fig. D-14 VHTP 5, Sinusoidal Steer, 45 mph: Lane Change Deviation versus Normalized Steer Angle (Calspan O.E. tires)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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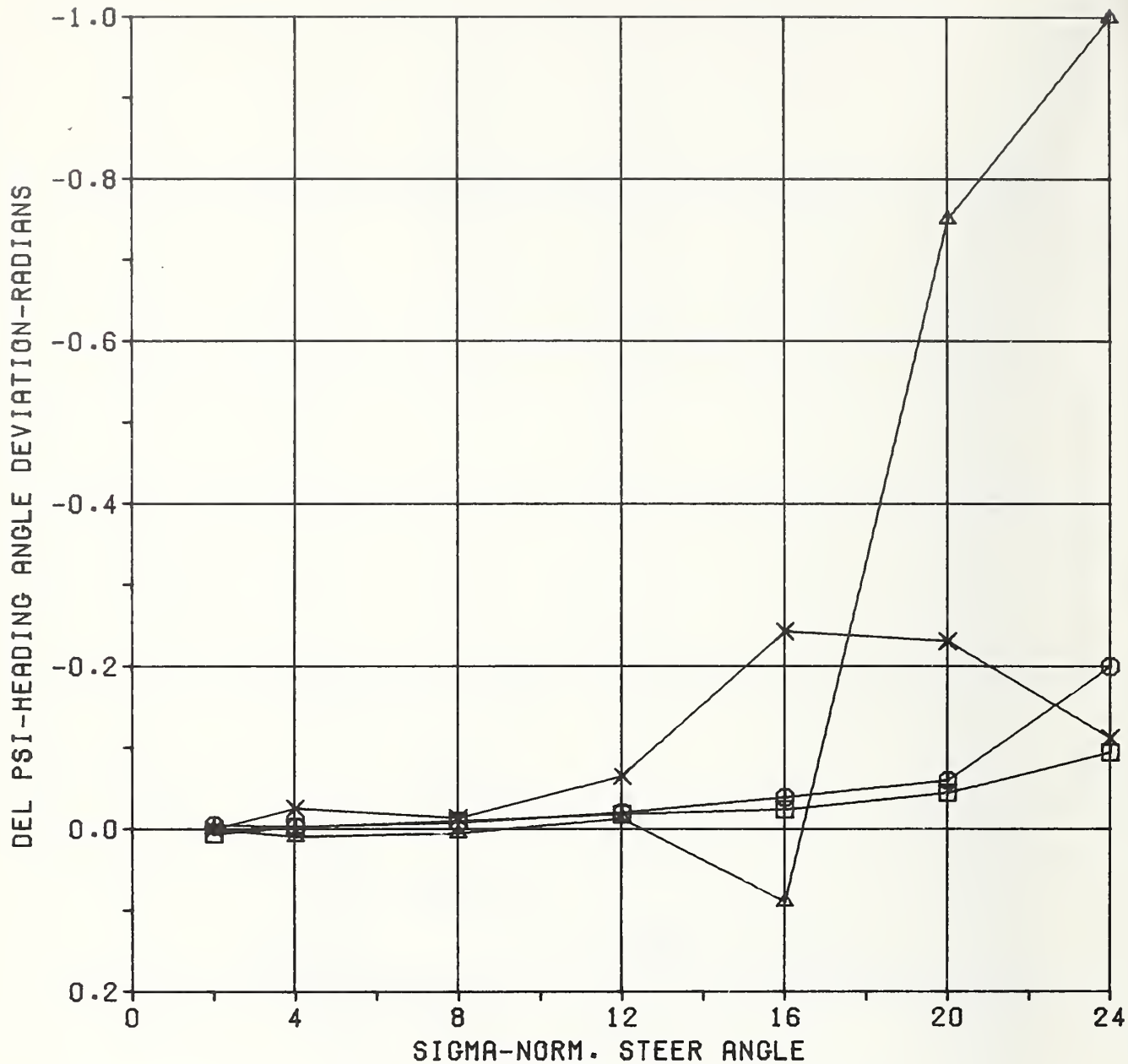
Fig. D-15 VHTP 5, Sinusoidal Steer, 45 mph: Sideslip Angle versus Lane Change Deviation (Calspan, O.E. tires)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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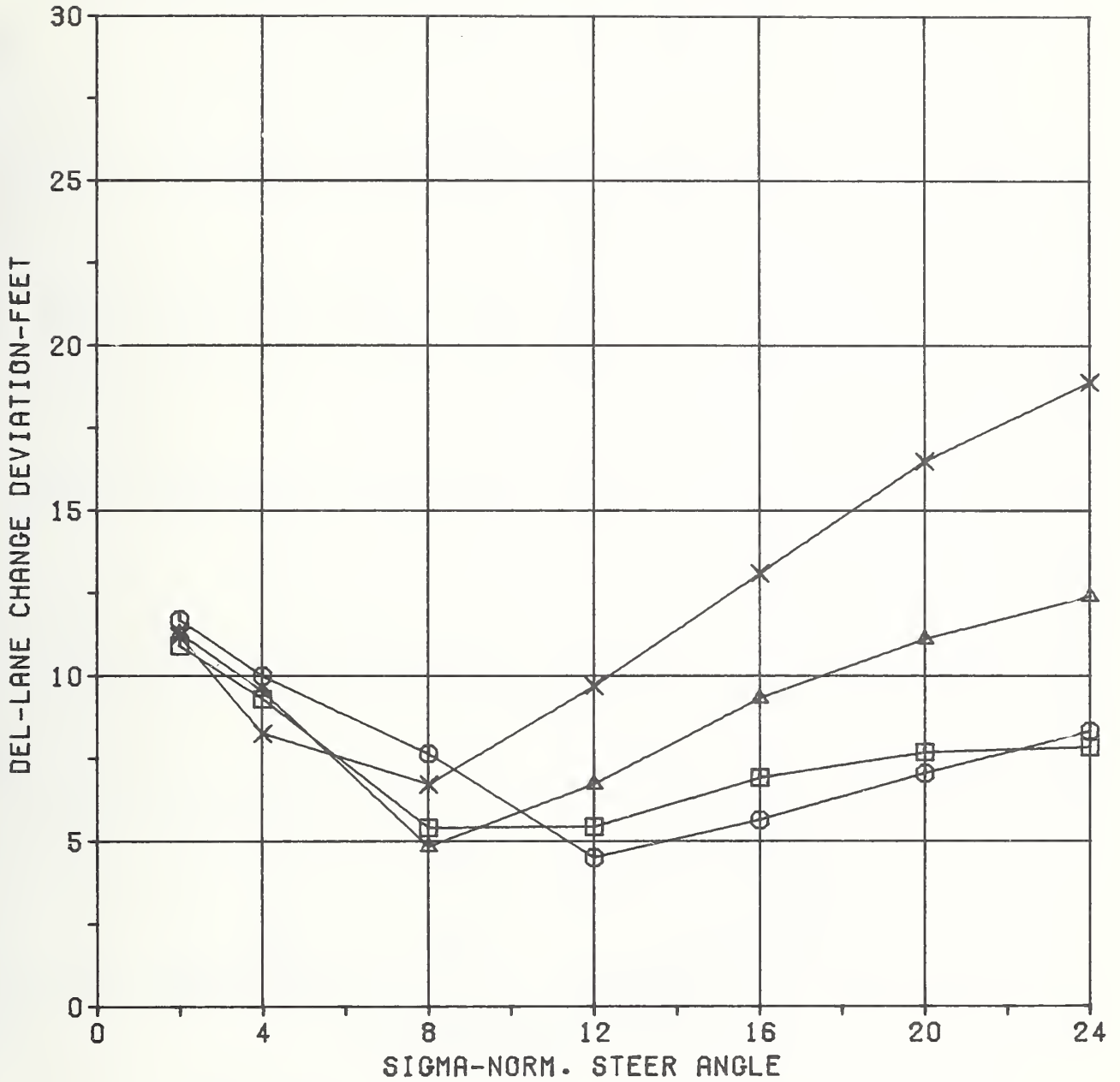
Fig. D-16 VHTP 5, Sinusoidal Steer, 45 mph: Sideslip Angle versus Normalized Steer Angle (Calspan, O.E. tires)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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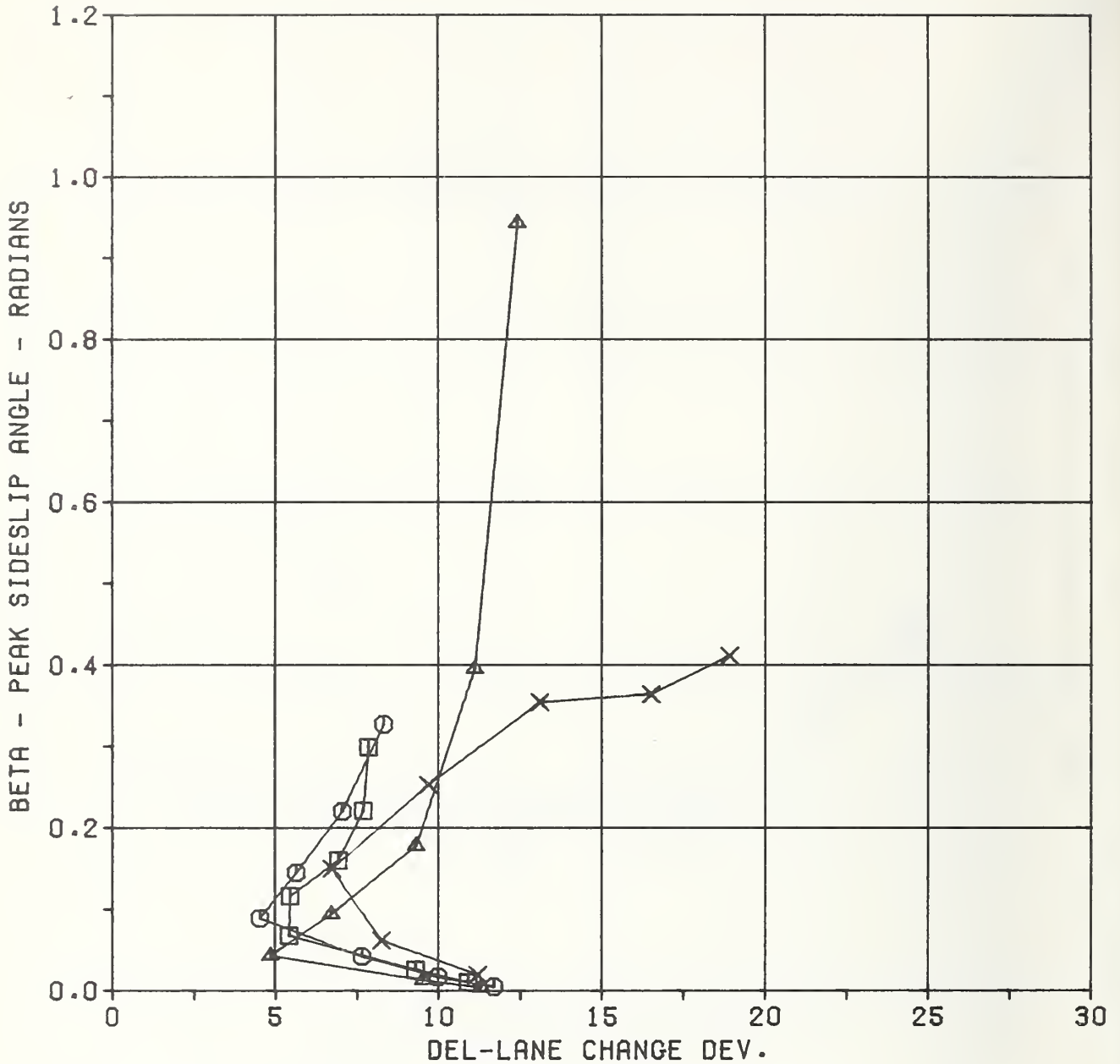
Fig. D-17 VHTP 5, Sinusoidal Steer, 60 mph: Heading Angle Deviation versus Normalized Steer Angle (Calspan, O.E. tires)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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Fig. D-18 VHTP 5, Sinusoidal Steer, 60 mph: Lane Change Deviation versus Normalized Steer Angle (Calspan, O.E. tires)

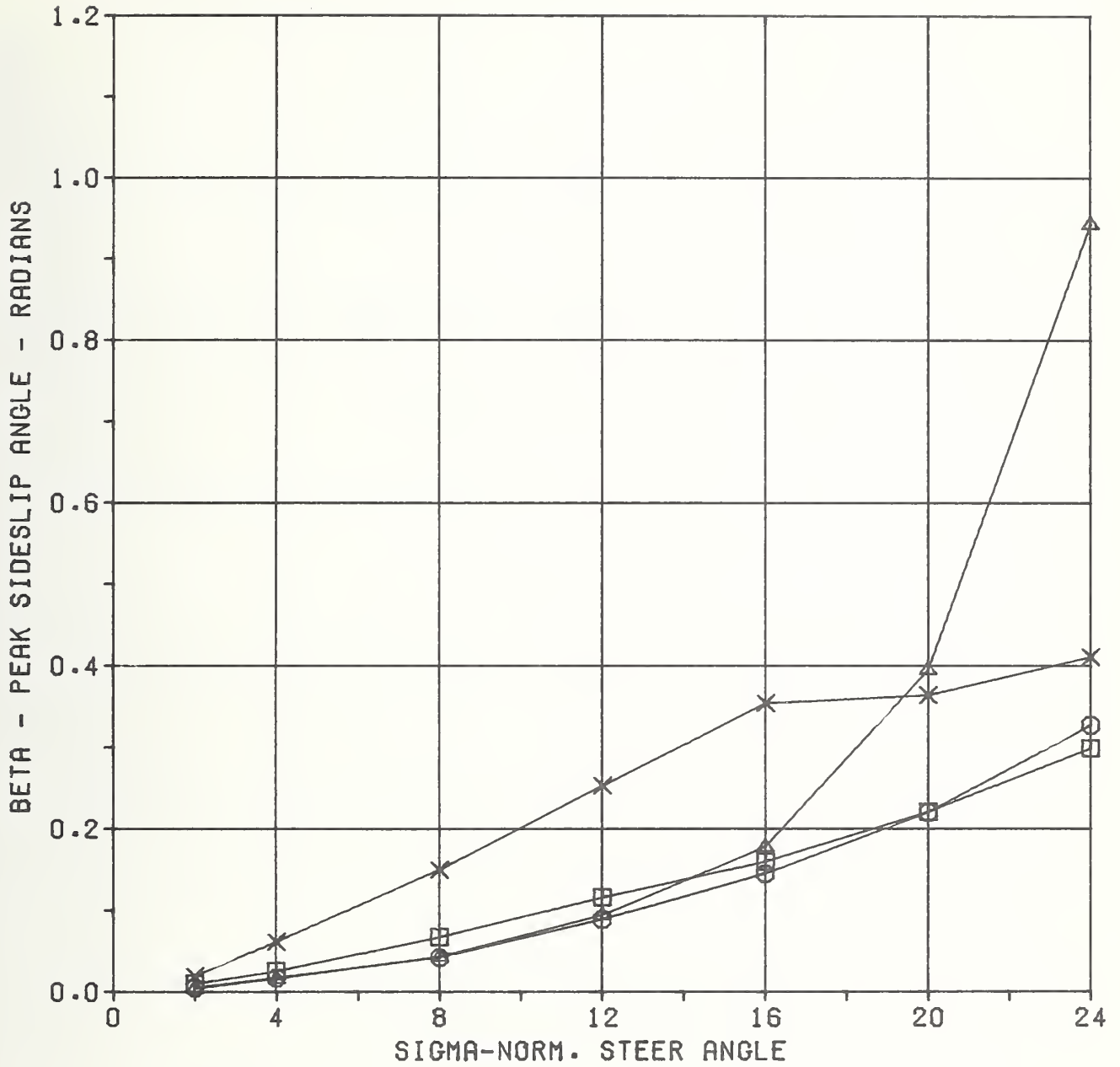


- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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Fig. D-19 VHTP 5, Sinusoidal Steer, 60 mph: Sideslip Angle versus Lane Change Deviation (Calspan, O.E. tires)





- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

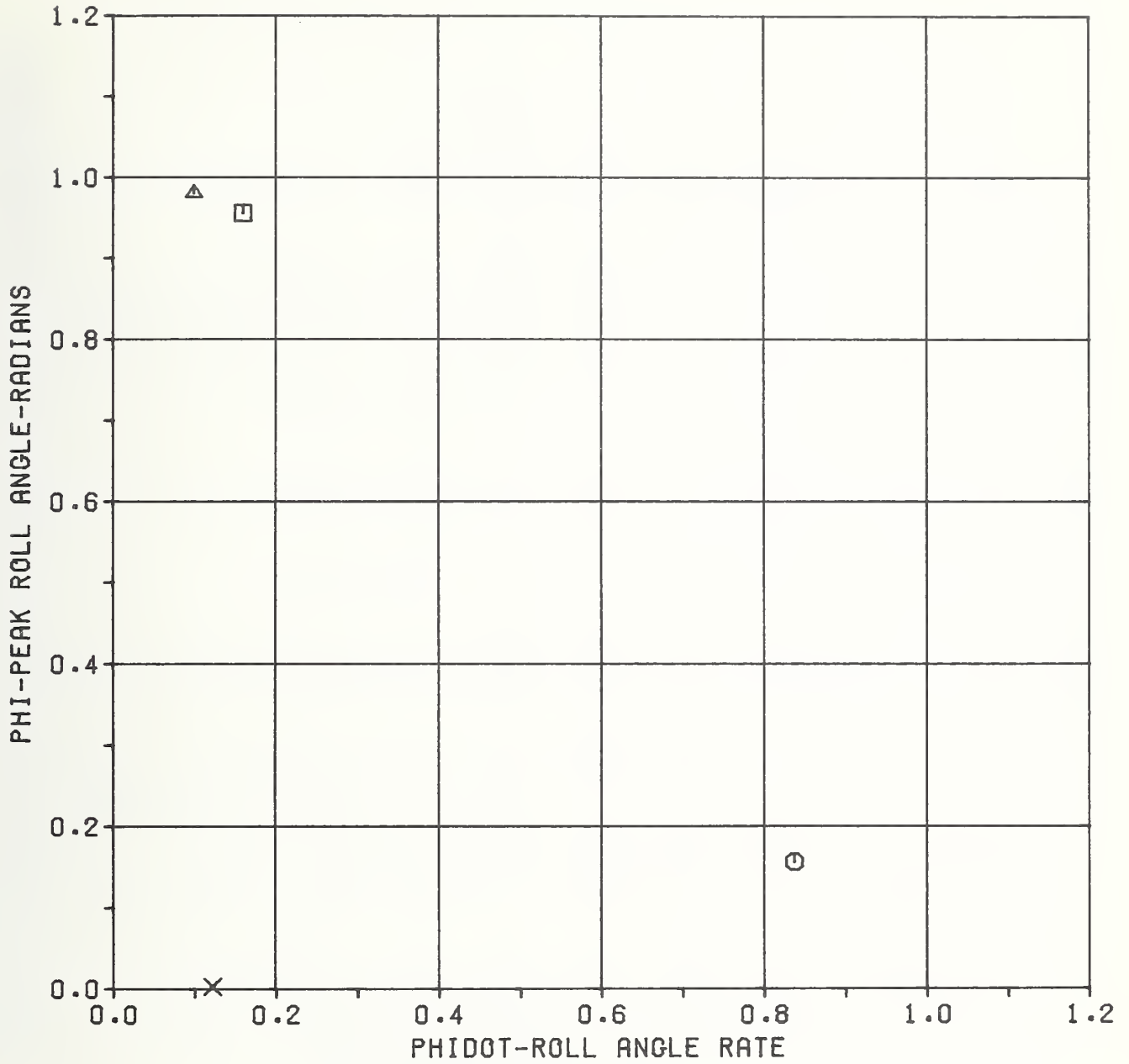
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Fig. D-20 VHTP 5, Sinusoidal Steer, 60 mph: Sideslip Angle versus Normalized Steer Angle (Calspan, O.E. tires)

6. VHTP No. 6: Drastic Steer and Brake

PHI - Peak roll angle (rad)

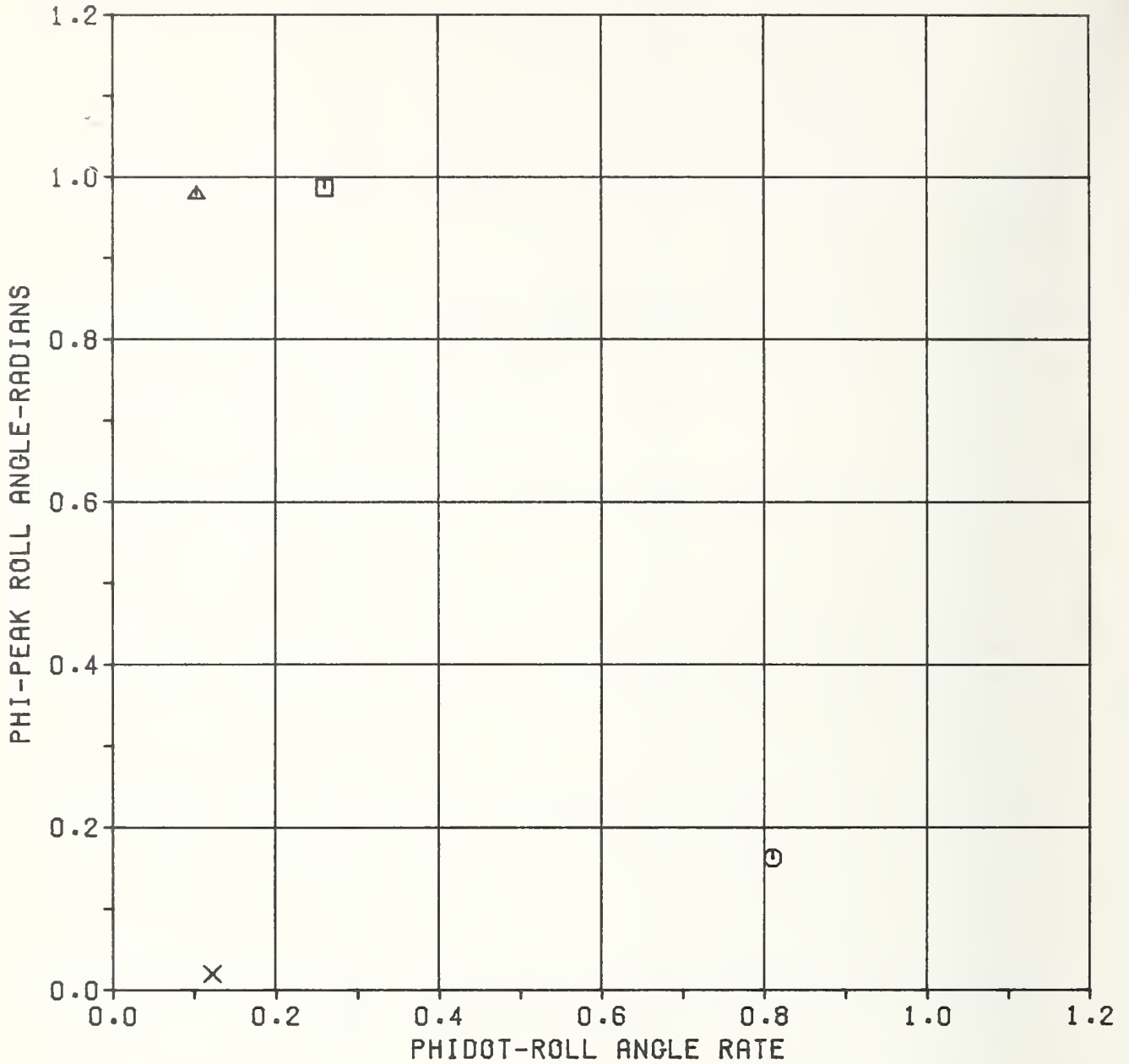
PHIDOT - Peak roll angle rate (rad/s)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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Fig. D-21 VHTP 6, Drastic Steer and Brake, 50 mph: Roll Angle versus Roll Angle Rate (Calspan, O.E. tires)



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

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Fig. D-22 VHIP 6, Drastic Steer and Brake, 60 mph: Roll Angle versus Roll Angle Rate (Calspan, O.E. tires)

## Appendix E

### SIMULATION OUTPUT

In addition to the user/computer transactions printed on the hybrid computer operator's printer, the simulation has several outputs that are normally available to the user. The output is summarized below:

1. Vehicle Handling Test Procedure (VHTP) comparison variable values,
2. Analog strip chart time history recordings (16 variables),
3. Digital printout of variables versus time (up to 50 variables),
4. Comparison variable graphs, and
5. X-Y printer plot of any two program variables.

The appropriate VHTP comparison variable values are printed following the execution of a VHTP maneuver. Typical examples are presented in Fig. E-1.

Sixteen channels of strip chart time history recordings are available. Time histories for the braking in a turn test procedure are presented in Fig. E-2. The variables are defined below:

Figure E-2, p. 1:

1. Longitudinal deceleration,  $A_x$  (g),
2. Lateral acceleration,  $A_y$  (g),
3. Vehicle yaw rate,  $r$  (rad/s),
4. Steering wheel input,  $\delta_{sw}$  (rad),
5. Vehicle forward velocity,  $u$  (ft/s),
6. Vehicle side velocity,  $v$  (ft/s),
7. Vehicle sideslip angle,  $\beta$  (rad), and
8. Turning radius of curvature,  $1/R$  ( $\text{ft}^{-1}$ ).

```

*****      THIS IS THE FIRST OF TWO SPECIAL CARDS FOR THE 2741 ACM      *****
      VEHICLE HANDLING SIMULATION
ENGAGE PATCH PANEL FOR TEST
TYPE CR WHEN READY
****
MAY      21 1974
TIME 14. 0:11.76
OPTION
**** F
ENTER
**** VHTFND 4
****
OPTION
**** IC
OPTION
**** F
ENTER
**** STR4
      27.90
**** STR4 300.
****
OPTION
**** X
MAY      21 1974
TIME 14. 2: 7.10
RUN 1 HAS STARTED
OUTPUT BELOW
AXAV= 0.0 DECL TIME= 0.000 AVCUR= 0.981 BTDMAX= 0.210 BTMAX= 0.126 DELBT= 0.126
AYMAX= 0.945 PHIMAX= 4.101 RMAX= 0.708 LANE CHNG DEL= 0.0 DELPSI= 0.0 MAX STEER= 300.000
RTROMAX= 0.0 RTROMAX= 0.0

OPTION
**** F
ENTER
**** VHTFND
      4.000
****
OPTION
**** MULTI
NUM OF LOOPS/VARS
**** 4 1
VAR
**** STR4
LOOP,VAL,INC
**** 1 27.9 27.9
****
OPTION
**** XM
MAY      21 1974
TIME 14. 4:16.24
RUN 2 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR4..( 1) BETAMX( 1) BETDMXI 1) CUVRAT( 1) AYMAX.( 1) RMAX..( 1)
 1      2      27.9      0.315E-02      0.208E-01      0.928E-01      0.134      0.694E-01
 2      3      55.8      0.105E-01      0.341E-01      0.260      0.342      0.186
 3      4      83.7      0.219E-01      0.646E-01      0.428      0.539      0.304
 4      5      112.      0.375E-01      0.909E-01      0.573      0.691      0.409
OPTION

```

Fig. E-1 IHVHP User's Interactive Control

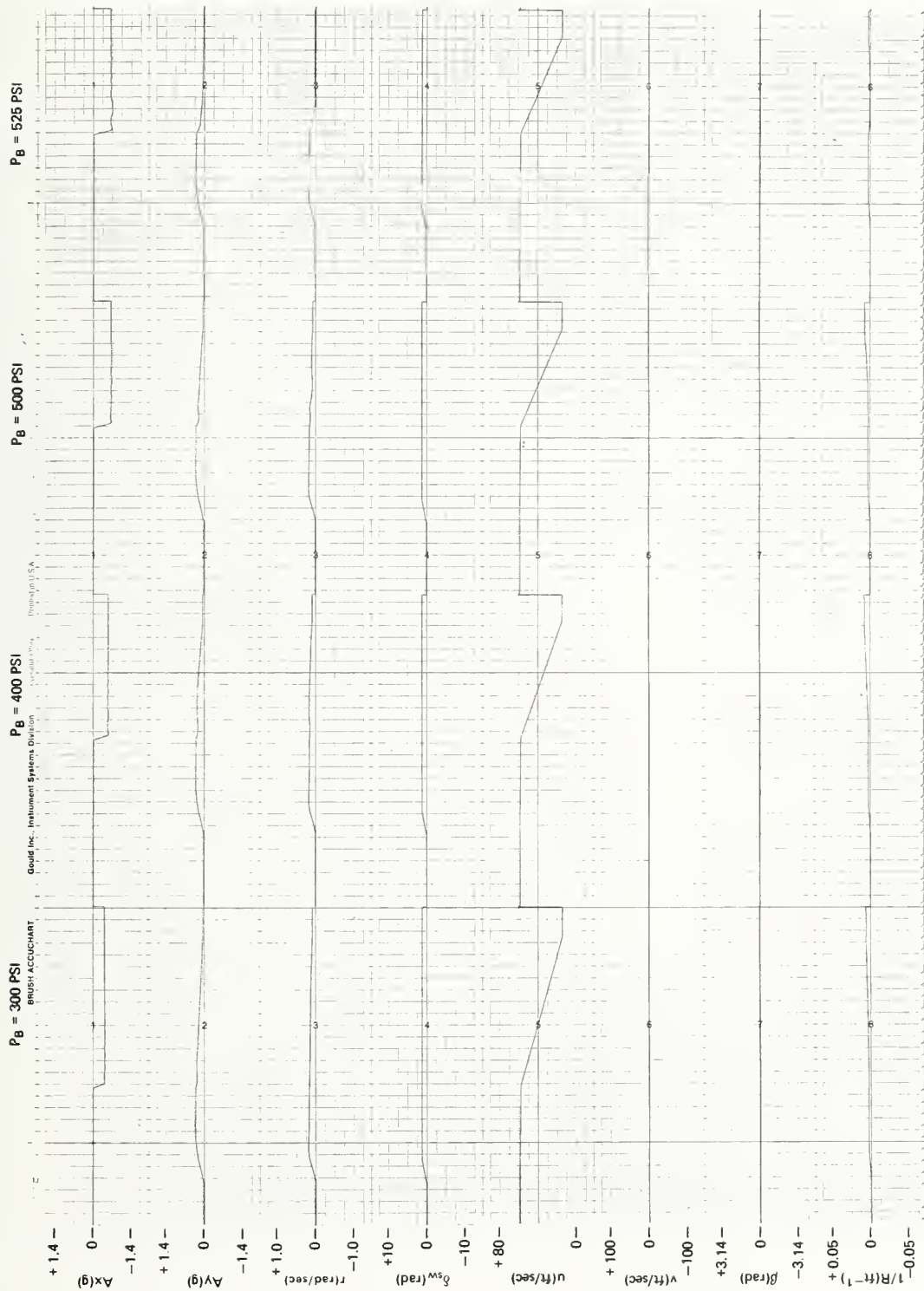


Fig. E-2 Time Histories — Braking in a Turn (p. 1)

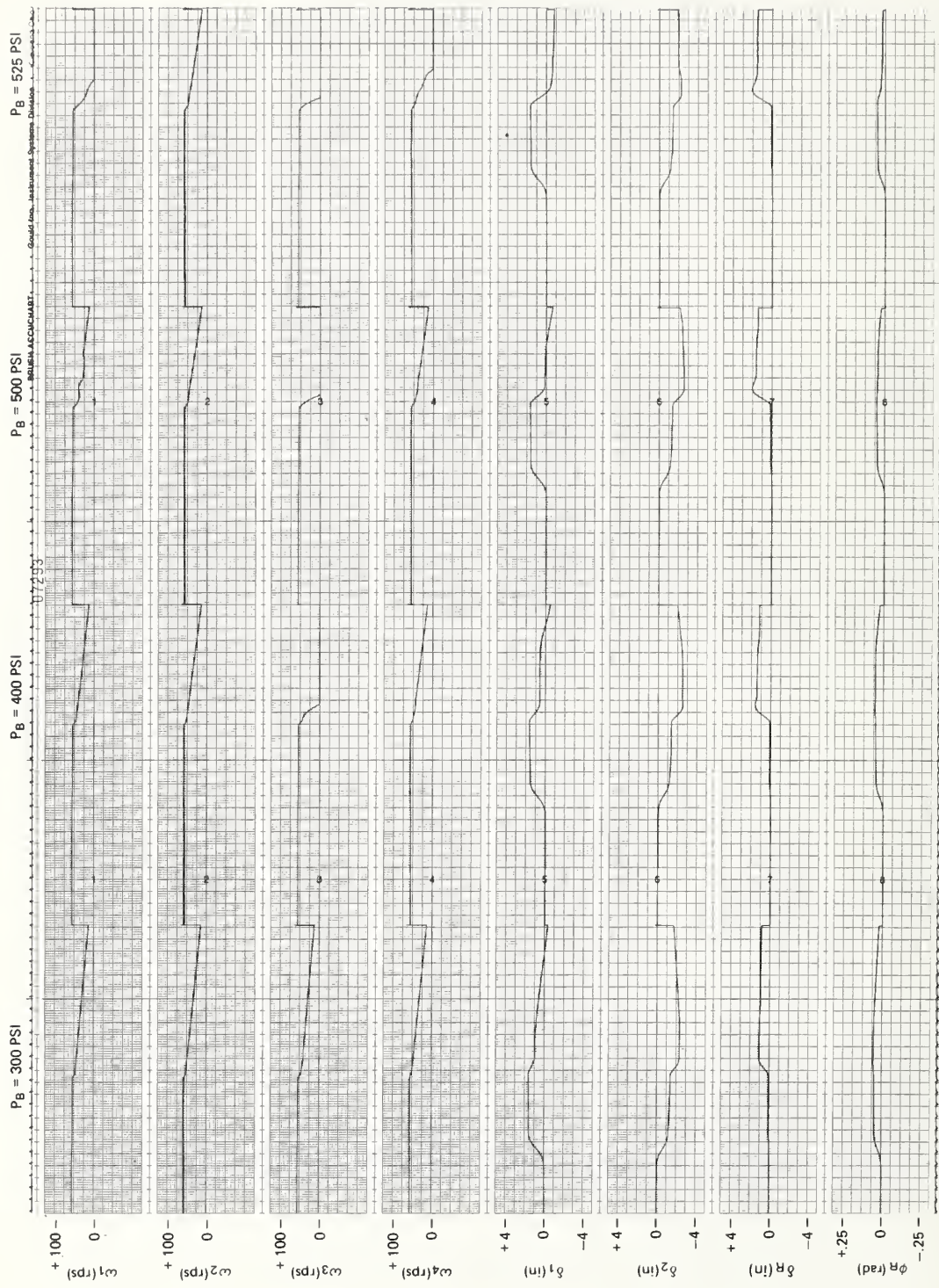


Fig. E-2 Time Histories — Braking in a Turn (p. 2)



Figure E-2, p. 2:

- 1-4 Angular velocities of the right front, left front, right rear, and left rear wheels,  $\omega_1$ ,  $\omega_2$ ,  $\omega_3$ ,  $\omega_4$ , respectively, (rad/s),
- 5-7 Deflection from the equilibrium position of the right front wheel, left front wheel, and rear axle,  $\delta_1$ ,  $\delta_2$ ,  $\delta_R$ , respectively (in.), and
- 8 Angular rotation of the rear axle with reference to the sprung mass,  $\phi_r$  (rad).

The digital printout of variables versus time is the typical output associated with digital simulation. The variables to be output can be specified in the program data deck or selected interactively during program execution. The time interval for output is also interactively selected. The interactive selection capability is particularly useful for simulation validation or studying unexpected dynamic phenomena. Any variable within the simulation can be selected for output. An output example is presented in Fig. E-3.

```

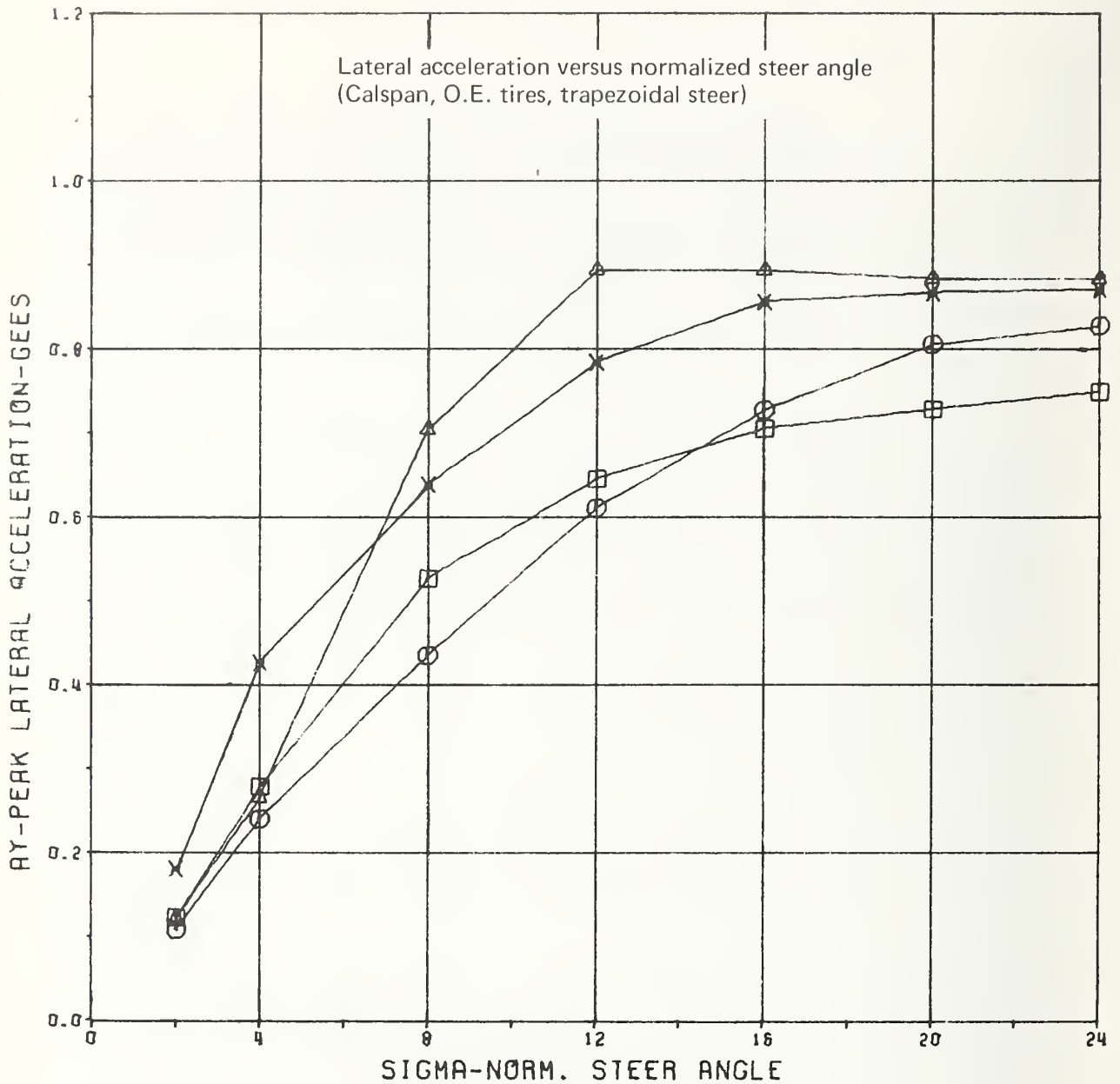
OPTION
**** TRACK
UNIT,MODE
**** T A
ENTER TIME ON/OFF/STEP
**** .5 1.1 .1
TYPE RETAIN OR ENTER NEW ARRAY
**** PSIDT PHIDT PHI ZIMX(1) ZIMX(3)
****

TIME  PSIDT.( 1)  PHIDT.( 1)  PHI..( 1)  ZIMX..( 1)  ZIMX..( 3)
0.50  0.43077    0.77597E-02  -0.11728    0.29986E-01  0.10125
0.60  0.35703    0.29683     -0.10414    0.29986E-01  0.10125
0.70  0.28586    0.49151     -0.59047E-01  0.29986E-01  0.10125
0.80  0.28740    0.32454     -0.16426E-01  0.29986E-01  0.10125
0.90  0.30123    0.14344E-02  -0.12279E-03  0.29986E-01  0.10125
1.00  0.28316     -0.14820     -0.90558E-02  0.29986E-01  0.10125
1.10  0.29048     -0.38197     -0.30314E-01  0.29986E-01  0.10125
OPTION

```

Fig. E-3 Digital Line Printer Output

To aid in quick analysis of vehicle performance, computer-generated comparison variable plots are made available. An example plot for a trapezoidal steer test procedure is presented in Fig. E-4.



- - DODGE CORONET
- - CHEVY BROOKWOOD
- ▲ - PONTIAC TRANS AM
- x - VW SUPERBEETLE

Fig. E-4 Performance Comparison Variable Plot

A cross-plot of any two interactive variables that are included in the TRACK option is available to the simulation user. An example of the PLOT option and of the required input data is shown below. Figure E-5 is a vehicle trajectory plot.

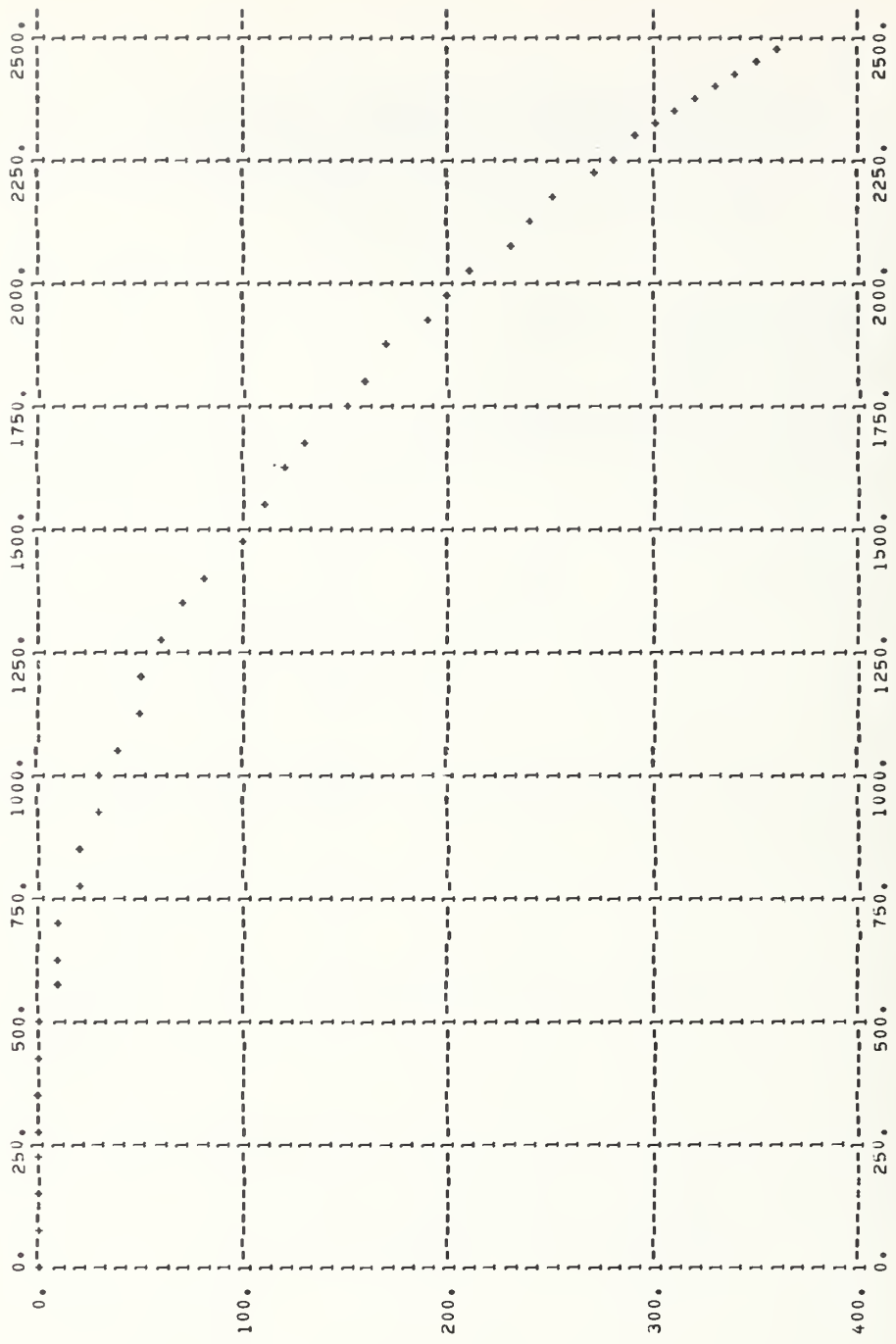
```
OPTION
***** PLOT
UNIT,MODE
***** L XEQ
ENTER NUMBER OF PLOTS
***** 1
ENTER DEPENDENT AND INDEPENDENT PLOT VARIABLES
***** Y X
*****
OPTION
```

Y..... VS X.....

\*\*\* A..... \*\*\*

DATE: 1/20/78

Y+E+2	X+E+J
0.042	0.497
0.121	0.708
0.206	0.848
0.320	0.989
0.389	1.059
0.549	1.199
0.640	1.269
0.739	1.338
0.846	1.408
0.959	1.477
1.078	1.545
1.203	1.613
1.331	1.679
1.462	1.743
1.596	1.805
1.730	1.865
1.866	1.922
2.001	1.977
2.135	2.030
2.267	2.079
2.398	2.126
2.527	2.171
2.653	2.213
2.775	2.252
2.893	2.288
3.007	2.322
3.116	2.354
3.219	2.383
3.317	2.410
3.407	2.434
3.490	2.455
3.567	2.474



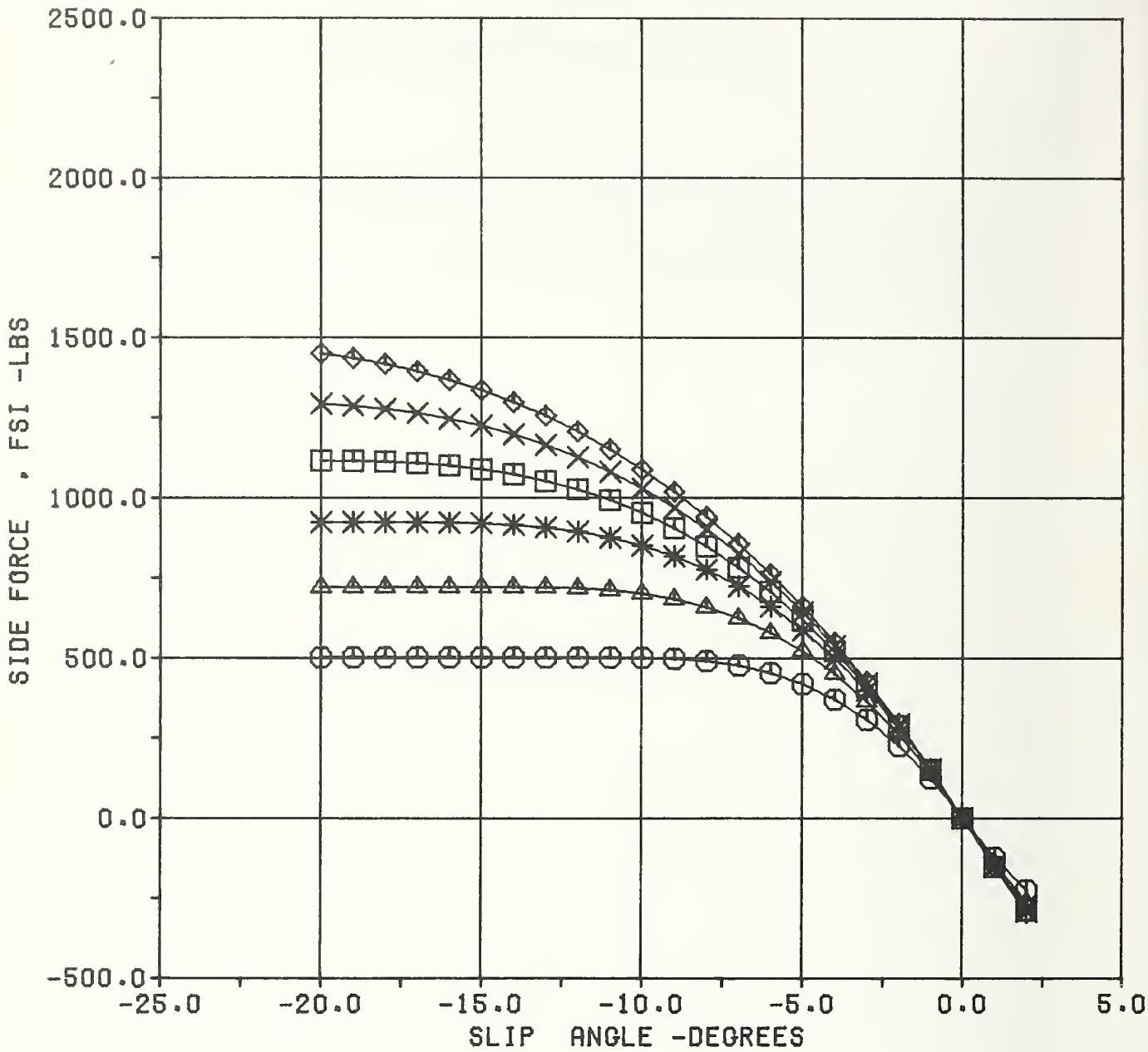
OPPOSITE AXIS LABEL \*\*\* Y..... \*\*\*

Fig. E-5 X-Y Line Printer Plot

## Appendix F

### TIRE FUNCTION GRAPHS

Figures F-1 through F-15 are the graphs used to validate the tire model output for a set of tire parameters. The figures are followed by a copy of the information available from Ref. 19 for a particular tire. The parameters from this data packet were used to generate the figures.



- NORMAL LOAD = 530.000 -LBS      ■ NORMAL LOAD = 1325.000 -LBS
- ▲ NORMAL LOAD = 795.000 -LBS      X NORMAL LOAD = 1590.000 -LBS
- NORMAL LOAD = 1060.000 -LBS      ◆ NORMAL LOAD = 1855.000 -LBS

Fig. F-1 Side Force versus Slip Angle with Normal Load Varying, 8 May 1978  
 (235 185-14X MI R XWW, camber = 0., slip = 0.)

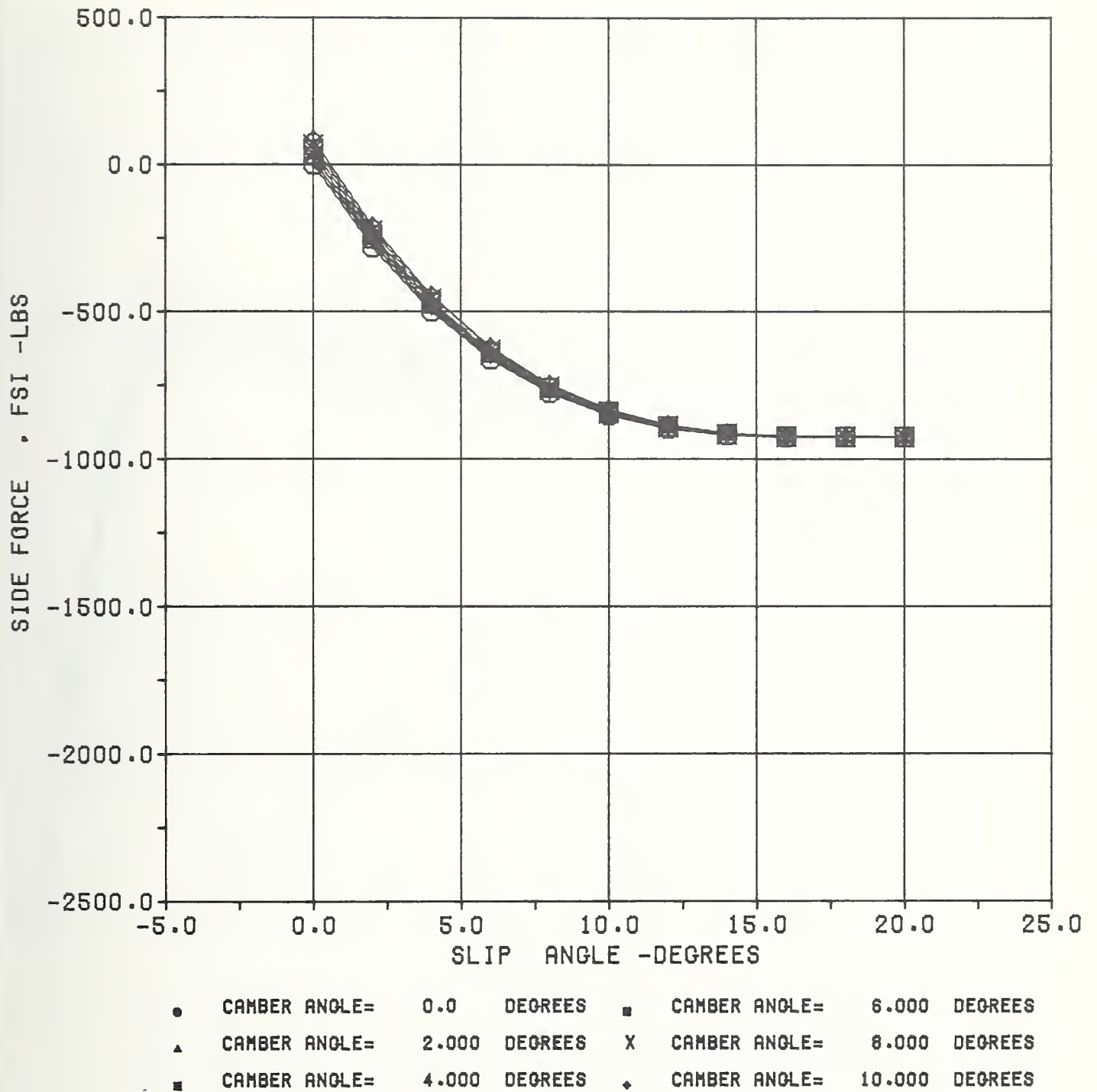
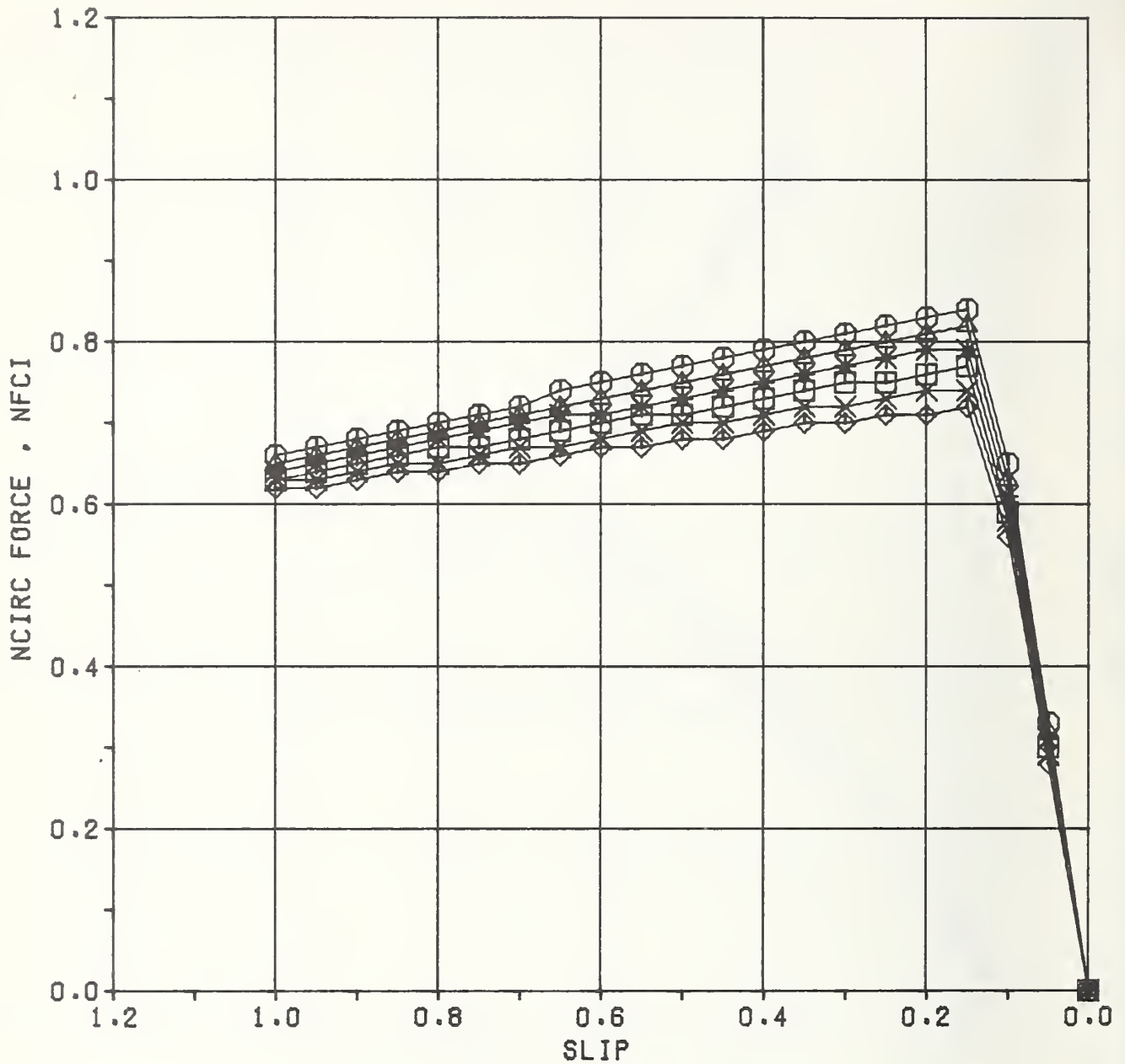


Fig. F-2 Side Force versus Slip Angle with Camber Angle Varying, 8 May 1978  
 (235 185-14X MI R XWW, load = 1060. lbs., slip = 0.)



- NORMAL LOAD = 530.000 -LBS      ■ NORMAL LOAD = 1325.000 -LBS
- ▲ NORMAL LOAD = 795.000 -LBS      X NORMAL LOAD = 1590.000 -LBS
- NORMAL LOAD = 1060.000 -LBS      ◆ NORMAL LOAD = 1855.000 -LBS

Fig. F-3 NCIRC Force versus Slip with Normal Load Varying, 8 May 1978  
 (235 185-14X MI R XWW, slip angle = 0., camber = 0.)



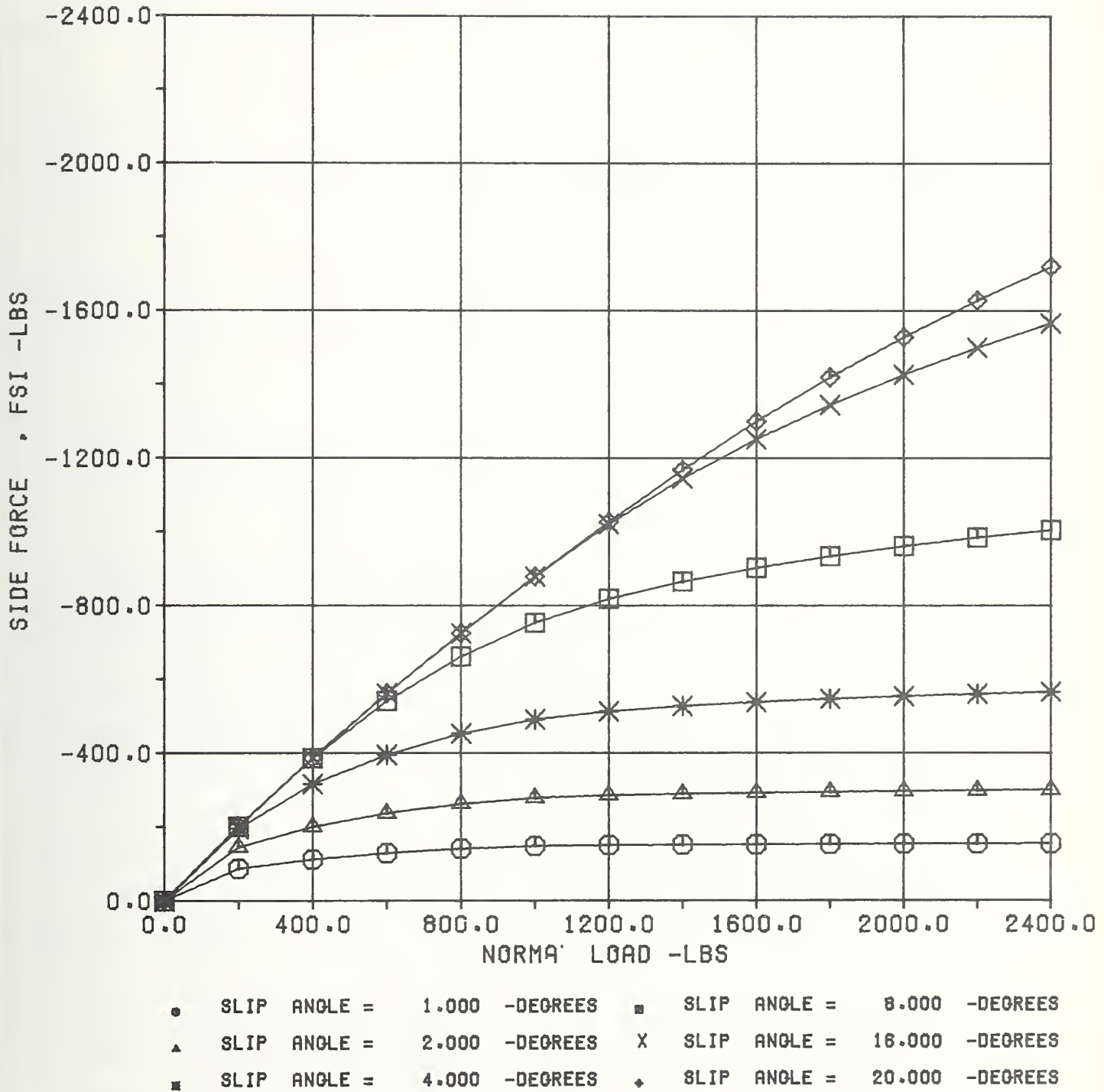
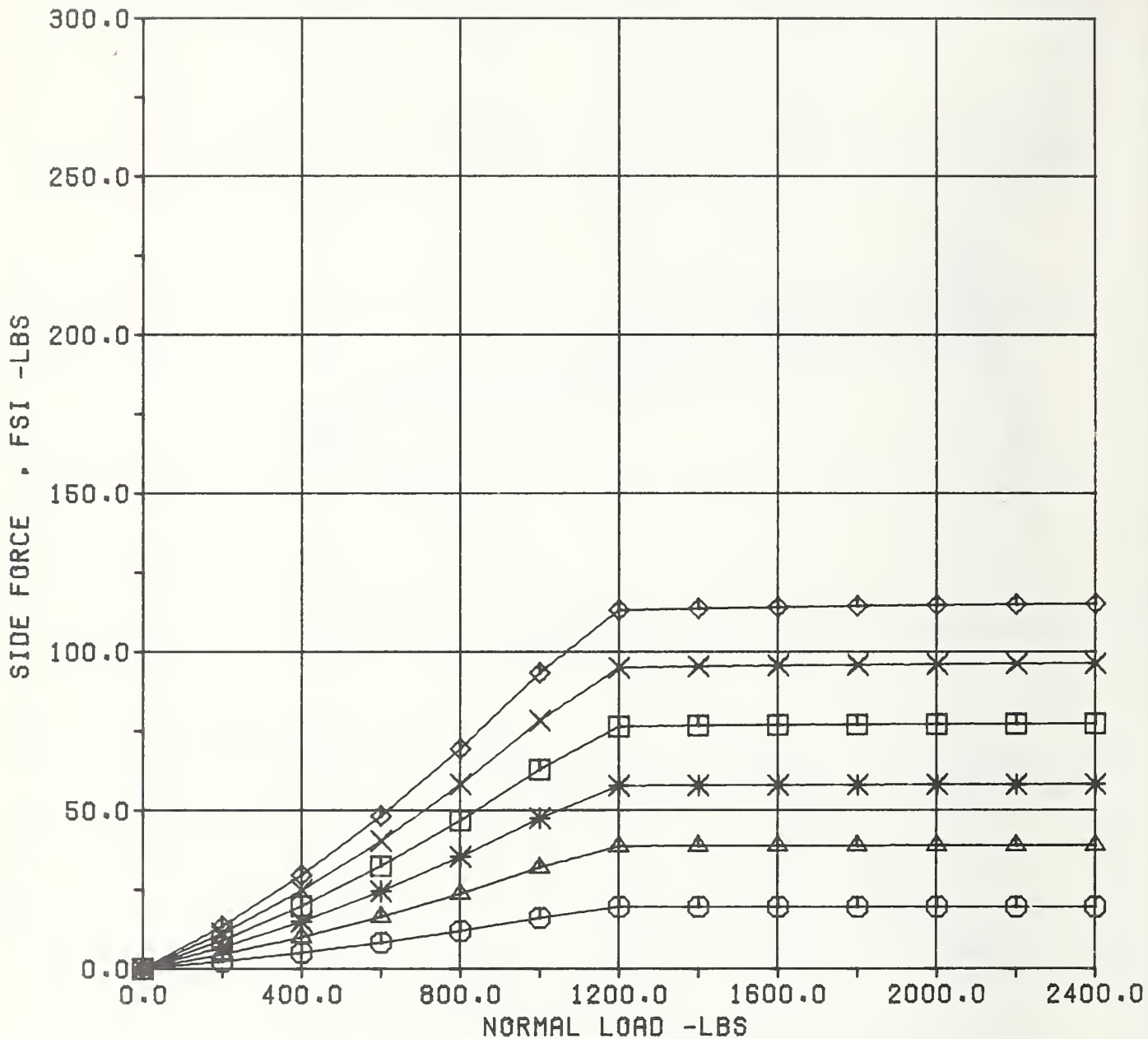
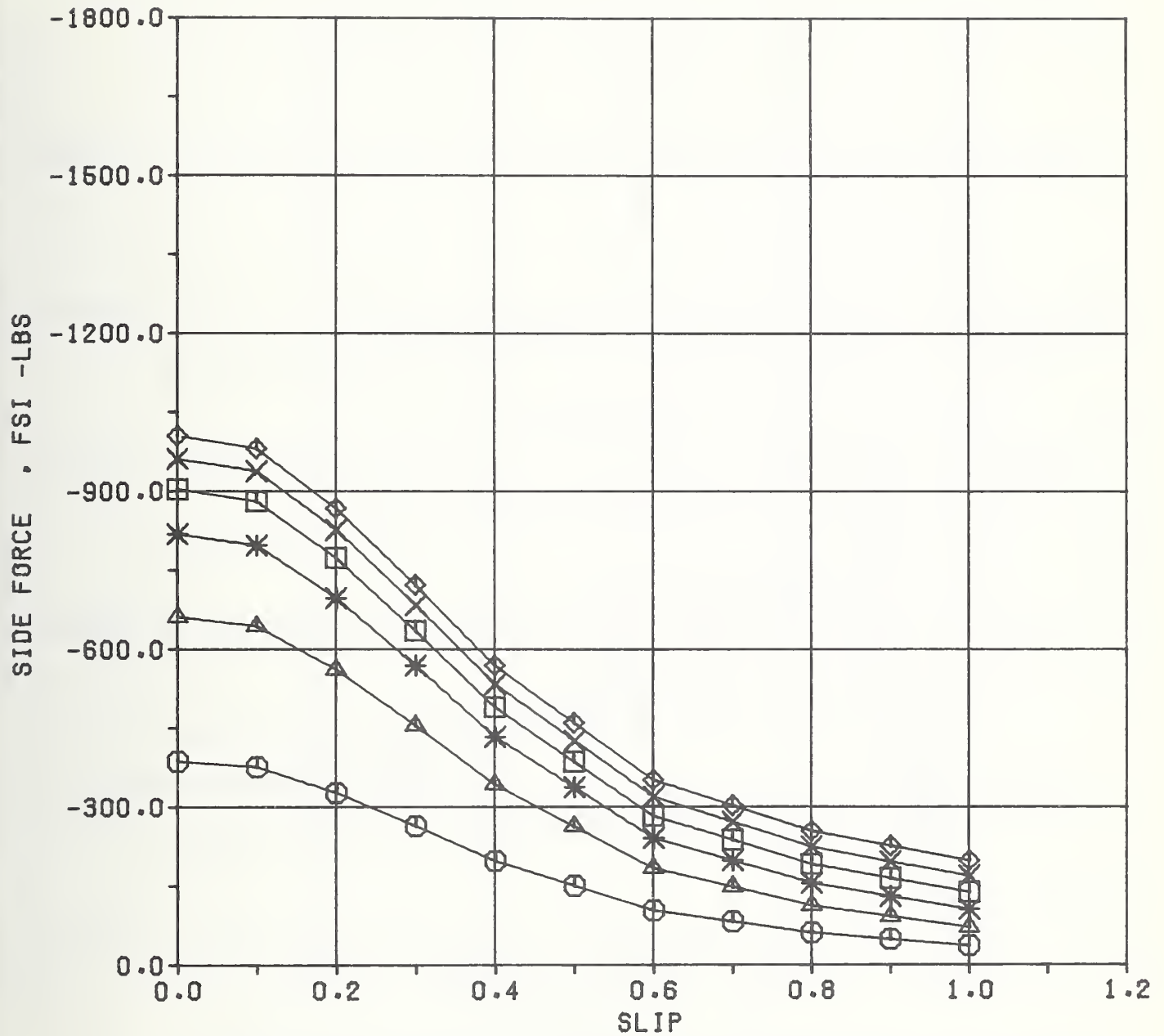


Fig. F-4 Side Force versus Normal Load with Slip Angle Varying, 4 May 1978  
 (235 185-14X MI R XWW, camber = 0., slip = 0.)



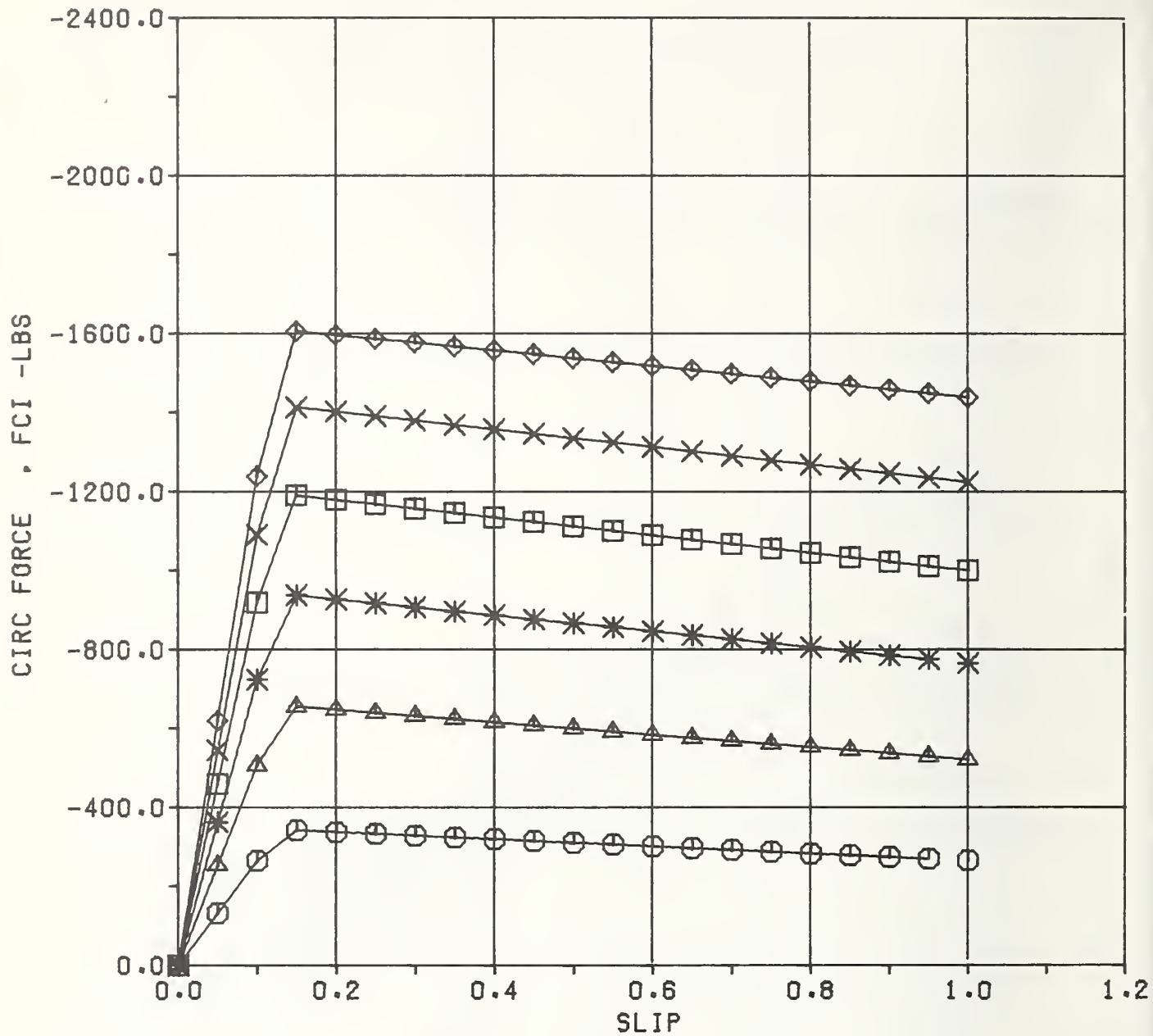
● CAMBER ANGLE= 2.000 DEGREES    ■ CAMBER ANGLE= 8.000 DEGREES  
 ▲ CAMBER ANGLE= 4.000 DEGREES    X CAMBER ANGLE= 10.000 DEGREES  
 ■ CAMBER ANGLE= 6.000 DEGREES    ◆ CAMBER ANGLE= 12.000 DEGREES

Fig. F-5 Side Force versus Normal Load with Camber Angle Varying, 5 May 1978  
 (235 185-14X MI R XWW, slip angle = 0., slip = 0.)



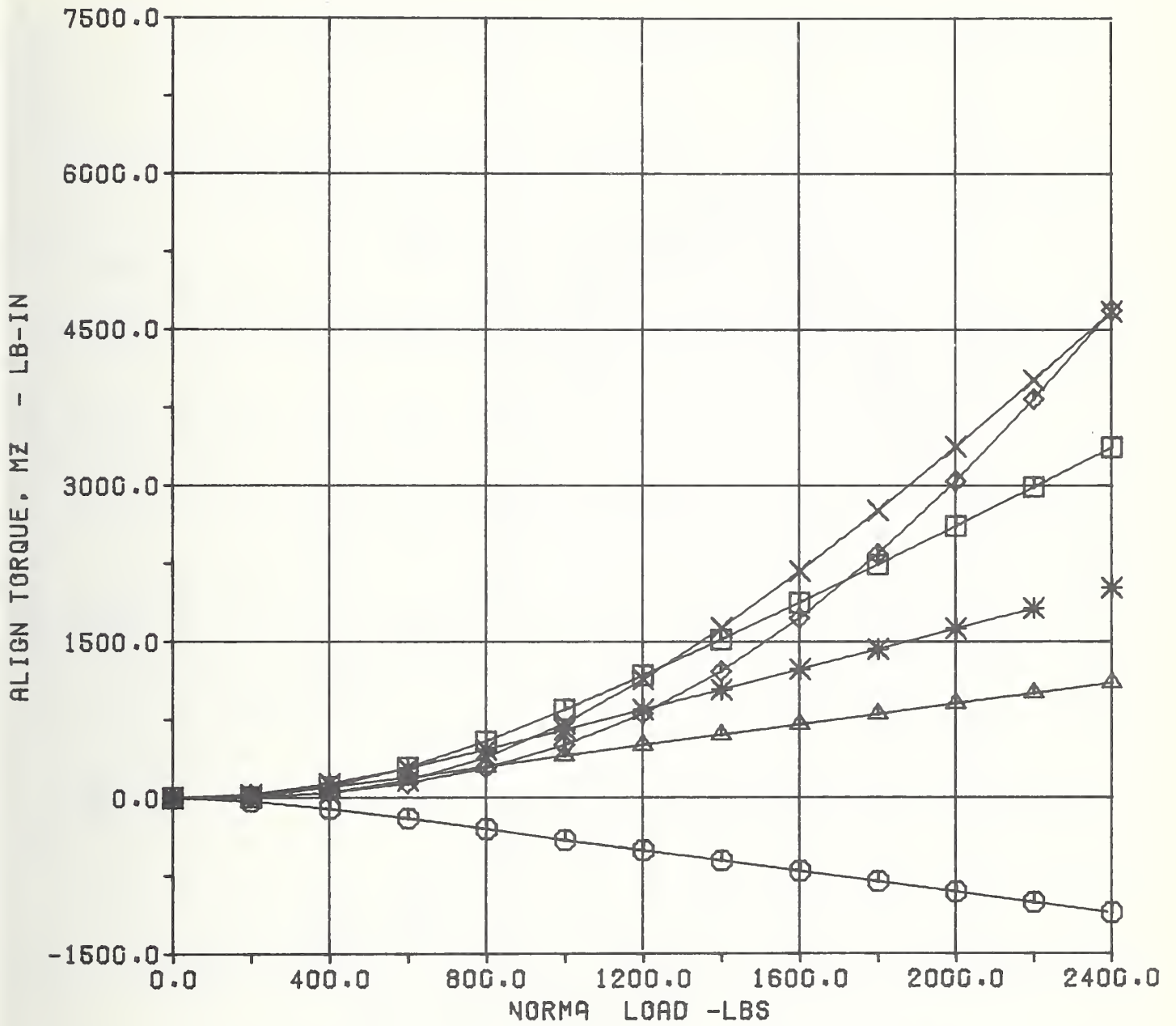
- NORMAL LOAD = 400.000 -LBS
- ▲ NORMAL LOAD = 800.000 -LBS
- NORMA LOAD = 1200.000 LBS
- NORMA LOAD = 1600.000 LBS
- X NORMA LOAD = 2000.000 -LBS
- ◆ NORMAL LOAD = 2400.000 -LBS

Fig. F-6 Side Force versus Slip with Normal Load Varying, 4 May 1978  
 (235 185-14X MI R XWW, slip angle = 8., camber = 0.)



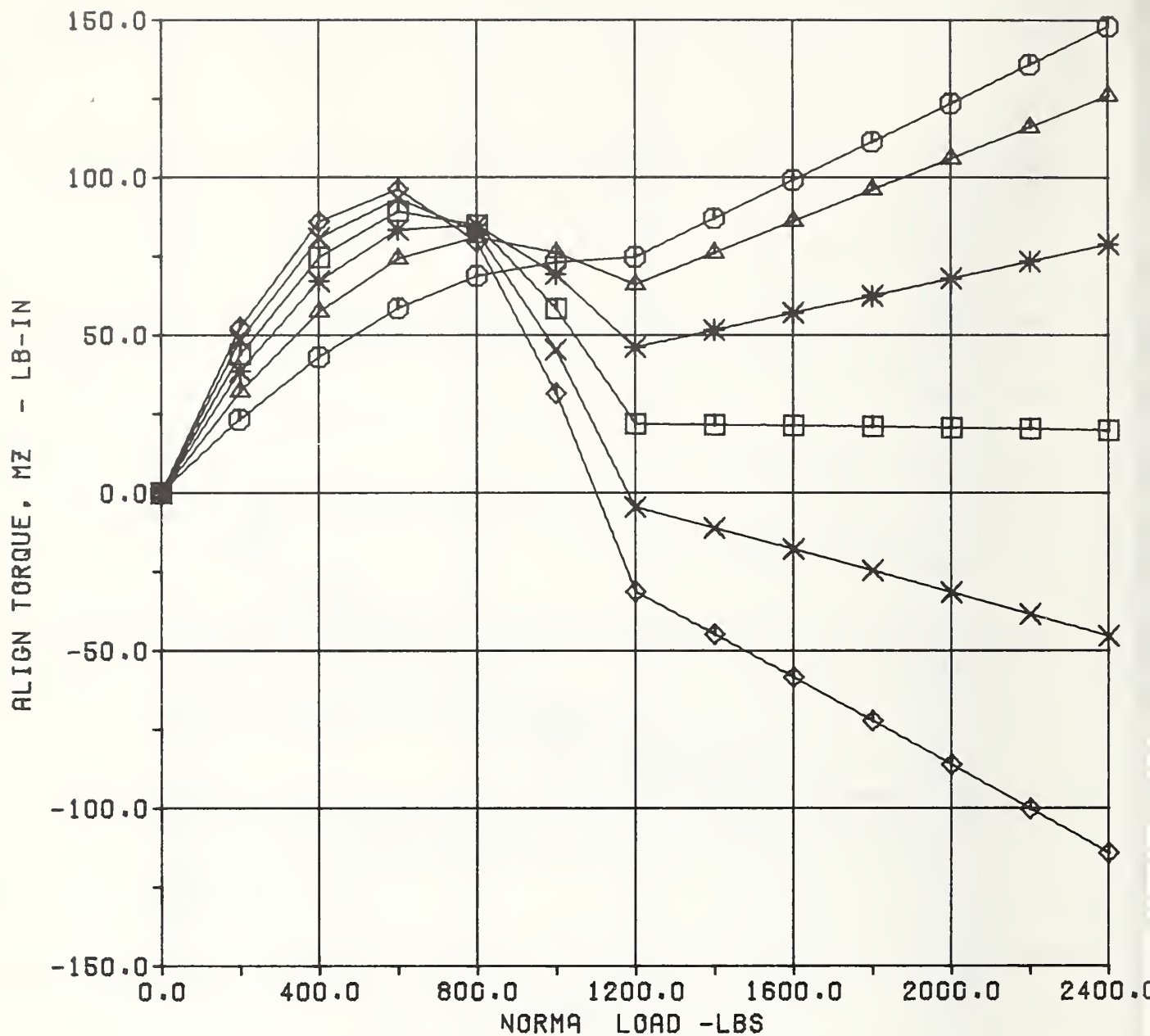
- NORMAL LOAD = 400.000 -LBS    ■ NORMAL LOAD = 1600.000 LBS
- ▲ NORMAL LOAD = 600.000 -LBS    × NORMAL LOAD = 2000.000 LBS
- NORMAL LOAD = 1200.000 -LBS    ◆ NORMAL LOAD = 2400.000 -LBS

Fig. F-7 CIRC Force versus Slip with Normal Load Varying, 4 May 1978  
 (235 185-14X MI R XWW, slip angle = 0., camber = 0.)



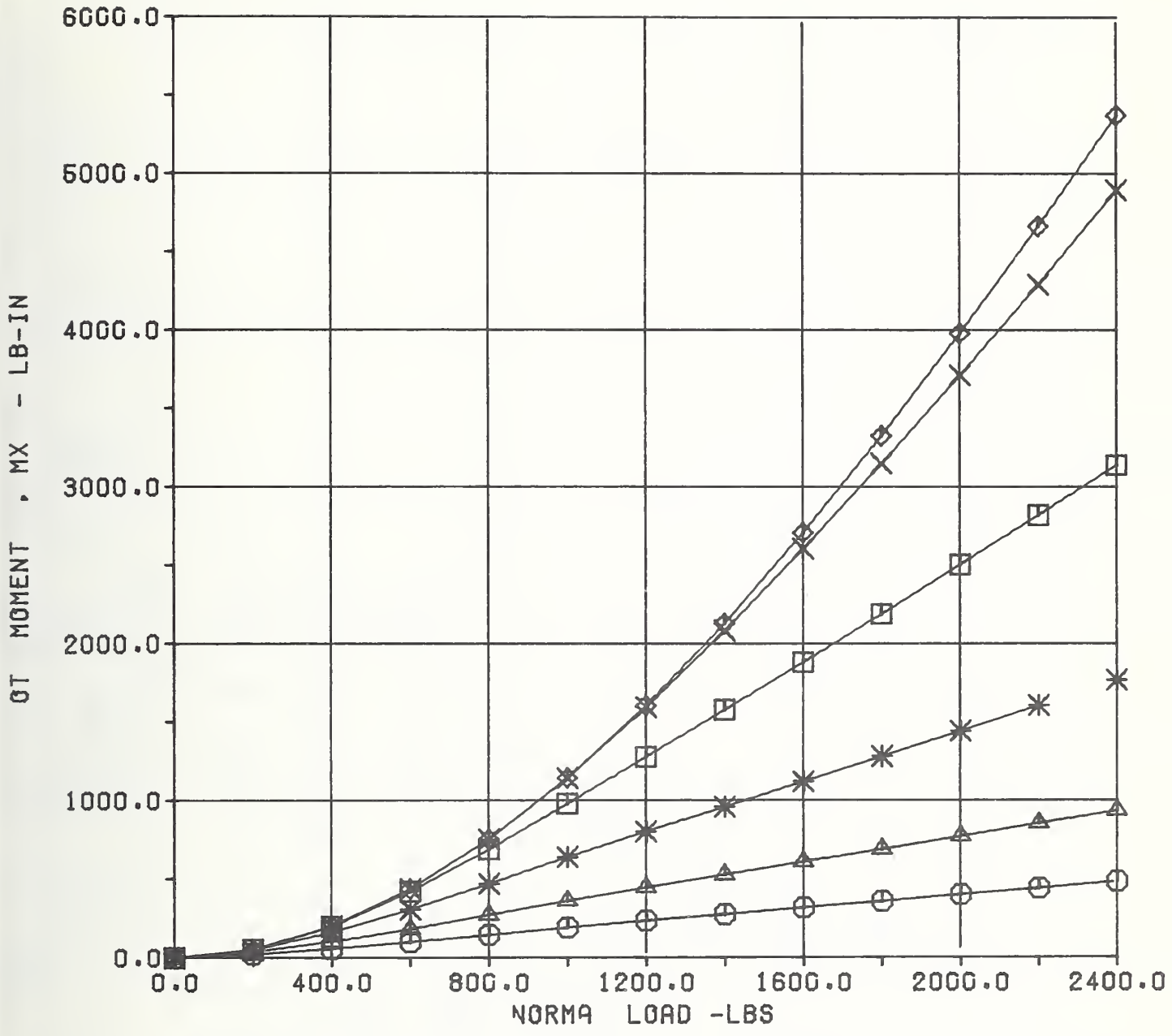
● SLIP ANGLE = -1.000 -DEGREES    ■ SLIP ANGLE = 4.000 -DEGREES  
 ▲ SLIP ANGLE = 1.000 -DEGREES    X SLIP ANGLE = 6.000 -DEGREES  
 ■ SLIP ANGLE = 2.000 -DEGREES    ◆ SLIP ANGLE = 16.000 -DEGREES

Fig. F-8 Align Torque versus Normal Load with Slip Angle Varying, 4 May 1978  
 (235 185-14X MI R XWW, camber angle = 0., slip = 0.)



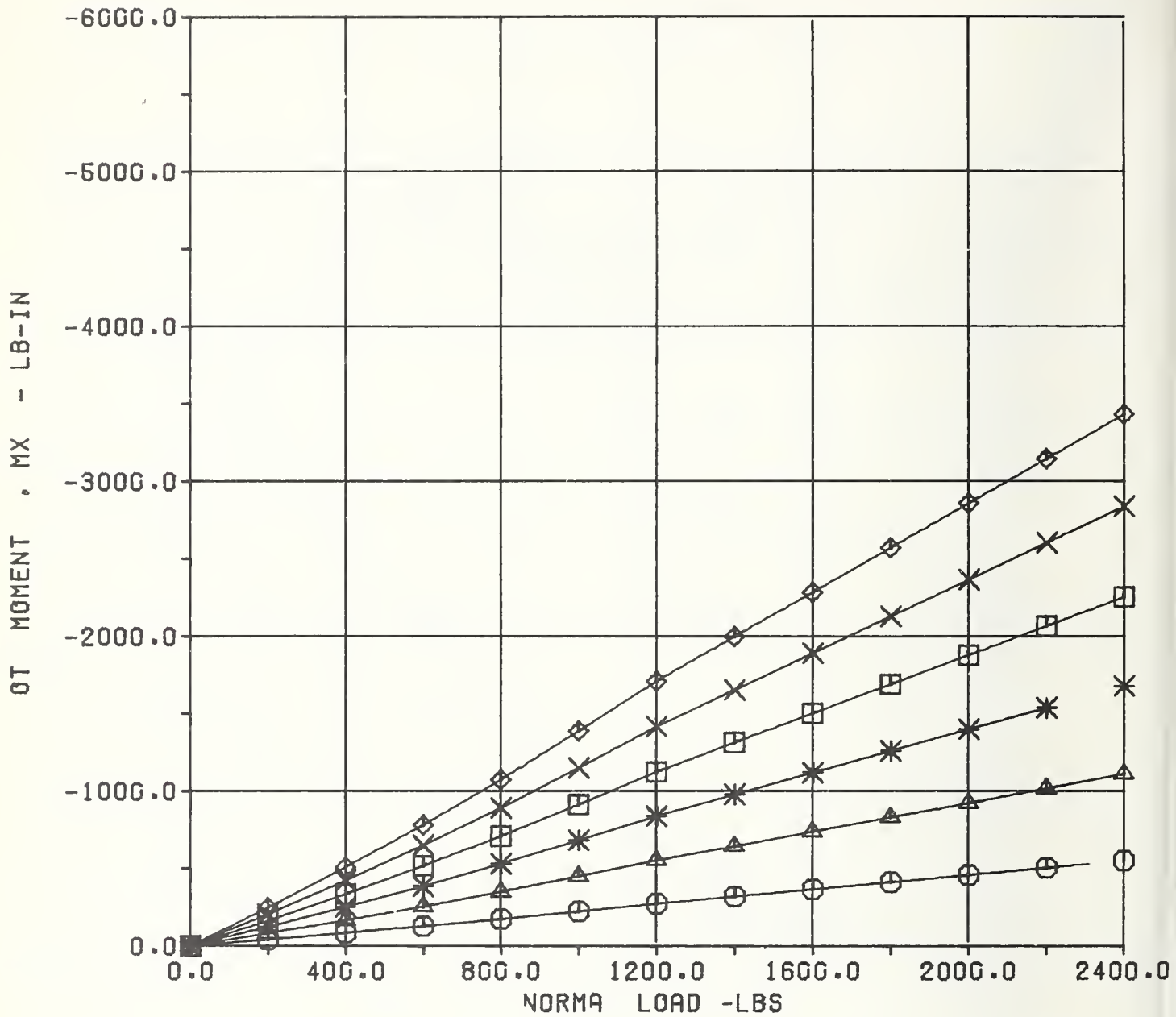
● CAMBER ANGLE= 2.000 DEGREES    ■ CAMBER ANGLE= 6.000 DEGREES  
 ▲ CAMBER ANGLE= 4.000 DEGREES    X CAMBER ANGLE= 10.000 DEGREES  
 ■ CAMBER ANGLE= 8.000 DEGREES    ◆ CAMBER ANGLE= 12.000 DEGREES

Fig. F-9 Align Torque versus Normal Load with Camber Angle Varying, 4 May 1978 (235 185-14X MI R XWW, slip angle = 0., slip = 0.)



- SLIP ANGLE = 1.000 -DEGREES      ■ SLIP ANGLE = 8.000 -DEGREES
- ▲ SLIP ANGLE = 2.000 DEGREES      X SLIP ANGLE = 16.000 -DEGREES
- SLIP ANGLE = 4.000 -DEGREES      ◆ SLIP ANGLE = 20.000 -DEGREES

Fig. F-10 OT Moment versus Normal Load with Slip Angle Varying, 4 May 1978 (235 185-14X MI R XWW, camber = 0., slip = 0.)



● CAMBER ANGLE= 2.000 DEGREES    ■ CAMBER ANGLE= 8.000 DEGREES  
 ▲ CAMBER ANGLE= 4.000 DEGREES    X CAMBER ANGLE= 10.000 DEGREES  
 ■ CAMBER ANGLE= 6.000 DEGREES    ◆ CAMBER ANGLE= 12.000 DEGREES

Fig. F-11 OT Moment versus Normal Load with Camber Angle Varying, 4 May 1978 (235 185-14X MI R XWW, slip angle = 0., camber = 0.)



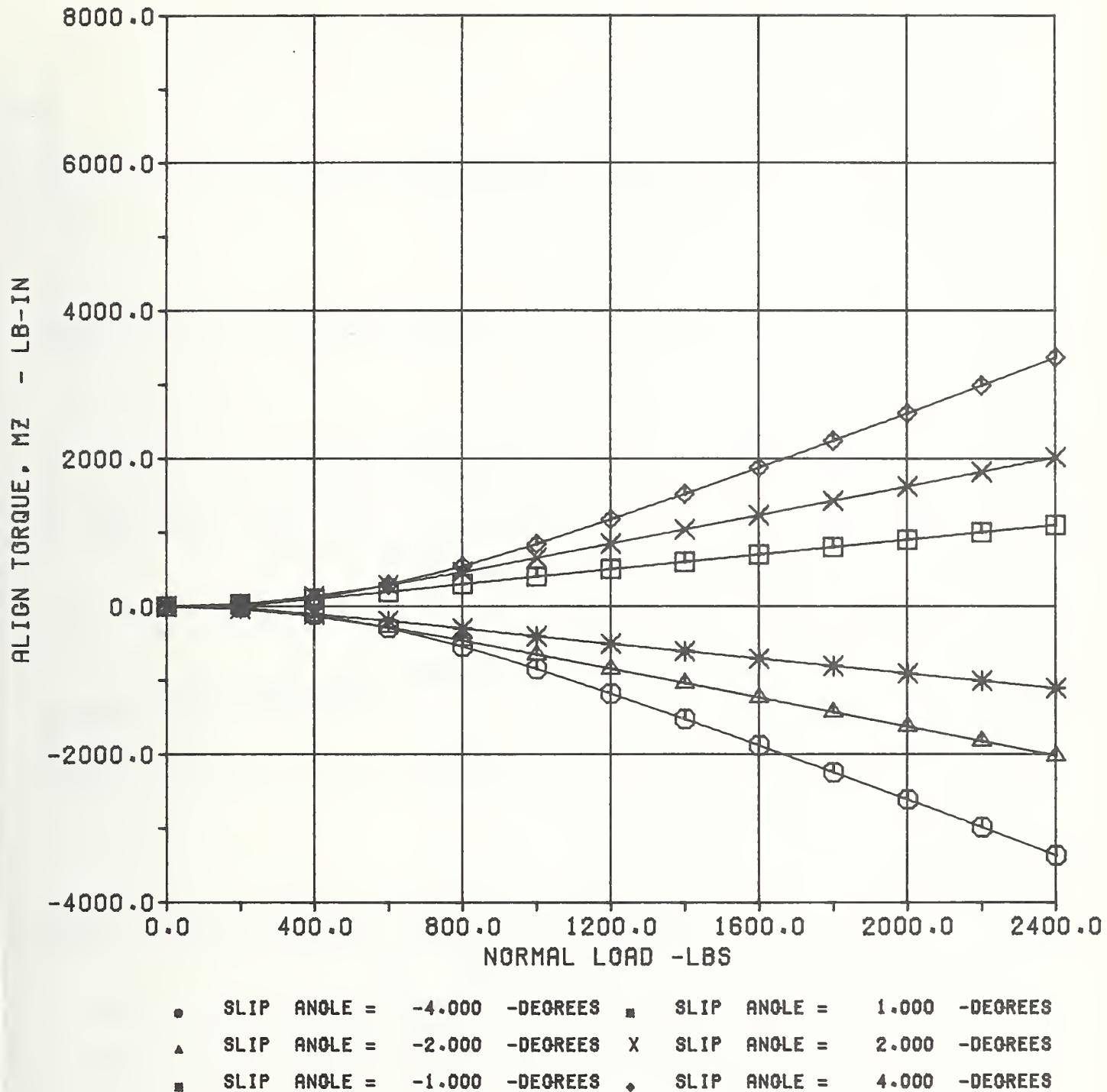
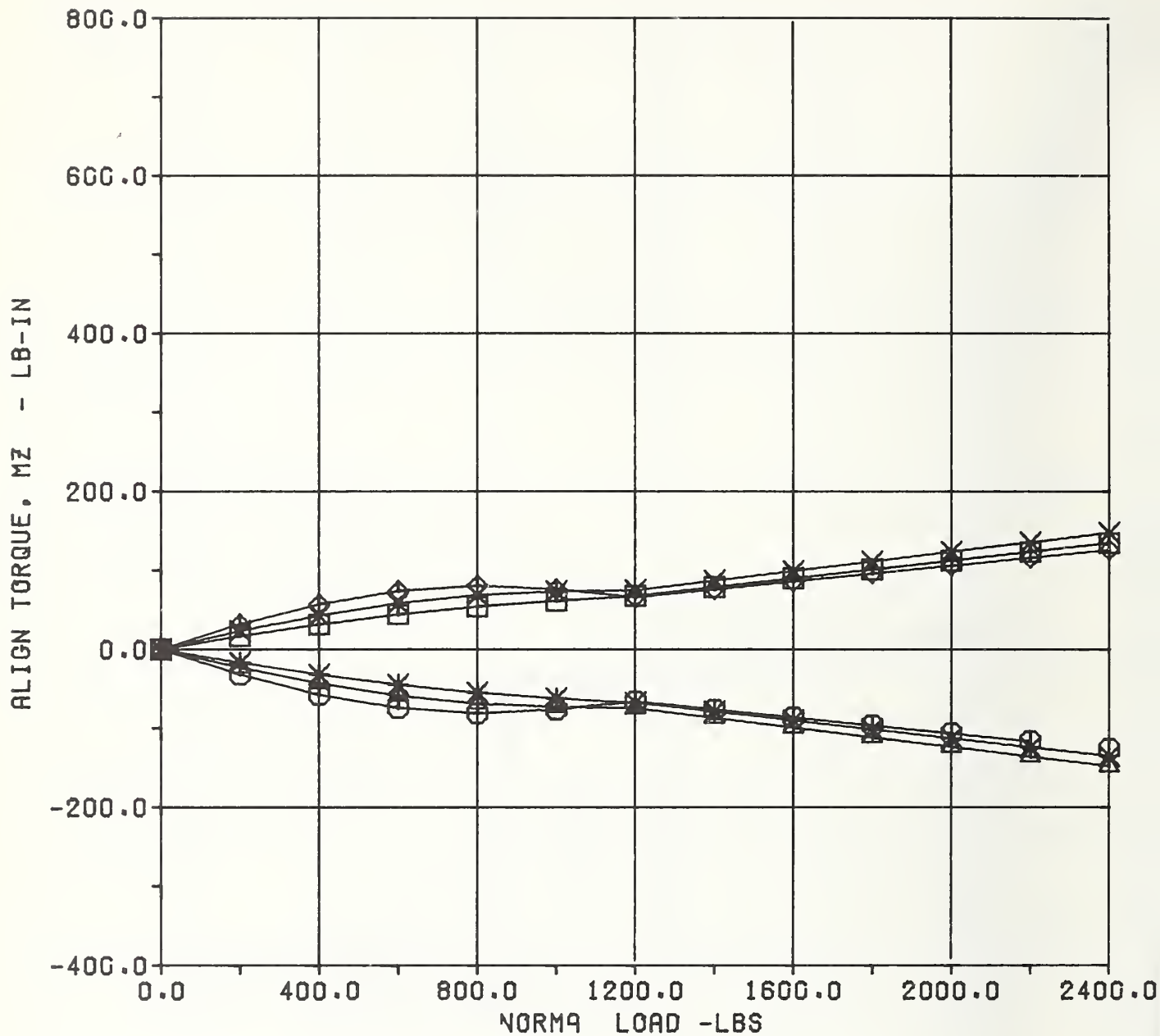
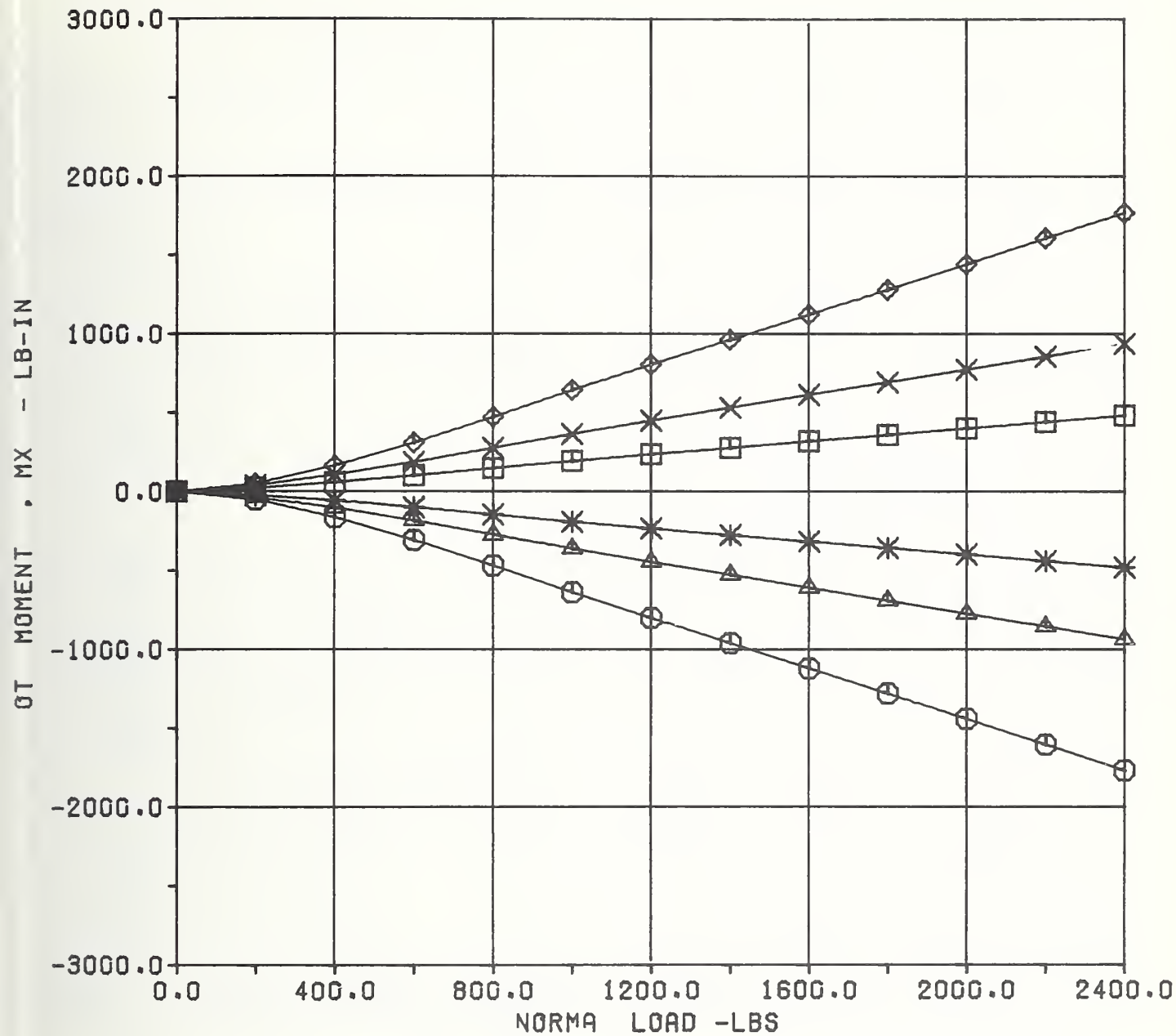


Fig. F-12 Align Torque versus Normal Load with Slip Angle Varying, 5 May 1978  
 (235 185-14X MI R XWW, camber = 0., slip = 0.)



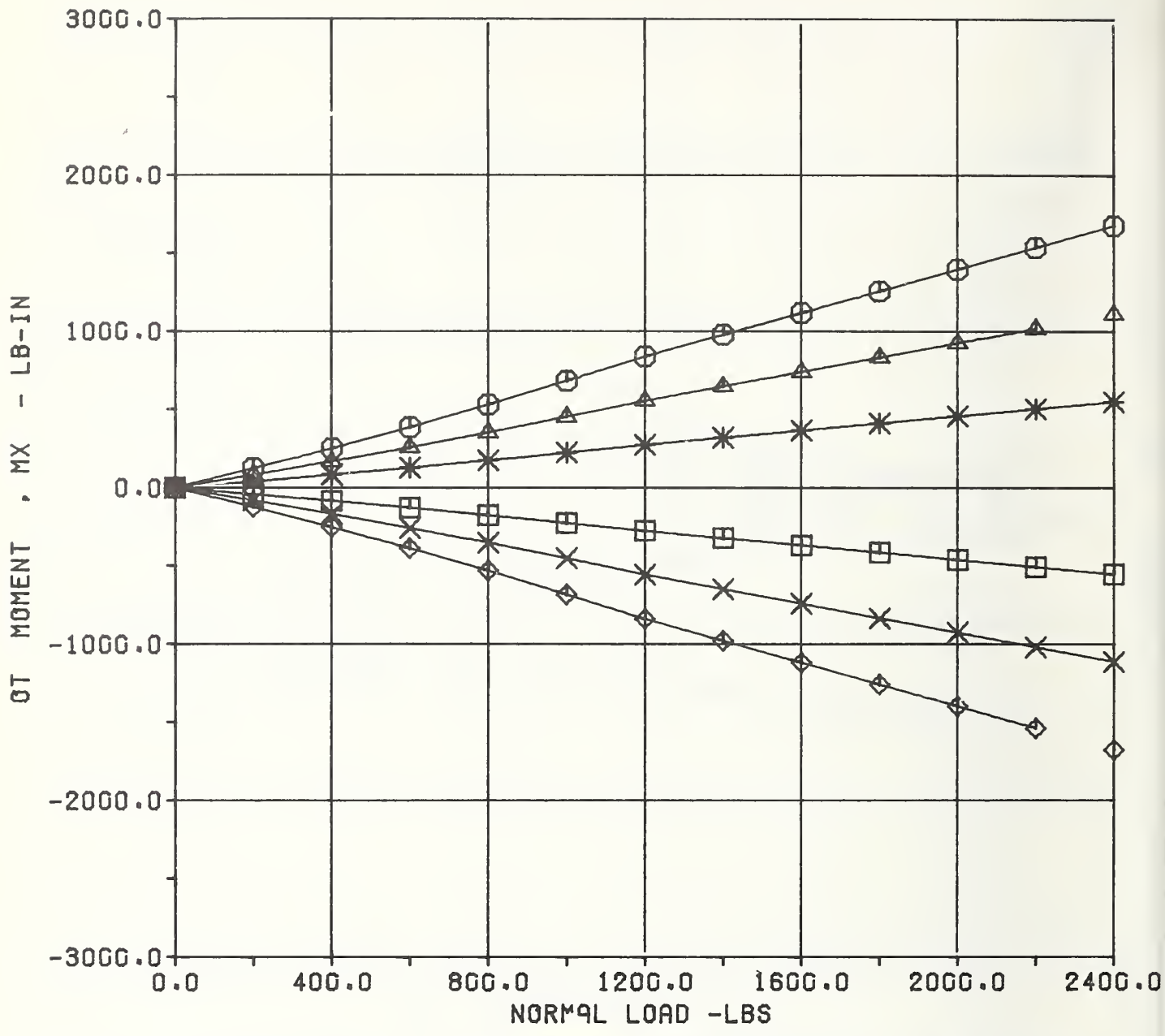
● CAMBER ANGLE = -4.000 DEGREES    ■ CAMBER ANGLE = 1.000 DEGREES  
 ▲ CAMBER ANGLE = -2.000 DEGREES    X CAMBER ANGLE = 2.000 DEGREES  
 ■ CAMBER ANGLE = -1.000 DEGREES    ◆ CAMBER ANGLE = 4.000 DEGREES

Fig. F-13 Align Torque versus Normal Load with Camber Angle Varying, 4 May 1978 (235 185-14X MI R XWW, slip angle = 0., slip = 0).



● SLIP ANGLE = -4.000 DEGREES    ■ SLIP ANGLE = 1.000 DEGREES  
 ▲ SLIP ANGLE = -2.000 DEGREES    × SLIP ANGLE = 2.000 DEGREES  
 ■ SLIP ANGLE = -1.000 DEGREES    ◇ SLIP ANGLE = 0.000 DEGREES

Fig. F-14 OT Moment versus Normal Load with Slip Angle Varying, 4 May 1978  
 (235 185-14X MI R XWW, camber = 0., slip = 0.)



● CAMBER ANGLE= 6.000 DEGREES    ■ CAMBER ANGLE= 2.000 DEGREES  
 ▲ CAMBER ANGLE= -4.000 DEGREES    X CAMBER ANGLE= .000 DEGREES  
 ◻ CAMBER ANGLE= -2.000 DEGREES    ◆ CAMBER ANGLE= 6.000 DEGREES

Fig. F-15 OT Moment versus Normal Load with Camber Angle Varying, 4 May 1978  
 (235 185-14X MI R XWW, slip angle = 0., slip = 0.)

### Tire Identification

TIRF Tire Number	011	
Size	F78-14	
Manufacturer (distributor)	GY	
Brand Name	Custom power cushion polyglas	
Load Range (ply rating)	B	
Maximum T&RA Load (lb)	1500	
Maximum Infl Press (psi)	32	
No. of Plies and Cord	Tread	2P + 2F
Material	Sidewall	2P
DOT No.	MP	L7   DDA   333 ..   ..   ...   ...
Construction Type	BB	
Aspect Ratio, Computed	76.8	
T&RA Rim Width	5.50	
Shore Hardness (std var)	59.8 ( )	
Remarks		

### Notations

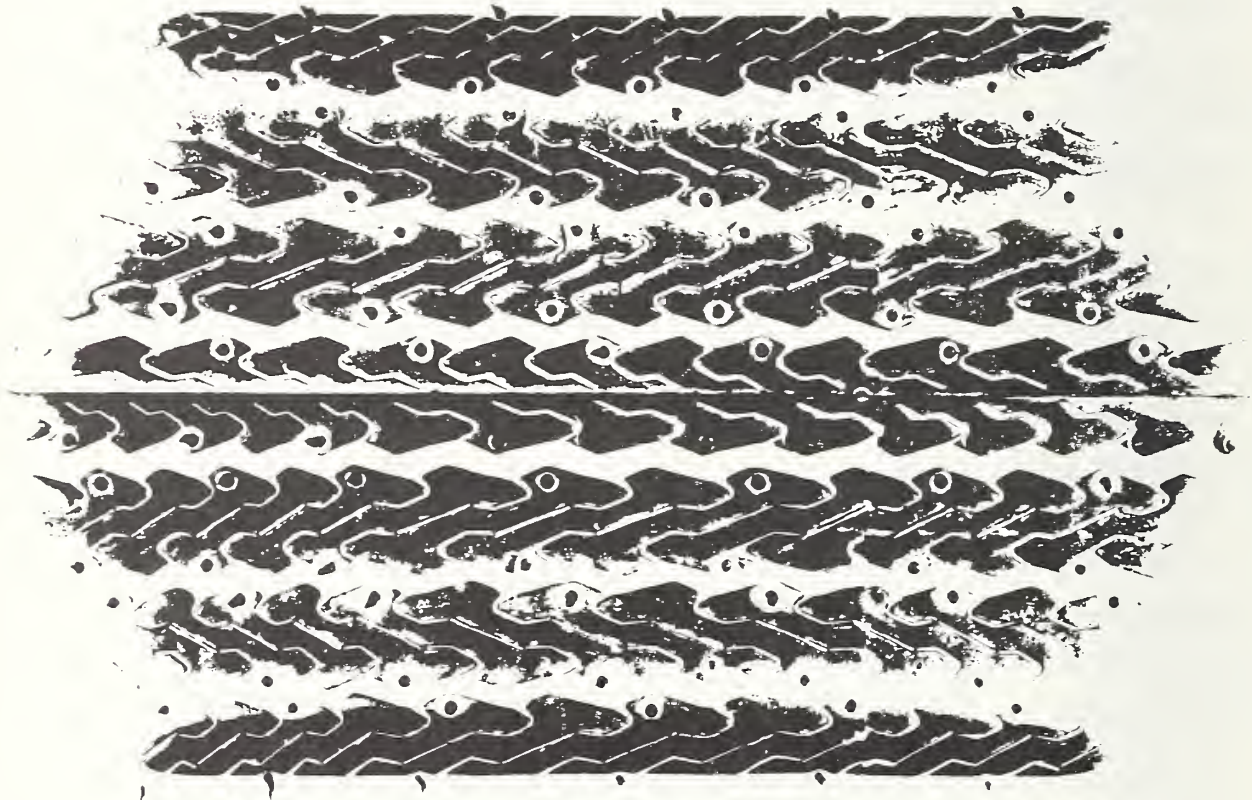
BFG	Goodrich
CO	Cooper
DA	Dayton
DU	Dunlop
FI	Firestone
GT	General Tire
GY	Goodyear
KS	Kelly Springfield
LE	Lee
MI	Michelin
PI	Pirelli
SE	Sears
UN	Uniroyal
B	Bias ply
BB	Bias belted
R	Radial ply
F	Fiberglas
H	High performance organic fiber
N	Nylon
P	Polyester
R	Rayon
S	Steel
TT	Tube-type
TL	Tubeless

### TIRF Run Identification

Run No. (0602 series)	389	464
Road Speed (mph)	30	
Water Depth (mil)	--	
Cold Infl Press (psi)	24	
100% Design Load (lb)	1280	
Rim Width (in.)	5.50	
Groove Depth (%)	100	
Road Skid No.	Dry	85
	Wet	--

Tire Uniformity  
(SAE recommended practice J332A)

TIRF Tire No.		011
Test Load at 28 psi (lb)		1090
Radial Force Variation, Peak-to-Peak (lb)	Total	22
	First harmonic	4
Lateral Force Variation, Peak-to-Peak (lb)	Total	8
	First harmonic	4
Mean Lateral Force (lb)	Forward	-40
	Reverse	+27
Conicity (lb)		-9
Ply Steer (lb)		-33



East ↓

Tire No. 011

CORNERING COEFFICIENTS

RUN: 389- 2- 6

CORNERING STIFFNESS, LB/RAD

A0 3318.89  
A1 7.40  
A2 2804.77

CAMBER STIFFNESS, LB/RAD

A3 1.266  
A4 6024.23

PEAK LATERAL FRICTION COEFFICIENT, LB/LB

B3 1.143  
B1 -2.848E-04  
B4 4.342E-08

OVERTURNING MOMENT, FT LB

C1 -1.162E-04  
C2 -5.638E-05  
C3 -0.446

ALIGNING TORQUE, FT LB

K1 -2.445E-04  
K2 2.343E-04  
K3 0.127

\*\*\*\*\* TEST DATA \*\*\*\*\*

LOAD LB	CALPHA LB/DEG	CA/FZ LB/DEG/LB	NALPHA FTLB/DEG	NA/FZ FTLB/DEG/LB	NA/CA FT
2234.8	119.6	0.054	51.6	0.023	0.432
1913.8	132.6	0.069	46.2	0.024	0.349
1595.0	144.2	0.090	40.0	0.025	0.277
1276.3	149.5	0.117	30.1	0.024	0.201
959.9	145.0	0.151	20.6	0.021	0.142
637.3	118.3	0.186	10.8	0.017	0.092
LOAD LB	CGAMMA LB/DEG	CG/FZ LB/DEG/LB	NGAMMA FTLB/DEG	NG/FZ FTLB/DEG/LB	NG/CG FT
2234.8	33.0	0.015	4.4	0.002	0.134
1913.8	28.1	0.015	4.0	0.002	0.142
1595.0	25.0	0.016	3.6	0.002	0.145
1276.3	22.4	0.017	3.5	0.003	0.158
959.9	20.6	0.021	3.6	0.004	0.172

LOAD LB	CG/CA	MUY PEAK	SA @ MUY PEAK DEG
2234.8	0.276	0.73	28.8
1913.8	0.212	0.74	21.5
1595.0	0.173	0.80	19.3
1276.3	0.150	0.86	18.4
959.9	0.142	0.91	17.1
637.3		0.98	-15.2

BRAKING COEFFICIENTS

RUN: 464- 2- 6

PEAK BRAKING COEFFICIENT, LB/LB

P0	1.0635	0.8879
P1	-2.127E-04	3.651E-05
P2		-8.913E-08

PEAK LONGITUDINAL SLIP

R0	-0.180
R1	-2.230E-06

SLIDE BRAKING COEFFICIENT, LB/LB

S0	0.7873	0.9844
S1	-1.257E-04	-4.221E-04
S2		1.040E-07

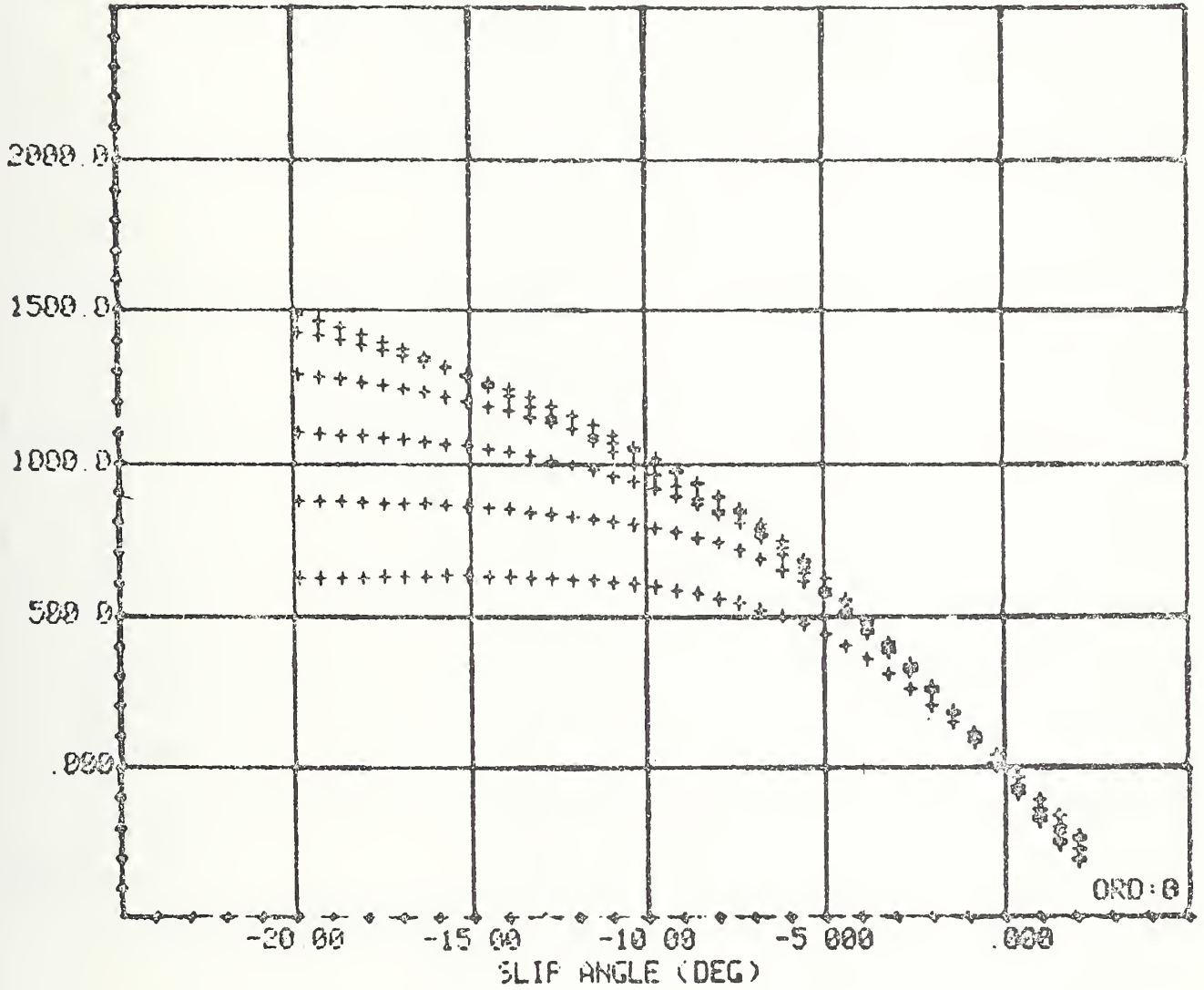
\*\*\*\*\* TEST DATA \*\*\*\*\*

LOAD LB	SL PEAK	MUX PEAK	MUX SLIDE	CS LB	CS/FZ LB/LB
1906.4	-0.196	0.647	0.562	20341.1	11.55
1589.0	-0.170	0.740	0.566	24428.9	16.43
1270.4	-0.172	0.797	0.628	25350.7	20.99
954.3	-0.193	0.853	0.674	17271.0	18.80



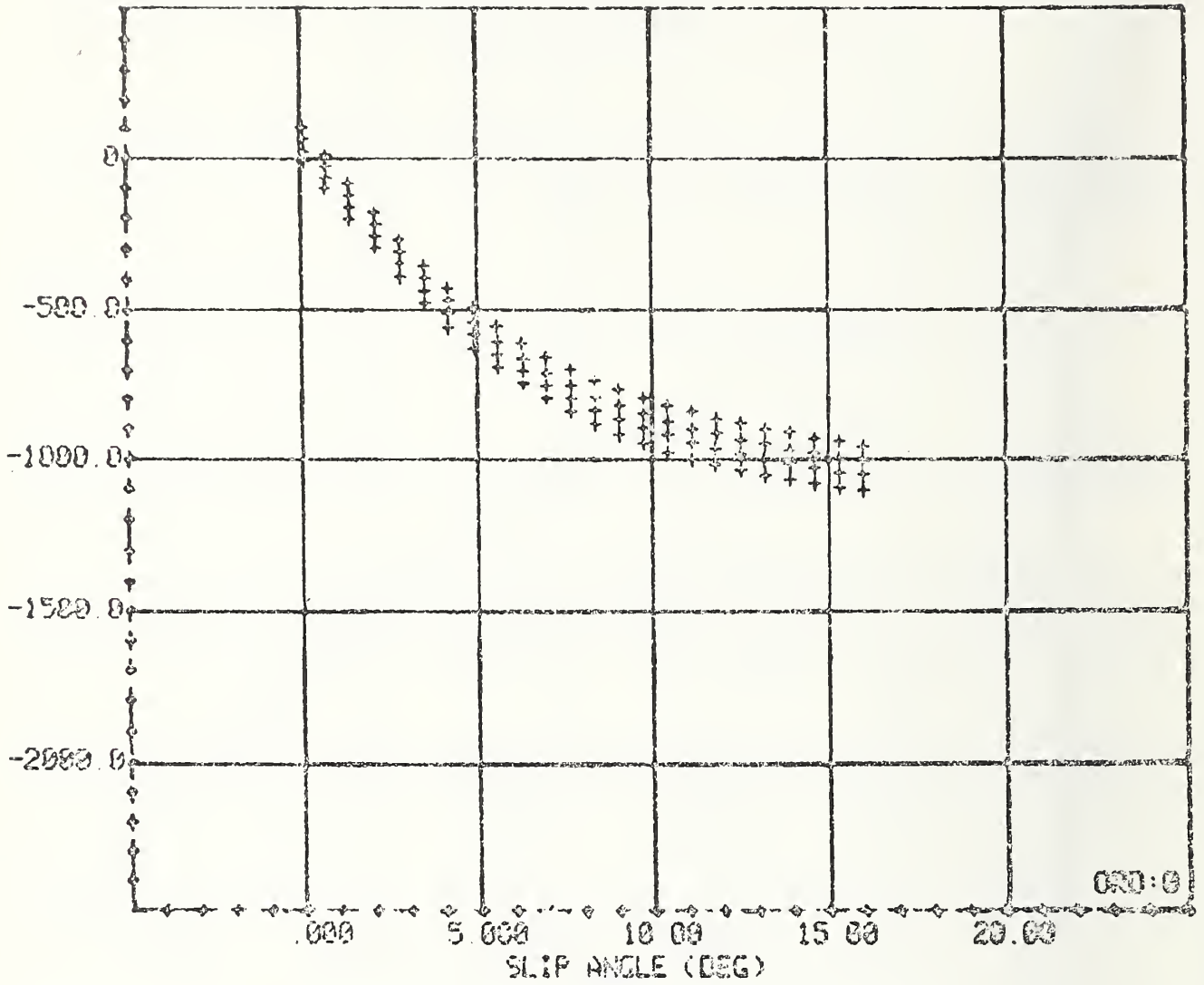
1. F Y (LB)

RUN 389- 2- 6



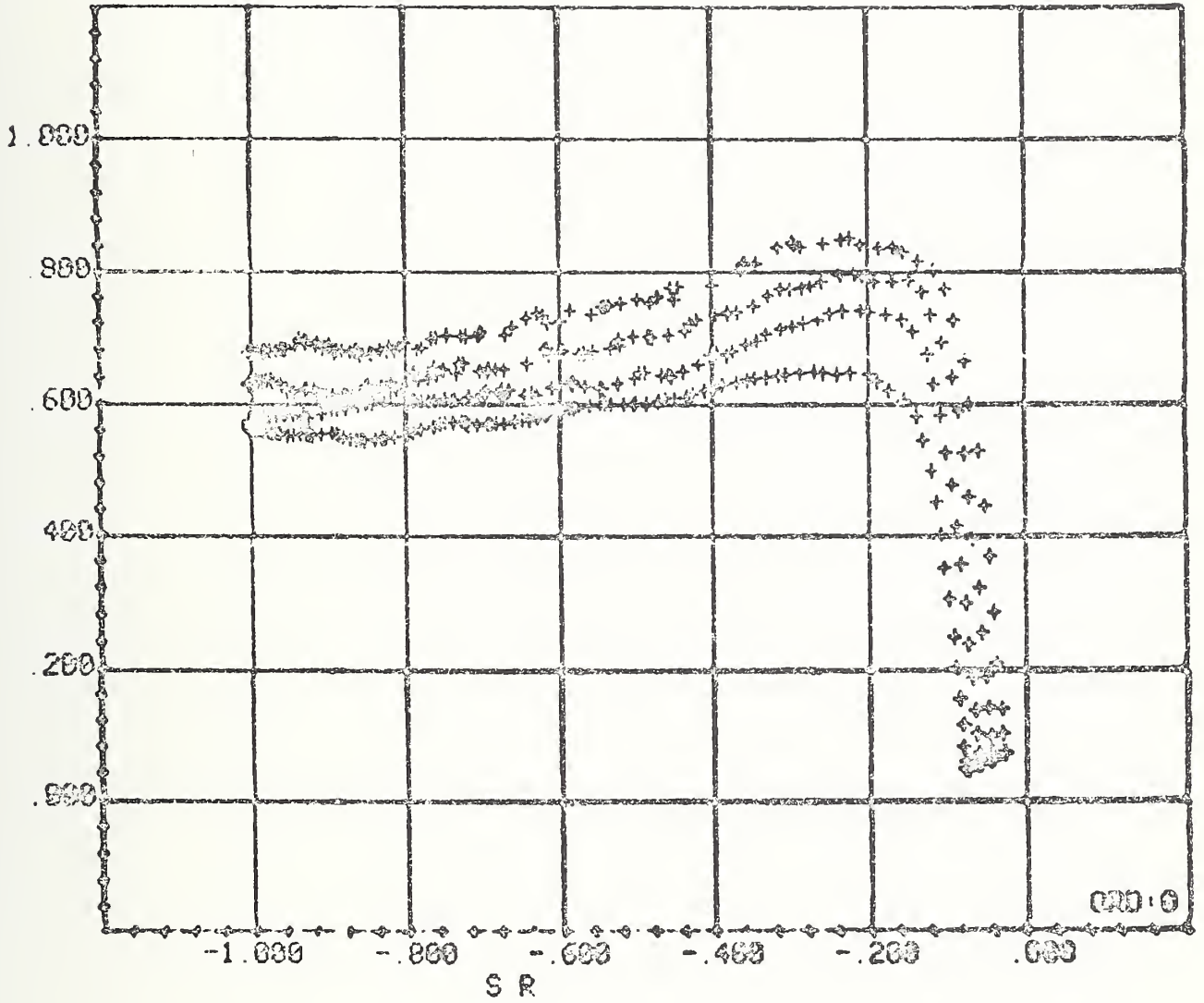
1 F Y (LB)

RUN 389- 2- 6



1 N F X (FX/FZ)

RUN 464- 2- 6





## Appendix G

### SIMULATION DATA

#### G-1. Input Data Decks

This section presents the listing of three input data decks:

1. Four-wheeled independent suspension, Volkswagen Campmobile;
2. Independent front, solid rear suspension, Dodge Coronet; and
3. Solid front and rear suspensions with dual rear tires, Winnebago Motor Home.

G-1.1. Four-Wheeled Independent Suspension, Volkswagen Camptobile

091 CARSSS VW VAN  
DELFW1 DELFW2  
TAUC  
CXC CYC CZC CLC CMC CNC  
SFXS SFYS SFZS  
SNPHIS SNTHES SNPSIS  
SFXU SFYU  
SNPHIU SNTHEU SNPSIU  
PHIDT THEDT PSIDT  
PHI THE PSI  
PDT QDT RDT  
P Q R  
UDT VDT WDT  
U V W

PFL AXAVE TIMDEC AYMAX SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)  
PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4) MAIN 50  
BMPN BMPS AYMAX RMAX CUVRAT BETDMX MAIN 60  
STR4 BETAMX BETDMX CUVRAT AYMAX RMAX PHIMAX  
STR5 AYMAX DEL BETAMX DELPSI PHIMAX UIN  
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN HRKUFF MAIN 90  
PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4) MAIN 100  
IOUT(01) 50.  
IOUT(02) 100.  
IOUT(03) 50.  
IOUT(04) 625.  
IOUT(05) .04  
IOUT(06) 0.4  
IOUT(07) 2.0  
IOUT(08) 1.0  
IOUT(09) .8  
IOUT(10) .003  
IOUT(11) 0.25  
IOUT(12) 0.25  
IOUT(13) 1.25  
IOUT(14) 0.1  
IOUT(15) .2  
IOUT(16) 1.25  
IOUT(17) .01  
IOUT(18) 1.25  
NOTUSED(1) 1.  
NOTUSED(1) 1.  
IOUT(21) -1000.  
IOUT(22) -1000.  
IOUT(23) -1000.  
IOUT(24) -1000.  
IOUT(25) 10000.  
IOUT(26) 10.  
IOUT(27) 400.  
IOUT(28) 1000.  
IOUT(29) -1000.  
IOUT(30) 28.  
IOUT(31) 10.  
IOUT(32) 10.  
IOUT(33) 20000.  
IOUT(34) 20000.  
IOUT(35) 20000.  
IOUT(36) 20000.  
ETAX 1.4

IOUT(38) 10000.  
IOUT(39) 10000.  
IOUT(40) 10000.  
IOUT(41) 10000.  
IOUT(42) 10000.  
IOUT(43) 10.  
IOUT(44) 10000.  
IOUT(45) 10.  
IOUT(46) 10000.

ETAL 1.4  
RTV 1.5706  
ENDNODAC  
U 1200.  
V 1000.  
W 100.  
PHI -.66667  
PSI 4.  
THE 0.25  
P 2.0  
Q 0.8  
DEL1DT -100.  
DEL2 10.  
DEL2DT -100.  
DEL1 10.  
DEL3DT -100.  
DEL3 10.  
DEL4DT -100.  
DEL4 10.  
UDT -800.  
VDT -1500.  
R 4.  
DELFW1 -0.5  
DELFW2 -0.5  
RDT -20.  
ARPS(1) -100.  
ARPS(2) -100.  
ARPS(3) -100.  
ARPS(4) -100.

S1P 2000.  
S2P 2000.  
ZETDRF 100.  
ZETDLF 100.  
ZETDRR 100.  
ZETDLR 100.  
QDT -2.  
PDT -12.  
WDT 200.  
PHIDT -2.  
THEDT -.25  
PSIDT -2.  
ENDNOADC  
ALAMDA=0.  
PARAM(341) 0.0  
PARAM(342) 0.0  
PARAM(343) 0.0  
PARAM(344) 0.0

INDXCN 1

VEHICLE MODEL \* VW CAMPMOBILE 1973

MAIN 590

MAIN 880

MAIN 890

MAIN 900

0.9509401 .06331873 .04225659 .04367653 .01231053 .0010975920.0  
 2.757724 -.1297874 -.03045931-.00649462-.00049561.0000235900.0  
 -.07321143-.03634039-.01556503-.00756957-.00160251-.000129640.0  
 -1.010893 .7207570 -.00401940.004555903-.00042666-.000099750.0  
 0.0 0.0 0.0 0.0 0.0 0.0 0.0  
 -.05058013-.06585461-.02369034-.00156075.000995467.0002581200.0  
 0.0 0.0

TABLE I \* BRAKE TORQUE FUNCTION

1000. 8900.  
 99999.

MAIN1020

0.0 0.0 TABLE II \* BRAKE TORQUE FUNCTION  
 1000. 8900.  
 99999.

MAIN1070

0.0 0.0 TABLE III- SIDE FORCE SHAPING FUNCTION

0.05 .01  
 0.1 .03  
 0.15 .07  
 0.2 .17  
 0.30 .35  
 0.4 .54  
 0.6 .81  
 0.8 .93  
 1.0 1.

MAIN1180

99999. WIND PROFILE

-1000. 528.  
 0. 528.  
 1000. 528.  
 99999.

-3.14159	0.535	0.01	-0.025	0.086	-0.117	-0.003
-2.87979	0.805	0.85	-0.435	0.433	-0.169	-0.188
-2.61799	0.920	1.56	-0.750	0.674	-0.259	-0.280
-2.35619	0.810	2.12	-1.030	0.828	-0.332	-0.391
-2.09440	0.585	2.16	-1.275	0.876	-0.300	-0.291
-1.83260	0.330	2.55	-0.260	1.115	-0.139	-0.212
-1.57080	0.105	2.78	-0.170	1.117	0.062	-0.066
-1.3090	-0.074	2.74	-0.432	1.085	0.030	0.117
-1.0472	-0.297	2.63	-1.195	0.887	0.237	0.250
-.78540	-0.472	2.33	-1.280	0.848	0.252	0.417
-.69813	-0.562	2.07	-1.070	0.800	0.243	0.420
-.61087	-0.630	1.84	-0.910	0.723	0.232	0.416
-.52360	-0.680	1.61	-0.773	0.651	0.221	0.402
-.43633	-0.708	1.37	-0.660	0.562	0.212	0.376
-.34907	-0.715	1.14	-0.550	0.478	0.197	0.337
-.26180	-0.690	0.87	-0.445	0.363	0.172	0.272
-.17453	-0.640	0.60	-0.333	0.252	0.139	0.171
-.08727	-0.600	0.33	-0.276	0.138	0.125	0.080
0.0	-0.578	0.0	-0.252	0.011	0.121	-0.003
0.08727	-0.590	-0.32	-0.280	-0.089	0.136	-0.082
0.17453	-0.630	-0.62	-0.355	-0.203	0.153	-0.168
0.26180	-0.680	-0.89	-0.465	-0.316	0.187	-0.257
0.34907	-0.702	-1.13	-0.593	-0.423	0.227	-0.332
0.43633	-0.710	-1.35	-0.615	-0.511	0.255	-0.380
0.52360	-0.690	-1.65	-0.860	-0.619	0.266	-0.407
0.61087	-0.615	-1.90	-1.012	-0.716	0.259	-0.434
0.69813	-0.560	-2.17	-1.150	-0.790	0.262	-0.439
0.78540	-0.472	-2.33	-1.280	-0.848	0.262	-0.417
1.04720	-0.297	-2.63	-1.195	-0.887	0.237	-0.250
1.30900	-0.074	-2.74	-0.432	-1.085	0.030	-0.117
1.57080	0.105	-2.78	-0.170	-1.117	0.062	0.066
1.83260	0.330	-2.55	-0.260	-1.115	-0.139	0.212
2.09440	0.585	-2.16	-1.275	-0.876	-0.300	0.291



2.35619	0.810	-2.12	-1.030	-0.828	-0.332	0.309
2.61799	0.920	-1.56	-0.750	-0.674	-0.259	0.280
2.87979	0.805	-0.85	-0.435	-0.443	-0.169	0.188
3.14159	0.535	-0.01	-0.025	-0.086	-0.117	0.003

MICROBUS  
AERO DATA

99999.

0.0 0.0

99999.

0.0 0.0

STEER PROFILE

0.25 -13.6  
1.25 -31.45  
1.55 135.  
1.75 125.46  
2.0 62.73  
2.3 -200.  
2.5 -204.  
6. -204.

99999.

-10.0 -20688.73 VW FRONT SPRING DATA

-5.67 -1580.44 VW FRONT

-4.92 -908.44 VW FRONT

-3.74 -482.46 VW FRONT

0. 0.

.43 55.47 VW FRONT

10. 9003.42 VW FRONT

99999.

-10.0 -20688.73 VW FRONT SPRING DATA

-5.67 -1580.44 VW FRONT

-4.92 -908.44 VW FRONT

-3.74 -482.46 VW FRONT

0. 0.

.43 55.47 VW FRONT

10. 9003.42 VW FRONT

99999.

-10. -16375.09 VW REAR SPRING DATA

-4.61 -1466.35 VW REAR

-3.54 -980.57 VW REAR

-1.57 -334.41 VW REAR

0. 0. VW REAR

2.28 485.64 VW REAR

10. 8136.16 VW REAR

99999.

-10. -16375.09 VW REAR SPRING DATA

-4.61 -1466.35 VW REAR

-3.54 -980.57 VW REAR

-1.57 -334.41 VW REAR

0. 0. VW REAR

2.28 485.64 VW REAR

10. 8136.16 VW REAR

99999.

FRONT SHOCK ABSORBER DATA MICROBUS

-100 -466.

-26.7 -150.

-13.25 -92.

-4.71 -27.

0.0 0.0

4.71 130.

13.25 390.

26.7 585.

100. 1648.

99999.

-100 -466.

FRONT SHOCK ABSORBER DATA

-26.7      -150.  
 -13.25     -92.  
 -4.71      -27.  
 0.0        0.0  
 4.71       130.  
 13.25      390.  
 26.7       585.  
 100.       1648.  
 99999.

REAR SHOCK ABSORBER DATA

-100.      -425.  
 -26.7      -125.  
 -13.25     -70.  
 -4.71      -30.  
 0.0        0.0  
 4.71       50.  
 13.25      175.  
 26.7       315.  
 100.       1078.  
 99999.

REAR SHOCK ABSORBER DATA

-100.      -425.  
 -26.7      -125.  
 -13.25     -70.  
 -4.71      -30.  
 0.0        0.0  
 4.71       50.  
 13.25      175.  
 26.7       315.  
 100.       1078.  
 99999.

066	40.	40.	40.	30.	40.	45.	50.
074	0.	0.	0.	30.	0.	0.	0.
076	5.	10.	10.	5.	5.5	4.	3.
114	62.	0.	39.	72.	0.	0.	0.
115	1.	0.	1.	1.	1.	0.	0.
116	.5	100.	.5	.5	.4	100.	100.
117	3.	0.	3.	0.	0.	0.	0.
118	3.	0.	3.	0.	0.	0.	0.
121	300.	200.	200.	0.	0.	0.	1500.
124	0.	0.	0.	0.	0.	2.	1.
125	0.	0.	0.	0.	0.	0.	1.
126	0.	0.	0.	0.	0.	1.	1.
128	3.	1.	3.	4.	2.	5.	6.
192	1.	.1	.1	.1	.1	.1	.05
198	0.	0.	0.	12.	0.	0.	0.
199	0.	0.	0.	57.6	0.	0.	0.
201	0.	0.	0.	1000.	0.	0.	0.
277	0.	0.	0.	8.	0.	0.	0.
278	0.	0.	0.	0.	0.	0.	.52
279	0.	0.	0.	0.	0.	0.	1.02
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
001	8.6						
002	.507						
003	.489						
004	19.98						

005 19.92  
006 49.65  
007 44.85  
008 54.8  
009 57.2  
010 0.  
011 7380.  
012 24980.  
013 25660.  
014 1140.  
015 696969.  
016 30.  
017 153000.  
018 10.  
019 129.  
020 129.  
021 213.  
022 213.  
023 0.  
024 0.  
025 33.  
026 33.  
027 56.  
028 56.  
029 0.0  
030 0.  
031 12.75  
032 2000.  
033 .5  
034 4566.64  
035 7.87  
036 2303.58  
037 0.294  
038 -1747.37  
039 0.  
040 0.  
041 8592.  
042 16.3  
043  
044  
045  
046  
047 8.27  
048 696969.  
049 8.93  
050 9.28  
051 .3  
052 5.375  
053 0.  
054 0.  
055 .59  
056 3.47  
057 -3.47  
058 -.0873  
059 .0873  
060 1.0  
061 0.0  
062 0.0  
063  
064

MAIN1820

MAIN2190

MAIN2220  
MAIN2230

065		MAIN2240
066	40.	MAIN2250
067		MAIN2260
068		MAIN2270
069		MAIN2280
070		MAIN2290
071		MAIN2300
072		MAIN2310
073		MAIN2320
074		MAIN2330
075	.005	
76	5.0	MAIN2350
077	894.	
078	894.	
079	894.	
080	894.	
081		MAIN2400
082		MAIN2410
083		MAIN2420
084		MAIN2430
085	-.0002056	
086	0.0	
087	1.045	
088	.00000003991	
089		MAIN2480
090		MAIN2490
091	0.0	MAIN2500
092	-1.54	
093	-1.03	
094		MAIN2530
095		MAIN2540
096		MAIN2550
097		MAIN2560
098		MAIN2570
099		MAIN2580
100		MAIN2590
101		MAIN2600
102		MAIN2610
103		MAIN2620
104		MAIN2630
105		MAIN2640
106		MAIN2650
107	1.0	MAIN2660
108	.4	MAIN2670
109	0.0	
110	4428.	
111	738.	
112	0.0	MAIN2710
113	1.	MAIN2720
114	62.	MAIN2730
115	1.0	MAIN2740
116	0.5	MAIN2750
117	3.	MAIN2760
118	3.	MAIN2770
119	0.0	
120	0.0	
121	300.	MAIN2800
122		MAIN2810
123		MAIN2820
124		MAIN2830

125  
126  
127  
128 3.0  
129 0.  
130 .038  
131 .320  
132 44000.  
133 44000.  
134 6.2  
135 6.20  
136 17.6  
137 126.  
138 5.68  
139 .010  
140 -.010  
141 0.  
142 0.0  
143 0.  
144 0.  
145 .00000001147  
146 0.0  
147 0.0  
148 0.0  
149 0.0  
150 0.0  
151 0.0  
152 0.0  
153 0.0  
154 0.0  
155 0.0  
156 4233.6  
157 94.5  
158 1094.0  
159  
160  
161  
162  
163  
164  
165  
166  
167  
168  
169 73.  
170 75.  
171 75.  
172 2.  
173  
174  
175 .25  
176 1.0  
177  
178  
179  
180 0.0  
181  
182 .13  
183 .13  
184 .13

MAIN2840  
MAIN2850  
MAIN2860  
MAIN2870  
MAIN2880

MAIN3010

MAIN3180  
MAIN3190  
MAIN3200  
MAIN3210  
MAIN3220  
MAIN3230  
MAIN3240  
MAIN3250  
MAIN3260  
MAIN3270

MAIN3300  
MAIN3310  
MAIN3320  
MAIN3330

MAIN3360  
MAIN3370

185	.13	
186	27.6	
187	27.6	
188	10.6	
189	10.6	
190		MAIN3490
191		MAIN3500
192	1.	MAIN3510
193		MAIN3520
194		MAIN3530
195	0.0	
196	0.	
197	0.	
198		MAIN3570
199		MAIN3580
200	1.5	MAIN3590
201		MAIN3600
202	0.8988	
203	-.00009497	
204	0.8988	
205	-.00009497	
206	.6770	
207	.6770	
208	.03	
209	0.	MAIN3680
210	-.00003226	
211	-.00003226	
212	0.	MAIN3710
213	0.	MAIN3720
214	0.	MAIN3730
215	0.0	
216	0.0	
217	0.0	
218	0.	MAIN3770
219	0.	
220	0.	
221	0.0	
222	0.0	
223	0.	MAIN3820
224	0.	MAIN3830
225	0.	MAIN3840
226	0.	MAIN3850
227	0.	MAIN3860
228	0.	MAIN3870
229	0.	MAIN3880
230	0.	MAIN3890
231	400.	
232	400.	
233	1.0	
234		
235		
236		
237		
238	1.9	
239	1.9	
240	1.0	
241	1.0	
242	-.0000372	
243	-.000022	
244	.0000020	

245 -.0002056  
246 0.0  
247 1.045  
248 .00000003991  
249 -.0031764  
250 .0029568  
251 .66  
252 -.0031764  
253 .0029568  
254 .66  
255 0.0  
256 -.001302  
257 -.0027288  
258 -5.796  
259 0.0  
260 -.001302  
261 -.0027288  
262 -5.796  
263 0.  
264 0.  
265 0.  
266 .29  
267 .03  
268 0.  
269 0.  
270 0.  
271 0.  
272 .13  
273 .03  
274 0.  
275 0.0  
276 0.0  
277 0.  
278 0.  
279 0.  
280 0.  
281  
282  
283 0.  
284 0.0  
285 3.56  
286 0.0  
287 2.  
288 0.  
289 4.  
290 .5  
291 4566.64  
292 7.87  
293 2303.58  
294 0.294  
295 -1747.37  
075 .01  
112 50.  
175 .9985  
193 0.0  
194 100.  
195 1200.  
215 100.  
216 100.  
217 1.

MAIN4340  
MAIN4350  
MAIN4360  
MAIN4370  
MAIN4380  
MAIN4390

MAIN4420

MAIN4450

MAIN4470  
MAIN4480

304  
./

ENDUP

MAIN4550  
MAIN4560



G-1.2. Independent Front, Solid Rear Suspensions, Dodge Coronet

091 CARCAL DODGE71  
 DELFW1 DELFW2  
 TAUC  
 CXC CYC CZC CLC CMC CNC  
 SFXS SFYS SFZS  
 SNPHIS SNTHES SNPSIS  
 SFXU SFYU  
 SNPHIU SNTHEU SNPSIU  
 PHIDT THEDT PSIDT  
 PHI THE PSI  
 PDT QDT RDT  
 P Q R  
 UDT VDT WDT  
 U V W

PFL AXAVE TIMDEC AYMAX SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)  
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4) MAIN 50  
 BMPN BMPS AYMAX RMAX CUVRAT BETDMX MAIN 60  
 STR4 BETAMX BETDMX CUVRAT AYMAX RMAX PHIMAX  
 STR5 AYMAX DEL BETAMX DELPSI PHIMAX UIN  
 PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN BRKUFF MAIN 90  
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4) MAIN 100  
 IOUT(01) 50.  
 IOUT(02) 100.  
 IOUT(03) 50.  
 IOUT(04) 625.  
 IOUT(05) .04  
 IOUT(06) 0.4  
 IOUT(07) 2.0  
 IOUT(08) 1.0  
 IOUT(09) .8  
 IOUT(10) .003  
 IOUT(11) 0.25  
 IOUT(12) 0.25  
 IOUT(13) 1.25  
 IOUT(14) 0.1  
 IOUT(15) .2  
 IOUT(16) 1.25  
 IOUT(17) .01  
 IOUT(18) 1.25  
 NOTUSED(1) 1.  
 NOTUSED(1) 1.  
 IOUT(21) -1000.  
 IOUT(22) -1000.  
 IOUT(23) -1000.  
 IOUT(24) -1000.  
 IOUT(25) 10000.  
 IOUT(26) 10.  
 IOUT(27) 400.  
 IOUT(28) 1000.  
 IOUT(29) -1000.  
 IOUT(30) 28.  
 IOUT(31) 10.  
 IOUT(32) 10.  
 IOUT(33) 20000.  
 IOUT(34) 20000.  
 IOUT(35) 20000.  
 IOUT(36) 20000.  
 ETAX 1.4

IOUT(38) 10000.  
IOUT(39) 10000.  
IOUT(40) 10000.  
IOUT(41) 10000.  
IOUT(42) 10000.  
IOUT(43) 10.  
IOUT(44) 10000.  
IOUT(45) 10.  
IOUT(46) 10000.

ETAL 1.4  
BTV 1.5706  
ENDNODAC  
U 1200.  
V 1000.  
W 100.  
PHI -.66667  
PSI 4.  
THE 0.25  
P 2.0  
Q 0.8  
DEL1DT -100.  
DEL2 10.  
DEL2DT -100.  
DEL1 10.  
DELRDT -100.  
DELR 10.  
PHIRDT -10.  
PHIR 1.  
UDT -800.  
VDT -1500.  
R 4.  
DELFW1 -0.5  
DELFW2 -0.5  
RDT -20.

ARPS(1) -100.  
ARPS(2) -100.  
ARPS(3) -100.  
ARPS(4) -100.

S1P 1000.  
S2P 1000.  
ZETDRF 100.  
ZETDLF 100.  
ZETDRR 100.  
ZETDLR 100.  
QDT -2.  
PDT -12.  
WDT 200.  
PHIDT -2.  
THEDT -.25  
PSIDT -2.  
ENDNOADC  
PARAM(341) 0.0  
PARAM(342) 0.0  
PARAM(343) 0.0  
PARAM(344) 0.0

INDXCN 1

VEHICLE MODEL \* DODGE CORONET 1971  
-0.38 .1061661 .1684393 .01604185 -.00579372-.00220835 0.0

MAIN 590

MAIN 880

MAIN 890

MAIN 900

0.75	0.0	0.0	0.0	0.0	0.0	0.0	MAIN9110
-0.27	-.2416662	-.00944941	.01291661	-.00089631	-.00125	0.0	
0.0	0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	0.0	0.0	0.0	0.0	0.0	MAIN9140
0.0	0.0	0.0	0.0	0.0	0.0	0.0	MAIN9150

TABLE I - FRONT BRAKE TORQUE FUNCTION

1000.	20640.						
99999.							MAIN9190

TABLE II - REAR BRAKE TORQUE FUNCTION

0.	0.						
1000.	20640.						
99999.							MAIN9230

TABLE III - SIDE FORCE SHAPING FUNCTION

0.	0.						
.05	.01						
.1	.03						
.15	.07						
.2	.17						
.3	.35						
.4	.54						
.6	.81						
.8	.93						
1.	1.						

WIND PROFILE

99999.							MAIN9410
-1000.	528.						
0.	528.						
1000.	528.						
99999.							
0.0	0.0	0.0	0.0	0.0	0.0	0.0	AERO
99999.							
0.0	0.0						

STEER PROFILE

0.0	0.0						
0.25	-13.6						
1.25	-31.45						
1.55	135.						
1.75	125.46						
2.0	62.73						
2.3	-200.						
2.5	-204.						
6.	-204.						

RIGHT FRONT SPRING DATA

99999.							
-10.0	-1688.						
-2.4	-252.						
0.0	0.0						
2.1	221.						
10.0	4866.						

LEFT FRONT SPRING DATA

99999.							
-10.0	-1688.						
-2.4	-252.						
0.0	0.0						
2.1	221.						
10.0	4866.						

RIGHT REAR SPRING DATA

99999.							
-10.0	-2342.						
-4.4	-528.						
0.0	0.0						
3.6	432.						
10.0	5962.						

LEFT REAR SPRING DATA

99999.							
-10.0	-2342.						
-4.4	-528.						

0.0 0.0  
 3.6 432.  
 10.0 5962.

99999.

-100. -433.

RIGHT FRONT SHOCK ABSORBER DATA

0.0 0.0

100. 936.

99999.

-100. -433.

LEFT FRONT SHOCK ABSORBER DATA

0.0 0.0

100. 936.

99999.

-100. -199.

RIGHT REAR SHOCK ABSORBER DATA

-7.2 -59.9

0.0 0.0

100. 663.

99999.

-100. -199.

LEFT REAR SHOCK ABSORBER DATA

-7.2 -59.9

0.0 0.0

100. 663.

99999.

066	40.	40.	40.	30.	40.	45.	50.
074	0.	0.	0.	30.	0.	0.	0.
076	5.	10.	10.	5.	5.5	4.	3.
112					55.		
114	62.	0.	82.	139.	0.	0.	0.
115	1.	0.	1.	1.	1.	0.	0.
116	.5	100.	.5	.5	.4	100.	100.
117	3.	0.	3.	0.	0.	0.	0.
118	3.	0.	3.	0.	0.	0.	0.
121	300.	200.	200.	0.	0.	0.	1000.
124	0.	0.	0.	0.	0.	2.	1.
125	0.	0.	0.	0.	0.	0.	1.
126	0.	0.	0.	0.	0.	1.	1.
128	3.	1.	3.	4.	2.	5.	6.
192	1.	.1	.1	.1	.1	.1	.05
198	0.	0.	0.	12.	0.	0.	0.
199	0.	0.	0.	57.6	0.	0.	0.
201	0.	0.	0.	1000.	0.	0.	0.
277	0.	0.	0.	8.	0.	0.	0.
278	0.	0.	0.	0.	0.	0.	.52
279	0.	0.	0.	0.	0.	0.	1.02
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.

001 8.43

002 0.51

003 0.82

004 11.3

005 11.3

006 49.3

007 68.7

008 59.8

009 61.8

010 47.0

011 3758.

012 23047.  
013 23327.  
014 530.  
015 550.  
016 30.  
017 40400.  
018 10.  
019 105.0  
020 105.0  
021 120.0  
022 120.0  
023 0.  
024 -5100.  
025 40.0  
026 40.0  
027 38.0  
028 38.0  
029 0.  
030 0.020  
031 13.2  
032 1000.  
033 0.75  
034 2701.  
035 10.14  
036 2533.  
037 1.30  
038 4591.  
039 0.0  
040 0.0  
041 8000.  
042 14.2  
043  
044  
045  
046  
047 6.4  
048 0.0  
049 9.4  
050 9.4  
051 0.7  
052 2.71  
053 0.0  
054 0.0  
055 -0.66  
056 4.59  
057 -4.59  
058 -.1309  
059 .1309  
060 1.0  
061 0.0  
062 0.0  
063  
064  
065  
066 40.  
067  
068  
069  
070  
071

MAIN9800

MAIN9900

MAIN0200  
MAIN0210  
MAIN0220

MAIN0240  
MAIN0250  
MAIN0260  
MAIN0270

072		MAIN0290
073		MAIN0300
074		MAIN0310
075	.005	
76	5.0	
077	1450.	
078	1450.	
079	1450.	
080	1450.	
081		
082		
083		
084		
085	-.00033	
086	0.0	
087	1.228	
088	.0000000759	
089		MAIN0460
090		MAIN0470
091	0.0	MAIN0480
092	-0.8	
093	-.68	
094		MAIN0510
095		MAIN0520
096		MAIN0530
097		MAIN0540
098		MAIN0550
099		MAIN0560
100		MAIN0570
101		MAIN0580
102		MAIN0590
103		MAIN0600
104		MAIN0610
105		MAIN0620
106		MAIN0630
107	1.0	MAIN0640
108	0.5	
109	0.0	
110	0.0	
111	0.0	
112	0.0	
113	1.	MAIN0700
114	25.	
115	1.0	
116	0.5	
117	3.	
118	3.	
119		MAIN0760
120		MAIN0770
121	300.	
122		MAIN0790
123		MAIN0800
124		MAIN0810
125		MAIN0820
126		MAIN0830
127		MAIN0840
128	3.0	
129	0.	MAIN0860
130	0.06	
131	.2792	

132 55900.  
133 55900.  
134 6.62  
135 6.62  
136 11.0  
137 54.  
138 5.20  
139 .00785  
140 .00785  
141 0.  
142 88.  
143 .03  
144 .04  
145 .001  
146 .10  
147 .010  
148 .001  
149 .006  
150 .001  
151 .001  
152 .0001  
153 .0001  
154 .0003  
155 .0004  
156 500.  
157  
158  
159  
160  
161  
162  
163  
164  
165  
166  
167  
168  
169 73.  
170 73.  
171 73.  
172 2.  
173  
174  
175 0.25  
176 1.  
177  
178  
179  
180 0.0  
181  
182 0.17  
183 0.17  
184 0.17  
185 0.17  
186 9.36  
187 9.36  
188 6.63  
189 6.63  
190  
191

MAIN0980

MAIN1140  
MAIN1150  
MAIN1160  
MAIN1170  
MAIN1180  
MAIN1190  
MAIN1200  
MAIN1210  
MAIN1220  
MAIN1230  
MAIN1240  
MAIN1250

MAIN1290  
MAIN1300  
MAIN1310  
MAIN1320

MAIN1340  
MAIN1350

MAIN1470  
MAIN1480

192	1.	MAIN1490
193		MAIN1500
194		MAIN1510
195		MAIN1520
196	0.	
197	0.	
198		
199		MAIN1570
200	1.5	
201		
202	0.94	
203	-.00008	
204	0.94	
205	-.00008	
206	0.65	
207	0.65	
208	.03	
209	0.	
210	0.	MAIN1680
211	0.0	
212	0.	
213	0.	MAIN1710
214	0.	
215	0.	
216	0.	
217	0.	
218	0.	
219	0.	
220	0.	
221	0.	
222	0.	
223	0.0	
224	0.	
225	0.	
226	0.	
227	0.	
228	0.	
229	0.	
230	0.	
231	400.	
232	400.	
233	1.0	
234		
235		
236		
237		
238	1.	
239	1.	
240	.67	
241	.67	
242	-.0000393	
243	-.0000332	
244	.00000175	
245	-.00033	
246	0.0	
247	1.228	
248	.0000000759	
249	-.00318	
250	.00349	
251	1.404	



252	-.00318	
253	.00349	
254	1.404	
255	0.0	
256	-.0015	
257	-.005244	
258	-5.592	
259	0.0	
260	-.0015	
261	-.005244	
262	-5.592	
263	-0.13	
264	-.03	
265	.0	
266	0.15	
267	.015	
268	.0	
269	0.089	
270	.01	
271	.0	
272	0.0	
273	.0	
274	.0	
275	0.0	
276	0.0	MAIN2340
277	0.	MAIN2350
278	0.	MAIN2360
279	0.	MAIN2370
280	0.	
281		
282		MAIN2400
283	0.	
284	2.7	
285	3.9	
286	0.0	
287	1.	MAIN2450
288	0.	
289	4.	MAIN2470
290	0.75	
291	2701.	
292	10.14	
293	2533.	
294	1.30	
295	4591.	
001	8.82	
004	10.9	
005	10.8	
006	50.5	
007	67.5	
011	3832.	
012	24003.	
013	24311.	
092	-1.1	
093	-1.08	MAIN2660
304		
./	ENDUP	

G-1.3. Solid Front and Rear Suspension with Dual Rear Tires,  
Winnebago Motor Home

091 CARCAL MOTOR

DELFW1 DELFW2

TAUC

CXC CYC CZC CLC CMC CNC

SFXS SFYS SFZS

SNPHIS SNTHES SNPSIS

SFXU SFYU

SNPHIU SNTHEU SNPSIU

PHIDT THEDT PSIDT

PHI THE PSI

PDT QDT RDT

P Q R

UDT VDT WDT

U V W

PFL AXAVE TIMDEC AYMAX SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)

PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)

MAIN 50

BMPN BMPS AYMAX RMAX CUVRAT BETDMX

MAIN 60

STR4 BETAMX BETDMX CUVRAT AYMAX RMAX PHIMAX

STR5 AYMAX DEL BETAMX DELPSI PHIMAX UIN

PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN BRKOFF

MAIN 90

PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)

MAIN 100

IOUT(01) 50.

IOUT(02) 100.

IOUT(03) 50.

IOUT(04) 625.

IOUT(05) .04

IOUT(06) 0.4

IOUT(07) 2.0

IOUT(08) 1.0

IOUT(09) .8

IOUT(10) .003

IOUT(11) 0.25

IOUT(12) 0.25

IOUT(13) 1.25

IOUT(14) 0.1

IOUT(15) .2

IOUT(16) 1.25

IOUT(17) .01

IOUT(18) 1.25

NOTUSED(1) 1.

NOTUSED(1) 1.

IOUT(21) -1000.

IOUT(22) -1000.

IOUT(23) -1000.

IOUT(24) -1000.

IOUT(25) 10000.

IOUT(26) 10.

IOUT(27) 400.

IOUT(28) 1000.

IOUT(29) -1000.

IOUT(30) 28.

IOUT(31) 10.

IOUT(32) 10.

IOUT(33) 20000.

IOUT(34) 20000.

IOUT(35) 20000.

IOUT(36) 20000.

ETAX 1.4

IOUT(38) 10000.  
IOUT(39) 10000.  
IOUT(40) 10000.  
IOUT(41) 10000.  
IOUT(42) 10000.  
IOUT(43) 10.  
IOUT(44) 10000.  
IOUT(45) 10.  
IOUT(46) 10000.

ETAL 1.4  
BTV 1.5706  
ENDNODAC  
U 1200.  
V 1000.  
W 100.  
PHI -.66667  
PSI 4.  
THE 0.25  
P 2.0  
Q 0.8  
DELFDT -100.  
PHIF 1.  
PHIFDT -10.  
DELF 10.  
DELRDT -100.  
DELR 10.  
PHIRDT -10.  
PHIR 1.  
UDT -800.  
VDT -1500.  
R 4.  
DELFW1 -0.5  
DELFW2 -0.5  
RDT -20.

MAIN 590

ARPS(1) -100.  
ARPS(2) -100.  
ARPS(3) -100.  
ARPS(4) -100.

S1P 4000.  
S2P 4000.  
ZETDRF 100.  
ZETDLF 100.  
ZETDRR 100.  
ZETDLR 100.  
QDT -2.  
PDT -12.  
WDT 200.  
PHIDT -2.  
THEDT -.25  
PSIDT -2.  
ENDNOADC  
PARAM(341) 0.0  
PARAM(342) 0.0  
PARAM(343) 0.0  
PARAM(344) 0.0

MAIN 880

INDXCN 1

MAIN 890

MAIN 900

VEHICLE MODEL \* WINNEBAGO MOTOR HOME TYPE A (DODGE RM 400/158.5" WB)  
0.0 0.0 0.0 0.0 0.0 0.0

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

TABLE I \* BRAKE TORQUE FUNCTION

80.	0.0
1000.	53000.
1600.	75000.
99999.	

TABLE II \* BRAKE TORQUE FUNCTION

0.0	0.0
80.	0.0
1000.	53000.
1600.	75000.
99999.	

TABLE III- SIDE FORCE SHAPING FUNCTION

0.	0.
.05	.01
.1	.03
.15	.07
.2	.17
.3	.35
.4	.54
.6	.81
.8	.93
1.	1.

99999.	
1128.	0.0
1140.	1056.
1248.	1056.
1260.	0.0
99999.	

WIND PROFILE DATA

MAIN1180

0.0	.78	0.0	.15	0.0	.19	0.0
0.08727	.79	.33	.29	.12	.25	-.12
0.1745	.83	.58	.45	.20	.29	-.15
0.2618	.90	.90	.55	.34	.33	-.15
0.3491	.94	1.33	.84	.48	.35	-.15
0.4364	.94	1.82	1.11	.64	.37	-.17
1.6	0.0	0.0	0.0	0.0	0.0	0.0
3.14	0.0	0.0	0.0	0.0	0.0	0.0

AERO

99999.	
0.0	0.0
.08727	0.0
.1745	0.0
.2618	0.0
.3491	0.0
.4364	0.0
1.6	0.0
3.14	0.0

STEER PROFILE DATA

0.0	0.0
0.25	-13.6
1.25	-31.45
1.55	135.
1.75	125.46
2.0	62.73
2.3	-200.
2.5	-204.
6.	-204.

99999.	
-10.0	-6579.

RIGHT FRONT SPRING DATA

-2.3 -1035.0  
 0.0 0.0  
 3.1 1395.0  
 10.0 10089.

99999.

-10.0 -6579.  
 -2.3 -1035.0  
 0.0 0.0  
 3.1 1395.0  
 10.0 10089.

99999.

-10.0 -10366.5  
 -3.9 -3412.5  
 0.0 0.0  
 2.7 2362.5  
 10.0 15137.5

99999.

-10.0 -10366.5  
 -3.9 -3412.5  
 0.0 0.0  
 2.7 2362.5  
 10.0 15137.5

99999.

-100. -391.8  
 -8.4 -107.9  
 0.0 0.0  
 1.4 165.4  
 6. 280.5  
 100. 1182.9

99999.

-100. -391.8  
 -8.4 -107.9  
 0.0 0.0  
 1.4 165.4  
 6. 280.5  
 100. 1182.9

99999.

-100. -799.8  
 -9.8 -34.  
 0.0 0.0  
 0.8 58.8  
 4.4 108.3  
 100. 618.8

99999.

-100. -799.8  
 -9.8 -34.  
 0.0 0.0  
 0.8 58.8  
 4.4 108.3  
 100. 618.8

99999.

066	40.	40.	40.	30.	40.	45.	50.
074	0.	0.	0.	30.	0.	0.	0.
076	5.	10.	10.	5.	5.5	4.	3.
114	62.	0.	62.	77.	0.	0.	0.
115	1.	0.	1.	1.	1.	0.	0.
116	.5	100.	.5	.5	.4	100.	100.
117	3.	0.	3.	0.	0.	0.	0.
118	3.	0.	3.	0.	0.	0.	0.
121	300.	200.	200.	0.	0.	0.	1000.

124	0.	0.	0.	0.	0.	2.5	1.
125	0.	0.	0.	0.	0.	0.	1.
126	0.	0.	0.	0.	0.	1.	1.
128	3.	1.	3.	4.	2.	5.	6.
192	1.	.1	.1	.1	.1	.1	.05
198	0.	0.	0.	12.	0.	0.	0.
199	0.	0.	0.	57.6	0.	0.	0.
201	0.	0.	0.	1000.	0.	0.	0.
277	0.	0.	0.	8.	0.	0.	0.
278	0.	0.	0.	0.	0.	0.	.52
279	0.	0.	0.	0.	0.	0.	1.02
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
123	0.	0.	0.	0.	0.	0.	0.
001	24.609						
002	1.721						
003	2.888						
004	36.30						
005	36.19						
006	99.41						
007	59.09						
008	66.15						
009	66.12						
010	41.24						
011	40300.						
012	219100.						
013	216500.						
014	7100.						
015	2400.						
016	30.						
017	153000.						
018	10.						
019	450.						
020	450.						
021	875.						
022	875.						
023	0.						
024	153000.						
025	100.						
026	100.						
027	150.						
028	150.						
029	0.0						
030	-.01						
031	16.87						
032	4000.						
033	1.0						
034	635.2						
035	11.98						
036	5447.9						
037	1.89						
038	6306.2						
039	56.62						
040	75.62						
041	8000.						
042	17.5						

MAIN1820

043		
044		
045		
046		
047	27.0	
048	1500.	
049	21.3	
050	48.0	
051	1.30	
052	4.56	
053	31.0	
054	.07	
055	1.31	
056	6.08	
057	-6.08	
058	-.12217	
059	.12217	MAIN2190
060	1.0	
061	0.	
062	0.	
063		MAIN2220
064		MAIN2230
065		MAIN2240
066	40.	MAIN2250
067		MAIN2260
068		MAIN2270
069		MAIN2280
070		MAIN2290
071		MAIN2300
072		MAIN2310
073		MAIN2320
074		MAIN2330
075	.005	
76	5.0	MAIN2350
077	3040.	
078	3040.	
079	3040.	
080	3040.	
081		MAIN2400
082		MAIN2410
083		MAIN2420
084		MAIN2430
085	-.000236	
086	0.0	
087	1.32	
088	.0000000297	
089		MAIN2480
090		MAIN2490
091	0.0	MAIN2500
092	0.0	
093	0.0	
094		MAIN2530
095		MAIN2540
096		MAIN2550
097		MAIN2560
098		MAIN2570
099		MAIN2580
100		MAIN2590
101		MAIN2600
102		MAIN2610

103		MAIN2620
104		MAIN2630
105		MAIN2640
106		MAIN2650
107	1.0	MAIN2660
108	.4	MAIN2670
109	0.0	
110	4428.	MAIN2690
111	738.	MAIN2700
112	0.0	MAIN2710
113	1.	MAIN2720
114	62.	MAIN2730
115	1.0	MAIN2740
116	0.5	MAIN2750
117	3.	MAIN2760
118	3.	MAIN2770
119	0.0	
120	0.0	
121	300.	MAIN2800
122		MAIN2810
123		MAIN2820
124		MAIN2830
125		MAIN2840
126		MAIN2850
127		MAIN2860
128	3.0	MAIN2870
129	0.	MAIN2880
130	.078	
131	.279	
132	150000.	
133	150000.	
134	8.02	
135	8.02	
136	11.	
137	120.	
138	7.50	
139	.009	
140	-.009	
141	0.	MAIN3000
142	0.0	MAIN3010
143	0.	
144	0.	
145	.0000001147	
146	0.0	
147	0.0	MAIN3060
148	0.0	MAIN3070
149	0.0	MAIN3080
150	0.0	MAIN3090
151	0.0	MAIN3100
152	0.0	MAIN3110
153	0.0	MAIN3120
154	0.0	MAIN3130
155	0.0	MAIN3140
156	9100.	
157	294.	
158	1094.	
159		MAIN3180
160		MAIN3190
161		MAIN3200
162		MAIN3210



163  
164  
165  
166  
167  
168  
169 73.  
170 75.  
171 75.  
172 2.  
173  
174  
175 0.25  
176 1.  
177  
178  
179  
180 0.0  
181  
182 .20  
183 .20  
184 .20  
185 .20  
186 118.15  
187 118.15  
188 73.5  
189 73.5  
190  
191  
192 1.  
193  
194  
195  
196 -.0018  
197 .0018  
198  
199  
200 1.5  
201  
202 1.04  
203 -.0000758  
204 1.04  
205 -.0000758  
206 .72  
207 .72  
208 .03  
209 0.  
210 0.  
211 0.0  
212 0.  
213 0.  
214 0.  
215 0.  
216 0.  
217 0.  
218 0.  
219 .0349  
220 -0.0349  
221 .0698  
222 .0698

MAIN3220  
MAIN3230  
MAIN3240  
MAIN3250  
MAIN3260  
MAIN3270

MAIN3300  
MAIN3310  
MAIN3320  
MAIN3330  
MAIN3340

MAIN3360  
MAIN3370

MAIN3490  
MAIN3500  
MAIN3510  
MAIN3520  
MAIN3530  
MAIN3540

MAIN3570  
MAIN3580  
MAIN3590  
MAIN3600

MAIN3680  
MAIN3690  
MAIN3700  
MAIN3710  
MAIN3720  
MAIN3730  
MAIN3740  
MAIN3750  
MAIN3760  
MAIN3770

223 0.  
224 0.  
225 0.  
226 0.  
227 0.  
228 0.  
229 0.  
230 0.  
231 600.  
232 600.  
233 0.  
234  
235  
236  
237  
238 1.13  
239 1.13  
240 1.0  
241 1.0  
242 -.000020  
243 -.000020  
244 .0000015  
245 -.000236  
246 0.0  
247 1.32  
248 .0000000297  
249 -.00157  
250 .00148  
251 1.608  
252 -.00157  
253 .00148  
254 1.608  
255 0.0  
256 -.000624  
257 .00240  
258 -9.132  
259 0.0  
260 -.000624  
261 .00240  
262 -9.132  
263 0.  
264 0.  
265 0.  
266 0.  
267 0.  
268 0.  
269 0.  
270 0.  
271 0.  
272 0.  
273 0.  
274 0.  
275 0.0  
276 0.0  
277 0.  
278 0.  
279 0.  
280 0.  
281  
282

MAIN3820  
MAIN3830  
MAIN3840  
MAIN3850  
MAIN3860  
MAIN3870  
MAIN3880  
MAIN3890

MAIN4380  
MAIN4390

283 0.  
284 0.  
285 0.  
286 0.0  
287 0.  
288 1.  
289 6.  
290 1.0  
291 635.2  
292 11.98  
293 5447.9  
294 1.89  
295 6306.2  
304  
./      ENDUP

MAIN4420

MAIN4450

MAIN4550

G-2. Wheel Spring and Shock Absorber Characteristics

G-2.1 Wheel Spring Characteristics

The entries in this table are the values of the slopes versus suspension displacement for the no-load (curb weight) vehicle configuration. The units of the entries are lb/in. and in.

Vehicle	Spring Force Effective at the Wheel for the Independent Front Suspension and at the Spring Location for the Solid Front Axle	Spring Force Effective at the Wheel for the Independent Rear Suspension and at the Spring Location for the Solid Rear Axle
VW Campmobile	935 for $\delta \geq 0.43$ 129 for $-3.74 < \delta < 0.43$ 361 for $-4.92 < \delta \leq -3.74$ 896 for $-5.67 < \delta \leq -4.92$ 4413 for $\delta \leq -5.67$	991 for $\delta \geq 2.28$ 213 for $-1.57 < \delta < 2.28$ 328 for $-3.54 < \delta \leq -1.57$ 454 for $-4.61 < \delta \leq -3.54$ 2766 for $\delta \leq -4.61$
Dodge Coronet	558 for $\delta > 2.1$ 105 for $-2.4 < \delta < 2.1$ 189 for $\delta < -2.4$	864 for $\zeta \geq 3.6$ 120 for $-4.4 < \zeta < 3.6$ 324 for $\zeta \leq -4.4$
Winnebago Motor Home	1260 for $\zeta \geq 3.1$ 450 for $-2.3 < \zeta < 3.1$ 720 for $\zeta \leq -2.3$	1750 for $\zeta \geq 2.7$ 875 for $-3.9 < \zeta < 2.7$ 1140 for $\zeta \leq -3.9$

G-2.2 Shock Absorber Characteristics

The entries in this table are the values of the slopes versus suspension velocity. The units of the entries are lb/(in./s) and in./s.

Vehicle	Viscous Damping Force Effective at the Wheel for the Independent Front Suspension and at the Spring Location for the Solid Front Axle	Viscous Damping Force Effective at the Wheel for the Independent Rear Suspension and at the Spring Location for the Solid Rear Axle
VW Campmobile	5.14 for $\dot{\delta} \geq 11.8$ 17.63 for $3.0 \leq \dot{\delta} < 11.8$ 9.55 for $0 \leq \dot{\delta} < 3.0$ 4.06 for $-15.0 \leq \dot{\delta} < 0$ 2.09 for $\dot{\delta} < -15.0$	11.24 for $\dot{\delta} > 9.8$ 35.60 for $4.2 \leq \dot{\delta} < 9.8$ 22.86 for $0 \leq \dot{\delta} < 4.2$ 7.93 for $-10.6 \leq \dot{\delta} < 0$ 2.49 for $\dot{\delta} < -10.6$
Dodge Coronet	9.36 for $\dot{\delta} \geq 0$ 4.33 for $\dot{\delta} < 0$	6.63 for $\dot{\zeta} \geq 0$ 8.32 for $-7.2 < \dot{\zeta} < 0$ 1.50 for $\dot{\zeta} < -7.2$
Winnebago Motor Home	9.6 for $\dot{\zeta} \geq 6.0$ 25.02 for $1.4 \leq \dot{\zeta} < 6.0$ 118.15 for $0 \leq \dot{\zeta} < 1.4$ 12.84 for $-8.4 \leq \dot{\zeta} < 0$ 3.10 for $\dot{\zeta} < -8.4$	5.34 for $\dot{\zeta} \geq 4.4$ 13.76 for $0.8 \leq \dot{\zeta} < 4.4$ 73.50 for $0 \leq \dot{\zeta} < 0.8$ 3.47 for $-9.8 \leq \dot{\zeta} < 0$ 8.49 for $\dot{\zeta} < -9.8$

G-3. Camber, Caster, and Toe Data

To obtain these data, the wheel was moved from the full rebound position to compression bump stop. In order to use these data in calculations, one must know the values of camber, caster, and toe at a reference value of suspension displacement that depends upon vehicle loading. The units of the entries are in. and deg. The data presented here were measured with reference to a no-load (curb weight) vehicle configuration.

Vehicle	Displacement	Camber	Caster	Toe
VW Campmobile (right front wheel) (static displacement = 0.0)	0.5	1.00	2.67	-0.10
	0.0	0.95	2.77	-0.07
	-1.0	0.90	2.85	-0.05
	-2.0	0.80	2.95	-0.02
	-3.0	0.70	3.00	0.00
	-4.0	0.60	3.05	0.03
	-5.0	0.50	3.08	0.07
	-5.5	0.35	3.05	0.10
VW Campmobile (right rear wheel) (static displacement = 0.0)	2.5	0.80	0.00	-0.333
	2.0	0.45	0.00	-0.258
	1.0	-3.00	0.00	-0.146
	0.0	-1.00	0.00	-0.050
	-1.0	-1.75	0.00	0.000
	-2.0	-2.50	0.00	0.000
	-3.0	-3.35	0.00	-0.004
	-4.0	-4.25	0.00	-0.075
-4.5	-4.85	0.00	-0.162	
Dodge Coronet (left front wheel) (static displacement = 3.0)	0.	0	0.75	0
	1.	0.41	0.00	-0.37
	2.	0.98	0.00	-0.59
	3.	1.26	0.00	-0.85
	4.	1.22	0.00	-1.05
	5.	0.95	0.00	-1.21
	6.	0.43	0.00	-1.36
Winnebago Motor Home	The attitudes of the wheels of a solid axle suspension are evaluated from axle angular displacement, suspension geometry (roll steer), and suspension compliance.			

PARAMETER VALUES - MODEL C - VEHICLE MODEL \* VW CAMPMOBILE 1973

1	MS=	8.6000	2	MUF=	0.50700	3	MUR=	0.48900	4	ZF=	19.980	5	ZR=	19.920
6	A=	49.650	7	B=	24.850	8	TF=	54.800	9	TR=	57.200	10	TSR=	0.0
11	IX=	7380.0	12	IY=	44980.0	13	IZ=	25660.0	14	IXZ=	1140.0	15	IR=	0.65967E+06
16	ROOR=	30.000	17	RF=	0.15300E+06	18	STOP=	10.000	19	AKF1=	129.00	20	AKF2=	129.00
21	AKR3=	213.00	22	AKR4=	213.00	23	ALS=	0.0	24	RR=	0.0	25	CF1P=	33.000
26	CF2P=	33.000	27	CR3P=	56.000	28	CR4P=	56.000	29	ZBAS=	0.0	30	KRS=	0.0
31	RW=	12.750	32	SCAL=	2000.0	33	FOT=	0.50000	34	A0=	4566.6	35	A1=	7.8700
36	A2=	2303.6	37	A3=	0.29400	38	A4=	-1747.4	39	TTR=	0.0	40	TOR=	0.0
41	KSC=	R592.0	42	NG=	16.300	43	TSD=	0.0	44	DSLME=	0.0	45	TFT=	0.0
46	DSW2=	0.0	47	IFW=	8.2700	48	IF=	0.6969/E+06	49	IWF=	8.9300	50	IWR=	9.2800
51	IDR=	0.30000	52	ARR=	5.3750	53	TSF=	0.0	54	KFS=	0.0	55	PT=	0.59000
56	YSA1=	3.4700	57	YSA2=	-3.4700	58	PHS1=	-0.87300E-01	59	PHS2=	0.87300E-01	60	CTSW=	1.0000
61	IDF=	0.0	62	ARF=	0.0	63	P-IN=	0.0	64	Q-IN=	0.0	65	R-IN=	0.0
66	U-IN=	40.000	67	V-IN=	0.0	68	PHIN=	0.0	69	X-IN=	0.0	70	Y-IN=	0.0
71	Z-IN=	-31.659	72	THIN=	0.91247E-01	73	PHIN=	0.0	74	PSIN=	0.0	75	DT=	0.10000E-01
76	TN=	5.0000	77	KT1=	894.00	78	KT2=	894.00	79	KT3=	894.00	80	KT4=	894.00
81	RPS1=	0.0	82	RPS2=	0.0	83	RPS3=	0.0	84	RPS4=	0.0	85	BL=	-0.20560E-03
86	R2=	0.0	87	R3=	1.0450	88	R4=	0.39910E-07	89	D1DT=	0.0	90	D2DT=	0.0
91	D3DT=	0.0	92	DELF=	-1.5400	93	DELF=	-1.0300	94	DEL3=	0.0	95	PHDT=	0.0
96	PHIR=	0.0	97	DFW1=	0.0	98	DFW2=	0.0	99	UIPR=	0.0	100	U2PR=	0.0
101	U3PR=	0.0	102	U4PR=	0.0	103	S1PR=	0.0	104	S1PR=	0.0	105	S2PR=	0.0
106	S4PR=	0.0	107	PPRT=	1.0000	108	FREQ=	0.40000	109	U1PR=	0.0	110	TQMX=	4428.0
111	KTQ=	738.00	112	VC=	50.000	113	MTSW=	1.0000	114	S2PR=	0.0	115	TST=	1.0000
116	DSLPE=	0.45000	117	CGAM=	3.0000	118	CS=	3.0000	119	TGR=	0.0	120	TGF=	0.0
121	PFL=	300.00	122	TTD=	0.0	123	DSW1=	0.0	124	VHTP=	0.0	125	ISW5=	0.0
126	SW15=	0.0	127	TTD=	0.0	128	WTPS=	3.0000	129	VHTP=	0.0	130	AMCR=	0.38000E-01
131	ESP=	0.32000	132	KSL1=	44000.0	133	KSL2=	44000.0	134	AA1=	6.2000	135	AA2=	6.2000
136	CCR=	17.600	137	CFCK=	126.00	138	AP=	5.6800	139	EPI=	0.10000E-01	140	EP2=	0.10000E-01
141	AERQ=	0.0	142	VYW=	0.0	143	OMXW=	0.0	144	OMZW=	0.0	145	RHOA=	0.11470E+06
146	CYP=	0.0	147	CYR=	0.0	148	CZAL=	0.0	149	CZG=	0.0	150	CLP=	0.0
151	CLR=	0.0	152	CMAL=	0.0	153	CMG=	0.0	154	CNP=	0.0	155	CNR=	0.0
156	SF=	4233.6	157	VLEN=	94.500	158	REWV=	1094.0	159	CNP=	0.0	160	CNR=	0.0
161	=	0.0	162	=	0.0	163	=	0.0	164	=	0.0	165	=	0.0
166	=	0.0	167	=	0.0	168	=	0.0	169	SNT=	73.000	170	SNS0=	75.000
171	SNS1=	75.000	172	SNSW=	2.0000	173	DIST=	0.0	174	PL=	0.0	175	TSCP=	0.99850
176	SCSW=	1.0000	177	=	0.0	178	=	0.0	179	=	0.0	180	=	0.0
181	=	0.0	182	S11=	0.13000	183	S12=	0.13000	184	S13=	0.13000	185	S14=	0.13000
186	SARF=	27.600	187	SALF=	27.600	188	SARR=	10.600	189	SALR=	10.600	190	=	0.0
191	=	0.0	192	MTQB=	1.0000	193	DCSW=	0.0	194	LDF=	100.00	195	LDRF=	1200.0
196	EK1=	0.0	197	EK2=	0.0	198	BMPLE=	0.0	199	AMPS=	0.0	200	BMPH=	1.5000
201	XB=	0.0	202	APF1=	0.89480	203	APF2=	-0.9497UE-04	204	APR1=	0.89480	205	APR2=	0.94970E-04
206	MUSE=	0.67700	207	MUSH=	0.67700	208	HCON=	0.30000E-01	209	FCSW=	0.0	210	SIF=	-0.32260E-04
211	S1R=	-0.32260E-04	212	KLR=	0.0	213	KOTF=	0.0	214	KOTR=	0.0	215	=	100.00
216	=	100.00	217	=	1.0000	218	=	0.0	219	FEEL=	0.0	220	=	0.0
221	THE1=	0.0	222	THE2=	0.0	223	ALMC=	0.0	224	=	0.0	225	=	0.0
226	=	0.0	227	=	0.0	228	=	0.0	229	=	0.0	230	=	0.0
231	H1=	400.00	232	H2=	400.00	233	LAMD=	1.0000	234	=	0.0	235	=	0.0
236	PSO1=	0.0	237	PSO2=	0.0	238	KH1=	1.9000	239	RR2=	1.9000	240	BR3=	1.0000
241	RR4=	1.0000	242	KCF=	-0.37200E-04	243	KCF=	-0.22000E-04	244	KSR=	0.20000E-05	245	RBI=	-0.20560E-03
246	RR2=	0.0	247	RR3=	1.0450	248	RR4=	0.39910E-07	249	AFK1=	-0.31764E-02	250	AFK2=	0.29568E-02
251	AFK3=	0.66000	252	ARX1=	-0.31764E-02	253	ARX2=	-0.29568E-02	254	ARK3=	0.66000	255	OF0=	0.0
256	OF0=	-0.13020E-02	257	OF02=	-0.27288E-02	258	OF03=	-5.7456	259	ORC1=	-0.13020E-02	260	ORC2=	0.0
261	ORC3=	-0.27288E-02	262	ORC3=	-5.7960	263	CF0F=	0.0	264	CP1F=	0.0	265	CP2F=	0.0
266	CP0R=	0.29000	267	CP1R=	0.30000E-01	268	CP2R=	0.0	269	CR0F=	0.0	270	CR1F=	0.0
271	CR2F=	0.0	272	CR0R=	0.13000	273	CR1R=	0.30000E-01	274	CR2R=	0.0	275	STSW=	0.0
276	MMSW=	0.0	277	RMPN=	0.0	278	TGB0=	0.0	279	TGB1=	0.0	280	=	0.0
281	=	0.0	282	=	0.0	283	=	0.0	284	HFC=	0.0	285	HRC=	3.5600
286	DRSW=	0.0	287	AXLE=	2.0000	288	DUAL=	0.0	289	TIRE=	4.0000	290	ROT=	0.50000
291	HA0=	4566.6	292	RA1=	7.8700	293	RA2=	2303.6	294	RA3=	0.29400	295	RA4=	-1.747.4

PARAMETER VALUES - MODEL C - VEHICLE MODEL \* DODGE CORONET 1971

1	MS=	8.8200	2	MUF=	0.51000	3	MUR=	0.82000	4	ZF=	10.900	5	ZR=	10.800
6	A=	50.500	7	B=	67.500	8	TF=	59.800	9	TR=	61.800	10	TSR=	47.000
11	IX=	3832.0	12	IY=	24003.	13	IY=	24311.	14	IXZ=	530.00	15	IR=	550.00
16	ROOR=	30.000	17	RF=	40.000	18	STOP=	10.000	19	AKF1=	105.00	20	AKF2=	105.00
21	AKR3=	120.000	22	AKR4=	120.000	23	ALS=	0.0	24	RR=	-5100.0	25	CF1P=	40.000
26	CF2P=	40.000	27	CR4P=	38.000	28	CR4P=	38.000	29	ZBAS=	0.0	30	KRS=	0.20000E-01
31	RW=	13.200	32	SCAL=	1000.0	33	F0I=	0.75000	34	A0=	2701.0	35	A1=	10.140
36	A2=	2533.0	37	A3=	1.3000	38	A4=	4591.0	39	TIR=	0.0	40	TOR=	0.0
41	KSC=	8000.0	42	NG=	14.200	43	TSD=	0.0	44	DSLML=	0.0	45	TFT=	0.0
46	DSW2=	0.0	47	IFW=	6.4000	48	IF=	0.0	49	IWF=	9.4000	50	IWR=	9.4000
51	IDR=	0.70000	52	ARR=	2.7100	53	TSF=	0.0	54	KFS=	0.0	55	PT=	-0.66000
56	YSA1=	4.5900	57	YSA2=	-4.5900	58	PHS1=	-0.13090	59	PHS2=	0.13090	60	CTS=	1.0000
61	IDF=	0.0	62	ARF=	0.0	63	P-IN=	0.0	64	X-IN=	0.0	65	R-IN=	0.0
66	U-IN=	40.000	67	V-IN=	0.0	68	PHIN=	0.0	69	X-IN=	0.0	70	Y-IN=	0.0
71	Z-IN=	-23.372	72	THIN=	-0.13596E-01	73	PHIN=	0.0	74	PSIN=	0.0	75	DT=	0.50000E-02
76	TN=	5.0000	77	KT1=	1450.0	78	KT2=	1450.0	79	KT3=	1450.0	80	KT4=	1450.0
81	RPS1=	56.502	82	RPS2=	56.502	83	RPS3=	55.927	84	RPS4=	55.927	85	BI=	-0.33000E-03
86	B2=	0.0	87	B3=	1.8280	88	B4=	0.75900E-07	89	D1D1=	0.0	90	D2D1=	0.0
91	D3D1=	0.0	92	DEL1=	-1.1000	93	DEL2=	-1.0800	94	DEL3=	0.0	95	PHDT=	0.0
96	PHTR=	0.0	97	U4PR=	0.0	98	DFW1=	0.0	99	UIPR=	0.0	100	U2PR=	0.0
101	U3PR=	0.0	102	U4PR=	0.0	103	S1PR=	0.0	104	S2PR=	0.0	105	S3PR=	0.0
106	S4PR=	0.0	107	PPRT=	1.0000	108	FREQ=	0.50000	109	VC=	0.0	110	TGMX=	0.0
111	KTQ=	0.0	112	VC=	0.0	113	MTSW=	1.0000	114	DSWM=	62.000	115	TST=	1.0000
116	DSLP=	0.50000	117	CGAM=	3.0000	118	CS=	3.0000	119	TGR=	0.0	120	TGF=	0.0
121	PFL=	300.00	122	TTD=	0.0	123	DSW1=	0.0	124	VHTP=	0.0	125	LSW5=	0.0
126	SW15=	0.0	127	TTD=	0.0	128	VTPS=	3.0000	129	VHTP=	0.0	130	AMCR=	0.60000E-01
131	ESP=	0.27920	132	KSL1=	55900.	133	KSL2=	55900.	134	AA1=	6.6200	135	AA2=	6.6200
136	CCR=	11.000	137	CFCR=	54.000	138	AP=	5.2000	139	EP1=	0.78500E-02	140	EP2=	0.78500E-02
141	AERO=	0.0	142	YVW=	88.000	143	OMXW=	0.30000E-01	144	OMZW=	0.40000E-01	145	RHOA=	0.10000E-02
146	CYP=	0.10000E-02	147	CYR=	0.10000E-01	148	CZAL=	0.10000E-02	149	CZQ=	0.60000E-02	150	CLP=	0.10000E-02
151	CLR=	0.10000E-02	152	CMAL=	0.10000E-03	153	CMQ=	0.10000E-03	154	CNP=	0.10000E-03	155	CNR=	0.40000E-03
156	SF=	500.00	157	VLEN=	0.0	158	REWV=	0.0	159	CNP=	0.0	160	CNR=	0.40000E-03
161	=	0.0	162	=	0.0	163	=	0.0	164	=	0.0	165	=	0.0
166	=	0.0	167	=	0.0	168	=	0.0	169	SNT=	73.000	170	SNS0=	73.000
171	SNS1=	73.000	172	SNSW=	2.0000	173	DIST=	0.0	174	PL=	0.0	175	TSCP=	0.25000
176	SCSW=	1.0000	177	=	0.0	178	=	0.0	179	=	0.0	180	=	0.0
181	SARF=	9.3600	182	S11=	0.17000	183	S12=	0.17000	184	S13=	0.17000	185	S14=	0.17000
186	=	0.0	187	SALF=	9.3600	188	SARR=	6.6300	189	SALR=	6.6300	190	=	0.0
191	E1=	0.0	192	MTQB=	1.0000	193	DCSW=	0.0	194	LDF=	0.0	195	LDRF=	0.0
196	EK1=	0.0	197	EK2=	0.0	198	BMP1=	0.0	199	BMP2=	0.0	200	BMPH=	1.5000
201	XB=	0.0	202	APF1=	0.94000	203	APF2=	0.80000E-04	204	APR1=	0.94000	205	APR2=	-0.80000E-04
206	MUSF=	0.65000	207	MUSR=	0.65000	208	RCON=	0.30000E-01	209	FCSW=	0.0	210	S1F=	0.0
211	S1R=	0.0	212	KLR=	0.0	213	KOTF=	0.0	214	KOTR=	0.0	215	S1F=	0.0
216	=	0.0	217	=	0.0	218	=	0.0	219	FEE1=	0.0	220	FEE2=	0.0
221	THE1=	0.0	222	THE2=	0.0	223	ALMC=	0.0	224	=	0.0	225	=	0.0
226	=	0.0	227	=	0.0	228	=	0.0	229	=	0.0	230	=	0.0
231	H1=	400.00	232	H2=	400.00	233	LAMD=	1.0000	234	=	0.0	235	=	0.0
236	PS01=	0.0	237	PS02=	0.0	238	BRI=	1.0000	239	BR2=	1.0000	240	BR3=	0.67000
241	BR4=	0.67000	242	KCF=	-0.39300E-04	243	KCR=	-0.33200E-04	244	KSR=	0.17500E-05	245	RBI=	-0.33000E-03
246	RB2=	0.0	247	RB3=	1.8280	248	RB4=	0.75900E-07	249	AFK1=	-0.31800E-02	250	AFK2=	0.34900E-02
251	AFK3=	1.4040	252	ARK1=	-0.31800E-02	253	ARK2=	0.34900E-02	254	ARK3=	1.4040	255	ORC1=	0.0
256	OFC1=	-0.15000E-02	257	OFC2=	-0.52440E-02	258	OFC3=	-5.5920	259	ORC0=	0.0	260	ORC1=	-0.15000E-02
261	ORC2=	-0.52440E-02	262	ORC3=	-5.5920	263	CP0F=	-0.13000	264	CP1F=	-0.30000E-01	265	CP2F=	0.0
266	CP0R=	0.15000	267	CP1R=	0.15000E-01	268	CP2R=	0.0	269	CR0F=	0.89000E-01	270	CR1F=	0.10000E-01
271	CR2F=	0.0	272	CR0R=	0.0	273	CR1R=	0.0	274	CR2R=	0.0	275	STSW=	0.0
276	MMSW=	0.0	277	BMPN=	0.0	278	TGB0=	0.0	279	TGB1=	0.0	280	=	0.0
281	=	0.0	282	=	0.0	283	=	0.0	284	HFC=	2.7000	285	HRC=	3.9000
286	DRSW=	0.0	287	AXLE=	1.0000	288	DUAL=	0.0	289	TIRE=	4.0000	290	ROT=	0.75000
291	RA0=	2701.0	292	RA1=	10.140	293	RA2=	2533.0	294	RA3=	1.3000	295	RA4=	4591.0



PARAMETER	VALUES	- MODEL C	- VEHICLE MODEL *	WINNEBAGO	MOTOR HOME TYPE A	(DODGE RM 400/158.5" WB)								
1	MS=	24.609	2	MUF=	1.7210	3	MUR=	2.8880	4	ZF=	36.300	5	ZR=	36.190
6	A=	99.410	7	B=	59.090	8	TF=	66.150	9	TR=	66.120	10	TSR=	41.240
11	IX=	40300.0	12	IY=	0.21910E 06	13	IZ=	0.21650E 06	14	IXZ=	7100.0	15	IR=	2400.0
16	HOOR=	30.000	17	RF=	0.15300E 06	18	STOP=	10.000	19	AKF1=	450.00	20	AKF2=	450.00
21	AKR3=	875.00	22	AKR4=	875.00	23	ALS=	0.0	24	RR=	0.15300E 06	25	CF1P=	100.00
26	CF2P=	100.00	27	CR3P=	150.00	28	CR4P=	150.00	29	ZRAS=	0.0	30	KRS=	-0.10000E-01
31	RW=	16.870	32	SCAL=	4000.0	33	FOT=	1.0000	34	A0=	635.20	35	A1=	11.980
36	A2=	5447.9	37	A3=	1.8900	38	A4=	6306.2	39	TIR	= 56.620	40	TOR	= 75.620
41	KSC=	8000.0	42	NG=	17.500	43	TSD=	0.0	44	OSLM=	0.0	45	TFT=	0.0
46	DSW2=	0.0	47	IFW=	27.000	48	IF	= 1500.0	49	IWF=	21.300	50	IWR=	48.000
51	IDR=	1.3000	52	ARR=	4.5600	53	TF=	31.000	54	KFS	= 0.70000E-01	55	PT=	1.3100
56	YSAL=	6.0800	57	YSA2=	-0.0800	58	PHS1=	-0.12217	59	PHS2=	0.12217	60	CTSW=	1.0000
61	IDF=	0.0	62	AHF=	0.0	63	P-IN=	0.0	64	G-IN=	0.0	65	R-IN=	0.0
66	U-IN=	40.000	67	V-IN=	0.0	68	W-IN=	0.0	69	X-IN=	0.0	70	Y-IN=	0.0
71	Z-IN=	-52.478	72	THIN=	-0.7722E-04	73	PHIN=	0.0	74	PSIN=	0.0	75	DT=	0.50000E-02
76	IN=	5.0000	77	KT1=	3040.0	78	KT2=	3040.0	79	KT3=	3040.0	80	KT4=	3040.0
81	RPS1=	0.0	82	RPS2=	0.0	83	RPS3=	0.0	84	RPS4=	0.0	85	BI=	-0.23600E-03
86	BZ=	0.0	87	B3=	1.3200	88	B4=	0.29700E-07	89	D1D1=	0.0	90	D2D1=	0.0
91	D3D1=	0.0	92	DEL1=	0.0	93	DEL2=	0.0	94	DEL3=	0.0	95	PHDT=	0.0
96	PHIR=	0.0	97	DFW1=	0.0	98	DFW2=	0.0	99	UIPR=	0.0	100	U2PR=	0.0
101	U3PR=	0.0	102	U4PR=	0.0	103	S1PR=	0.0	104	S2PR=	0.0	105	S3PR=	0.0
106	S4PR=	0.0	107	PHRT=	1.0000	108	FREQ=	0.40000	109	=	0.0	110	TOMX=	4428.0
111	KTQ=	738.00	112	VC=	0.0	113	MTSW=	1.0000	114	DSWM=	62.000	115	TST=	1.0000
116	DSL=	0.50000	117	CGAM=	3.0000	118	CS	= 3.0000	119	TGR=	0.0	120	TQF=	0.0
121	PFL=	300.00	122	TTD=	0.0	123	DSW1=	0.0	124	VTPE=	0.0	125	ISW5=	0.0
126	SW15=	0.0	127	SW16=	0.0	128	VTPS=	3.0000	129	VHTP=	0.0	130	AMCR=	0.78000E-01
131	ESP=	0.27900	132	KSL1=	0.15000E 06	133	KSL2=	0.15000E 06	134	AA1=	8.0200	135	AA2=	8.0200
136	CCR=	11.000	137	CFCH=	120.00	138	AP=	7.5000	139	EPI=	0.90000E-02	140	EP2=	-0.90000E-02
141	AERO=	0.0	142	VYW=	0.0	143	OMXW=	0.0	144	OMZW=	0.0	145	RHOA=	0.11470E-06
146	CYP=	0.0	147	CYR=	0.0	148	CZAL=	0.0	149	CZQ=	0.0	150	CLP=	0.0
151	CLR=	0.0	152	CMAL=	0.0	153	CMO=	0.0	154	CNP=	0.0	155	CNR=	0.0
156	SF	= 9100.0	157	VLEN=	294.00	158	REWV=	1094.0	159	=	0.0	160	=	0.0
161	=	0.0	162	=	0.0	163	=	0.0	164	=	0.0	165	=	0.0
166	=	0.0	167	=	0.0	168	=	0.0	169	SNT=	73.000	170	SNS0=	75.000
171	SNS1=	75.000	172	SNSW=	2.0000	173	DIST=	0.0	174	PL	= 0.0	175	TSCP=	0.25000
176	SCSW=	1.0000	177	=	0.0	178	=	0.0	179	=	0.0	180	=	0.0
181	SARF=	118.15	182	S11=	0.20000	183	S12=	0.20000	184	S13=	0.20000	185	SI4=	0.20000
186	=	0.0	187	SALF=	118.15	188	SARH=	73.500	189	SALR=	73.500	190	=	0.0
191	=	0.0	192	MTQB=	1.0000	193	DCSW=	0.0	194	LDF=	0.0	195	LDRF=	0.0
196	EK1=	-0.18000E-02	197	EK2=	0.18000E-02	198	BMPL=	0.0	199	RMPS=	0.0	200	BMPH=	1.5000
201	XB=	0.0	202	APF1=	1.0400	203	APF2=	-0.75800E-04	204	APR1=	1.0400	205	APR2=	-0.75800E-04
206	MUSP=	0.72000	207	MUSH=	0.72000	208	RCON=	0.30000E-01	209	FCSW=	0.0	210	SIF=	0.0
211	S1R=	0.0	212	KLR=	0.0	213	KOTF=	0.0	214	KOTR=	0.0	215	=	0.0
216	=	0.0	217	=	0.0	218	ALMC=	0.0	219	FEEL=	0.34900E-01	220	FEEL2=	-0.34900E-01
221	THE1=	0.69800E-01	222	THE2=	0.69800E-01	223	ALMC=	0.0	224	=	0.0	225	=	0.0
226	=	0.0	227	=	0.0	228	LAMD=	0.0	229	=	0.0	230	=	0.0
231	H1=	600.00	232	H2=	600.00	233	LAMD=	0.0	234	=	0.0	235	=	0.0
236	PSO1=	0.0	237	PSO2=	0.0	238	BRI=	1.1300	239	AR2=	1.1300	240	BR3=	1.0000
241	BR4=	1.0000	242	KCF=	-0.20000E-04	243	KCR=	-0.20000E-04	244	KSR=	0.15000E-05	245	RB1=	-0.23600E-03
246	RA2=	0.0	247	R83=	1.3200	248	H84=	0.29700E-07	249	AFK1=	-0.15700E-02	250	AFK2=	0.14800E-02
251	AFK3=	1.6080	252	ARK1=	-0.15700E-02	253	ARK2=	0.14800E-02	254	ARK3=	1.6080	255	OFC0=	0.0
256	OFC1=	-0.62400E-03	257	OFC2=	0.24000E-02	258	OFC3=	-9.1320	259	ORC0=	0.0	260	ORC1=	-0.62400E-03
261	ORC2=	0.24000E-02	262	ORC3=	-9.1320	263	CP0F=	0.0	264	CP1F=	0.0	265	CP2F=	0.0
266	CP0R=	0.0	267	CP1R=	0.0	268	CP2R=	0.0	269	CR0F=	0.0	270	CR1F=	0.0
271	CR2F=	0.0	272	CR0H=	0.0	273	CH1R=	0.0	274	CR2R=	0.0	275	STSW=	0.0
276	MMSW=	0.0	277	BMPN=	0.0	278	TGR0=	0.0	279	TOB1=	0.0	280	=	0.0
281	=	0.0	282	AXLE=	0.0	283	DUAL=	1.0000	284	HFC=	0.0	285	HRC=	0.0
286	DRSW=	0.0	287	RA1=	11.980	288	RA2=	5447.9	289	TIRE=	6.0000	290	ROT=	1.0000
291	RA0=	635.20	292	RA1=	11.980	293	RA2=	5447.9	294	RA3=	1.0000	295	RA4=	6306.2

G-5. APL Operational Vehicle Data Decks

Vehicle	Suspension	
	Front	Rear
VW Campmobile (73)	I	I
VW Super Beetle (71)	I	I
Chevrolet NOVA (74)	I	S
Chevrolet NOVA (75)	I	S
Ford Torino (75)	I	S
Ford Mustang (71)	I	S
Dodge Coronet (71)	I	S
Pontiac Trans Am (71)	I	S
Chevrolet Brookwood Station Wagon (71)	I	S
Chevrolet Caprice Station Wagon (73)	I	S
F-250 Pickup with 11 Foot Open Road Camper (74)	I	S
Ford Econoline Van (69)	I	S
Ford F-250 Pickup (74)	I	S
Plymouth Fury (77)	I	S
Ford Pinto (76/77)	I	S
Chevrolet Monte Carlo (76)	I	S
Ford LTD (76)	I	S
AMC Pacer (77)	I	S
Mercury Bobcat Wagon	I	S
Chevrolet NOVA (76)	I	S
Open Road Motor Home Type C (74) (Dodge MB 300/127" WB)	I	S,D
Jeep Wagoneer (74)	S	S
Winnebago Motor Home Type A (74) (Dodge Rm 400/158.5" WB)	S	S,D
White Road Boss (4x2) Heavy Truck (74)	S	S,D
GMC-PD 4107 Intercity Bus (66)	S	S,D

I = Independent  
 S = Solid  
 D = Dual tires, one rear axle

## Appendix H

### IMPROVED HYBRID COMPUTER VEHICLE HANDLING SIMULATION IMPLEMENTATION DOCUMENTATION

#### H-1. DSL/91 Digital Static Check Program

Presented here is the computer listing of the DSL/91 digital static check program.

#### INPUT FOR DSL/91 TRANSLATOR (VERSION 2)

```
TITLE   NEW VEHICLE FRCB = 91
PARAM  IAXLE = 0
PARAM  AKT1=1250.,AKT2=1250.,AKT3=1250.,AKT4=1250.
PARAM  RF=-24200.,RR=-69000.
PARAM  TSF=32.25,TSR=43.25,TF=57.3,TR=57.5
PARAM  HFC=.63,HRC=2.22,ZF=16.01,ZR=15.8
PARAM  CFP=73.,CRP=60.,A=49.61,B=60.39
PARAM  AMS=7.3,AMUF=.937,AMUR=.888
PARAM  AKF=700.,AKR3=210.,AKR4=210.
PARAM  IF=498.,IR=459.,SCALE=2000.
PARAM  AIX=7330.,AIY=25740.,AIZ=29700.,AIXZ=250.
PARAM  F3F1=80.,F3F2=23.,F3R3=152.2,F3R4=49.
PARAM  CMCN1F=0.0,CMCN1R=0.0
PARAM  GEE=386.4
PARAM  BETA=.25
PARAM  DTIN=.005
INCCN  UO=704.,VO=13.,WO=5.
INCCN  PC=.04,GC=.037,RO=.02
INCCN  THEO=-.00209,PHIO=-.003,PSIO=.002
INCCN  DEL1=.383,DEL1DT=10.
INCCN  DEL2=0.866,DEL2DT=15.
INCCN  DEL3=.200,DEL4=.300,DEL3DT=5.,DEL4DT=7.
INCCN  DELF=.8,DELFDT=25.,PHIF=.02,PHIFD=.6
INCCN  SNPHIF=-163.
INCCN  DELRDT=20.,PHIRD=.55
INCCN  DELR=.6,PHIR=.01895
INCCN  ANTI1=874.,ANTI2=874.,ANTI3=692.,ANTI4=692.
INCCN  FYU1=-33.45,FYU2=33.45,FYU3=-10.,FYU4=10.
INCCN  SFXU=-20.0,SFYU=30.0,SFZS=-1090.
INCCN  FZU1=-972.,FZU2=-972.,FZU3=-844.,FZU4=-844.
```

INCCN SNPHIU=-111.,SNTHEL=-274.,SNPSIU=-755.,SNPHIR=-163.  
 INCCN RPS1 =57.01, RPS2=57.01, RPS3=56.55, RPS4=56.55  
 CENTRL TSTART=0.,FINTIM=.002,DELTA=.001  
 DYNAMIC

P = PC  
 Q = QO  
 R = RO  
 U = UO  
 V = VO  
 W = WO  
 THE = THEO  
 PHI = PHIO  
 PSI = PSIO  
 COSTHE=CCS(THEC)  
 SINPHI=SIN(PHIC)  
 SINTHE=SIN(THEC)  
 CCSPHI=CCS(PHIC)  
 P2=PC\*PC  
 Q2=QO\*QO  
 R2=RO\*RO  
 QR=QO\*RO  
 PR=PC\*RO  
 WP=PC\*WO  
 VR=VO\*RO  
 WQ=WO\*QO  
 LR=RO\*LO  
 UQ=UO\*QO  
 PQ=PC\*QO  
 VP=VO\*PO  
 TFC2 = TF/2.  
 TRO2 = TR/2.  
 TSFO2 = TSF/2.  
 TSRC2 = TSR/2.  
 G=GEE  
 SM=AMS+AMUF+AMUR  
 GAM1 = A\*AMUF - B\*AMUR  
 IF(IAXLE.NE.O) GO TO 100  
 GAM2 = AMUF\*(ZF+DELF)+AMUR\*(ZR+DELR)  
 GAM3 = GAM2  
 GAM4 = 0.0  
 GAM5 = AMUF\*A\*\*2+AMUR\*B\*\*2  
 GAM6 = 2.\*AMUF\*DELFDT+2.\*AMUR\*DELRDT  
 GAM7 = 2.\*AMUF\*DELFDT\*(ZF+DELF)+2.\*AMUR\*DELRDT\*(ZR+DELR)  
 GAM8 = 0.0  
 GAM9 = 2.\*AMUF\*A\*DELFDT-2.\*AMUR\*B\*DELRDT  
 AIXP = AMUF\*(ZF+DELF)\*\*2+AMUR\*(ZR+DELR)\*\*2  
 AIYP = AIXP  
 AIZP = AMUF\*A\*\*2+AMUR\*B\*\*2+IF+IR  
 AIXZP = AMLF\*A\*(ZF+DELF)-AMUR\*B\*(ZR+DELR)  
 GC TC 1000

```

100 IF(IAXLE.NE.1) GO TO 200
GAM2 = AMUF*(ZF + (DEL1+DEL2)/2.0) + AMUR*(ZR+DELR)
GAM3 = GAM2
GAM4 = AMUF*TFC2/2.0*(DEL1-DEL2)
GAM5 = AMUF*(A**2-TFO2**2) + AMUR*B**2
GAM6 = AMUF*(DEL1CT+DEL2DT) + 2.*AMUR*DELRCT
GAM7 = AMUF*(ZF*(DEL1DT+DEL2DT) + DEL1*DEL1DT+DEL2*DEL2DT) ...
      + 2.0*AMUR*(ZR+DELR)*DELRCT
GAM8 = AMUF*TFC2*(DEL1DT-DEL2DT)
GAM9 = AMUF*A*(DEL1CT+DEL2DT) - 2.*AMUR*B*DELRDT
AIXP = AMUF/2.0*((ZF+DEL1)**2 + (ZF+DEL2)**2) + AMUR*(ZR+DELR)**2
AIYP = AIXP
AIZP = AMUF*(A**2+TFO2**2) + AMUR*B**2 + IR
AIXZP = AMUF*A/2.0*((ZF+DEL1) + (ZF+DEL2)) - AMUR*B*(ZR+DELR)
GC TC 1000
200 CONTINUE
GAM2 = AMUF*(ZF+(DEL1+DEL2)/2.)+AMUR*(ZR+(DEL3+DEL4)/2.)
GAM3 = GAM2
GAM4 = AMUF*TFC2/2.*(DEL1-DEL2)+AMUR*TRC2/2.*(DEL3-DEL4)
GAM5 = AMUF*(A*A-TFO2**2)+AMUR*(B*B-TRC2**2)
GAM6 = AMUF*(DEL1CT+DEL2DT)+AMUR*(DEL3CT+DEL4DT)
GAM7 = AMUF*(ZF*(DEL1DT+DEL2DT)+DEL1*DEL1DT+DEL2*DEL2DT) ...
      + AMUR*(ZR*(DEL3CT+DEL4DT)+DEL3*DEL3CT+DEL4*DEL4CT)
GAM8 = AMUF*TFC2*(DEL1DT-DEL2DT)+AMUR*TRC2*(DEL3DT-DEL4DT)
GAM9 = AMUF*A*(DEL1CT+DEL2DT)-AMUR*B*(DEL3CT+DEL4DT)
AIXP = AMUF/2.*((ZF+DEL1)**2+(ZF+DEL2)**2) ...
      + AMUR/2.*((ZR+DEL3)**2 + (ZR+DEL4)**2)
AIYP = AIXP
AIZP = AMUF*(A*A+TFO2**2)+AMUR*(B*B+TRC2**2)
AIXZP = AMUF*A/2.*((ZF+DEL1)+(ZF+DEL2)) ...
      - AMUR*B/2.*((ZR+DEL3)+(ZR+DEL4))
1000 CONTINUE
AIXXP = AIX + AIXP
AIYYP = AIY + AIYP
AIZZP = AIZ+AIZP
* UNSCALED DAC VALUES FOR SYSTEM EQUATIONS
CAC00 = GAM2/SM
CAC01 = GAM1/SM
CAC02 = GAM1/SM
CAC03 = GAM2/SM
CAC04 = GAM3/AIXXP
CAC05 = (AIXZ+AIXZP)/AIXXP
CAC06 = GAM7/AIXXP
CAC07 = GAM4/AIXXP
CAC08 = 1.0/AIXXP
CAC09 = GAM2/AIYYP
CAC10 = AIXZ/AIYYP
CAC11 = AIXZP/AIYYP
CAC12 = GAM7/AIYYP

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CAC13 = GAM4/AIYYP
CAC14 = 1.0/AIYYP
CAC15 = (AIXZ+AIXZP)/AIZZP
CAC16 = GAM1/AIZZP
CAC17 = GAM4/AIZZP
CAC20 = 55.71
CAC21 = 55.71
CAC22 = 64.76
CAC23 = 64.76
CAC26 = 1./SM*(-GAM6*Q+SFXU)
CAC27 = 1./SM*(GAM6*P+SFYU)
CAC28 = 1./AMS*SFZS
CAC29 = ((AIY-AIZ+AIXP)*QR+SNPHIU)/AIXXP
CAC30 = ((AIZ-AIX-AIYP)*PR+SNTHEU)/AIYYP
CAC31 = ((AIX-AIY-GAM5)*PQ+GAM8*Q+GAM9*P+SNPSIU)/AIZZP
CAC32 = 3692.0
CAC33 = 3692.0
CAC34 = 3151.0
CAC35 = 3151.0
CAC37 = ANTI1
CAC38 = ANTI2
CAC39 = ANTI3
CAC40 = ANTI4
IF(IAXLE.NE.0) GO TO 300
CAC28 = SFZS/10.939
CAC41 = 1.0/AMLF*(FZU1+FZU2)
CAC42 = 1.0/IF*SNPHIF
CAC43 = 1.0/AMLR*(FZU3+FZU4)
CAC44 = 1.0/IR*SNPHIR
GC TO 2000
300 IF(IAXLE.NE.1) GO TO 400
CAC41 = 2.0/AMUF*(FZU1-FYU1*TAN(2.0*HFC/TF))
CAC42 = 2.0/AMLF*(FZU2-FYU2*TAN(2.*HFC/TF))
CAC43 = 1.0/AMUR*(FZU3+FZU4)
CAC44 = 1.0/IR*SNPHIR
GO TO 2000
400 CCNTINLE
CAC41 = 2.0/AMLF*(FZU1-FYU1*TAN(2.0*HFC/TF))
CAC42 = 2.0/AMLF*(FZU2-FYU2*TAN(2.*HFC/TF))
CAC30 = .2702
CAC43 = 2./AMUR*(FZU3-FYU3*TAN(2.*HRC/TR))
CAC44 = 2./AMUR*(FZU4-FYU4*TAN(2.*HRC/TR))
2000 CCNTINLE
IF(IAXLE.NE.0) GO TO 500
ZET1 = TSFO2*PHIF+DELF
ZET2 = -TSFO2*PHIF+DELF
ZET3 = TSRO2*PHIR + DELR
ZET4 = -TSRO2*PHIR + DELR
ZET1DT = TSFO2*PHIFD+DELFDT
ZET2DT = -TSFO2*PHIFD+DELFDT

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ZET3DT = TSRO2*PHIRD + DELRDT
ZET4DT = -TSRO2*PHIRD + DELRDT
F1F1 = SIGN(1.,ZET1DT)*CFP
F1F2 = SIGN(1.,ZET2DT)*CFP
F1R3 = SIGN(1.,ZET3DT)*CRP
F1R4 = SIGN(1.,ZET4DT)*CRP
F2F1 = AKF*ZET1
F2F2 = AKF*ZET2
F2R3 = AKR3*ZET3
F2R4 = AKR4*ZET4
S1 = -F3F1-F2F1-(RF/TSF)*PHIF-F1F1+DAC37
S2 = -F3F2-F2F2-(RF/TSF)*PHIF-F1F2+DAC38
S3 = -F3R3-F2R3-(RR/TSR)*PHIR - F1R3 + DAC39
S4 = -F3R4-F2R4-(RR/TSR)*PHIR - F1R4 + DAC40
GC TO 5000
500 IF(IAXLE.NE.1) GO TO 600
ZET1 = DEL1
ZET2 = DEL2
ZET3 = TSRO2*PHIR + DELR
ZET4 = -TSRO2*PHIR + DELR
ZET1DT = DEL1DT
ZET2DT = DEL2DT
ZET3DT = TSRO2*PHIRD + DELRDT
ZET4DT = -TSRO2*PHIRD + DELRDT
F1F1 = SIGN(1.,ZET1DT)*CFP
F1F2 = SIGN(1.,ZET2DT)*CFP
F1R3 = SIGN(1.,ZET3DT)*CRP
F1R4 = SIGN(1.,ZET4DT)*CRP
F2F1 = AKF*ZET1
F2F2 = AKF*ZET2
F2R3 = AKR3*ZET3
F2R4 = AKR4*ZET4
AUXRL1 = (DEL2-DEL1)*RF/TF**2
AUXRL2 = -AUXRL1
S1 = AUXRL1-F3F1-F2F1-F1F1+DAC37
S2 = AUXRL2-F3F2-F2F2-F1F2+DAC38
S3 = -F3R3-F2R3-(RR/TSR)*PHIR - F1R3 + DAC39
S4 = -F3R4-F2R4-(RR/TSR)*PHIR - F1R4 + DAC40
GC TO 5000
600 CCNTINLE
ZET1 = DEL1
ZET2 = DEL2
ZET3 = DEL3
ZET4 = DEL4
ZET1DT = DEL1DT
ZET2DT = DEL2DT
ZET3DT = DEL3DT
ZET4DT = DEL4DT
F1F1 = SIGN(1.,ZET1DT)*CFP
F1F2 = SIGN(1.,ZET2DT)*CFP

```

```

F1R3 = SIGN(1.,ZET3DT)*CRP
F1R4 = SIGN(1.,ZET4DT)*CRP
F2F1 = AKF*ZET1
F2F2 = AKF*ZET2
F2R3 = AKR3*ZET3
F2R4 = AKR4*ZET4
AUXRL1 = (DEL2-DEL1)*RF/TF**2
AUXRL2 = -AUXRL1
AUXRL3 = (DEL4-DEL3)*RR/TR**2
AUXRL4 = -AUXRL3
S1 = ALXRL1-F3F1-F2F1-F1F1+DAC37
S2 = AUXRL2-F3F2-F2F2-F1F2+DAC38
S3 = ALXRL3-F3R3-F2R3-F1R3+DAC39
S4 = ALXRL4-F3R4-F2R4-F1R4+DAC40

```

5000

CCNTINUE

SUMSI = S1+S2+ S3+S4

\*

NCTE

\*

ACCELERATION TERMS HAVE BEEN ELIMINATED  
FROM R.H.S OF UDT,VDT,PDT,QDT AND RDT  
EQUATIONS. ALSO FROM AMPLIFIERS AC66 AND  
A106 DESCRIPTIONS.

\*

UDT = VR - WQ -GEE\*SIN THE -DAC00 \*(PR+0.0) + DAC01 ...  
\* (Q2+R2) + DAC26

VDT = WP - UR +GEE\*CCSTHE\*SINPHI -DAC02 \*(PQ+0.0) ...  
- DAC03 \*(QR-0.0) + DAC27

WDT = UQ - VP +GEE\*CCSTHE\*COSPHI + DAC28 - SUMSI/AMS

QDT = DAC09 \*(VR-0.0-WQ-GEE\*SIN THE) + (R2-P2)\*DAC10 ...  
+ (Q2+R2)\*DAC11 - (PG-0.0)\*DAC13 + DAC30 + ...

DAC14 \*(A\*(S1+S2) - B\*(S3+S4)) - Q\*DAC12

RDT = DAC16 \*(WP-0.0-UR +GEE\*CCSTHE\*SINPHI) + ...  
DAC17 \*(PR+0.0) - DAC15 \*(QR-0.0) + DAC31

\*

PSIDT = (R\*CCSPHI + C\*SINPHI)/CCSTHE

PHIDT = P + PSIDT\*SIN THE

THECT = Q\*CCSPHI - R\*SINPHI

IF(IAXLN.NE.0) GO TO 700

PCT = DAC04 \*(0.0+LR-WP-GEE\*CCSTHE\*SINPHI) + ...  
DAC05 \*(PG+0.0) - DAC07 \*(P2+R2) +DAC29 + ...

DAC08\*(TSFO2\*(S2-S1) + TSRO2\*(S4-S3)) -P\*DAC06

DELFD0 = UQ-VP+GEE\*CCSTHE\*COSPHI-A\*PR+(ZF+DEL F)\*(P2+Q2) ...  
-WDT+A\*QDT+DAC41+(S1+S2)/AMUF ...

-(AKT1+AKT2)/AMUF\*BETA\*(.008+.5\*DTIN/BETA)\*DEL FCT

PHIFDD = -(QR+PCT)+PHIF\*(Q2-R2)+DAC42+TSFO2\*(S1-S2)/IF ...

-(((AKT1+AKT2)\*TFO2\*TFO2\*BETA\*(.008+.5\*DTIN/BETA))/IF)\*PHIFC

DELRDD = UQ -VP + GEE\*CCSTHE\*COSPHI + B\*PR + (ZR+DEL R)\* ...  
(P2+Q2) - WDT -B\*QDT + DAC43 + (S3+S4)/AMUR ...

- (AKT3+AKT4)/AMUR\*BETA\*(.008+.5\*DTIN/BETA)\*DEL RDT

PHIRDD = -(QR+PCT) + PHIR\*(Q2-R2) + DAC44 + TSRO2\*(S3-S4)/IR...

-(((AKT3+AKT4)\*TRC2\*TRD2\*BETA\*(.008+.5\*DTIN/BETA))/IR)\*PHIRD

GC TO 7000



```

700  IF(IAXLE.NE.1) GO TO 800
      PDT      = DAC04 *(0.0+UR-WP-GEE*COSTHE*SINPHI) + ...
            DAC05 *(PG+0.0) - DAC07 *(P2+R2) +DAC29 + ...
            DAC08 *(TFO2*(S2-S1) + TSRO2*(S4-S3)) -P*DAC06
      DELPDD   = UQ - VP + GEE*COSTHE*COSPHI -A*PR -WDT + A*QDT
      DEL1DD  = DELPDD + (ZF+DEL1)*(P2+Q2) - TFC2*(PDT+QR) + CAC41 +...
            2.*S1/AMUF ...
- (2.*AKT1/AMUF)*BETA*      (.008+.5*CTIN/BETA)*DEL1DT
      DEL2DD  = DELPDD + (ZF+DEL2)*(P2+Q2) + TFC2*(PDT+QR) + ...
            DAC42 + 2.*S2/AMUF ...
- (2.*AKT2/AMUF)*BETA*      (.008+.5*CTIN/BETA)*DEL2DT
      DELRDD  = UQ -VP + GEE*COSTHE*COSPHI + B*PR + (ZR+DELR)* ...
            (P2+Q2) - WDT -B*QDT + DAC43 + (S3+S4)/AMUR ...
- (AKT3+AKT4)/AMUR*BETA*    (.008+.5*DTIN/BETA)*DELRDT
      PHIRDD  = -(QR+PDT) + PHIR*(Q2-R2) + CAC44 + TSRO2*(S3-S4)/IR...
- (((AKT3+AKT4)*TRC2*TRQ2*BETA*      (.008+.5*DTIN/BETA))/IR)*PHIRD
      GC TC 7000

```

```

800  CCNTINLE
      PDT      = DAC04 *(0.0+UR-WP-GEE*COSTHE*SINPHI) + ...
            DAC05 *(PG+0.0) - CACC7 *(P2+R2) +DAC29 + ...
            DAC08 *(TFO2*(S2-S1) + TRC2 *(S4-S3)) -P*DAC06
      DELPDD   = UQ - VP + GEE*COSTHE*COSPHI -A*PR -WDT + A*QDT
      DEL1DD  = DELPDD + (ZF+DEL1)*(P2+Q2) - TFC2*(PDT+QR) + CAC41 +...
            2.*S1/AMUF ...
- (2.*AKT1/AMUF)*BETA*      (.008+.5*CTIN/BETA)*DEL1DT
      DEL2DD  = DELPDD + (ZF+DEL2)*(P2+Q2) + TFC2*(PDT+QR) + ...
            DAC42 + 2.*S2/AMUF ...
- (2.*AKT2/AMUF)*BETA*      (.008+.5*CTIN/BETA)*DEL2DT
      DELPDR  = UQ-VP+GEE*COSTHE*COSPHI+B*PR-WDT-B*QDT
      DEL3DD  = DELPDR+(ZR+DEL3)*(P2+Q2)-(PDT+QR)*TRQ2+DAC43 ...
            + 2.*S3/AMUR ...
- (2.*AKT3/AMUR)*BETA*      (.008+.5*DTIN/BETA)*DEL3DT
      DEL4DD  = DELPDR+(ZR+DEL4)*(P2+Q2)+(PDT+QR)*TRQ2+DAC44 ...
            + 2.*S4/AMUR ...
- (2.*AKT4/AMUR)*BETA*      (.008+.5*CTIN/BETA)*DEL4DT

```

```

7000 CONTINLE
      RPS1DT = -OMCN1F*RPS2DD + DAC32 - DAC22 *RPS1
      RPS2DT = -OMCN1F*RPS1DC + DAC33 - DAC23 *RPS2
      RPS3DT = -OMCN1R*RPS4DD + DAC34 - DAC20 *RPS3
      RPS4DT = -OMCN1R*RPS3DC + DAC35 - DAC21 *RPS4

```

```

*
*
680 IC PCTS
F000=QC/.8
P005=UC/1200.
P020= -4.*THEC
P023=P SIC/4.
P075=DEL2/10.
P086=DEL2R/10.
P101=RPS1/100.
P110=RPS3/100.

```

```

*      LDT AND VDT DECOUPLING PCTS
      P111=0.0
      P114=0.0
*
*      REAR WHEELS DIFFERENTIAL DECOUPLING POTS
      P050=0.0
      P119=0.0
*
*      HAND SET PCTS
      Q002=DEL2DT/100.
      Q004=PHIRD/10.
      Q007=PHIR/1.
      Q009=DEL1/10.
      Q012=RC/4.
      Q014=VC/1000.
      Q017=PC/2.
      Q019=WC/100.
      Q022=DEL1DT/100.
      Q024=DELRDT/100.
      Q027 = -1.5*PHIC
      IF (IAXLE.NE.0) GO TO 900
      P075 = PHIF/1.
      Q002 = PHIFD/10.
      Q009 = DELF/10.
      Q022 = DELFDT/100.
      GO TO 9000
900   IF (IAXLE.NE.2) GO TO 9000
      P086 = DEL3/10.
      Q004 = DEL4DT/100.
      Q007 = DEL4/10.
      Q024 = DEL3DT/100.
9000  CONTINUE
*      680 AMPS
*      IC AMPS
      A000=QC/.8
      A005=JC/1200.
      A007=PC/2.
      A010=VC/1000.
      A012=RC/4.
      A015=WC/100.
      A020= 4. * THEC
      A025= -1.5* PHIC
      A027=P SIC/4.
      A040= PHIR/1.
      A095=-PHIRD/10.
      A050=-DEL1DT/100.
      A055=DEL1/10.
      A070=-DEL2DT/100.
      A075=DEL2/10.
      A080=-DELRDT/100.
      A085=DELR/10.

```

A100=-RPS1/100.  
 A105=-RPS2/100.  
 A110=-RPS3/100.  
 A115=-RPS4/100.

\*

A001= (QC\*SINPHI+RC\*COSPHI)/2.  
 A002=-LDT/800.  
 A004= -DEL1/10.  
 A008=SINPHI\*COSTHE  
 A009= -((DEL2-DEL1)/10.)  
 A011=-VDT/1500.  
 A014=DEL2DT/100.  
 A016=-S1/SCALE  
 A017= -(PHIR/1.-DELR/10.)  
 A018=VC\*RO/4000.  
 A019 = 0.0  
 A021=- S2/SCALE  
 A022=RPS4DT/10000.  
 A023=VP/2000.  
 A024=-PHIR/1.  
 A026=-S3/SCALE  
 A028=PHIR\*(Q2-R2)/4.  
 A029 = (DEL2-DEL1)\*(RF/(TF\*TF))/10000.  
 A030 = (S1+S2)/SCALE\*A/100. - (S3+S4)/SCALE\*B/100.  
 A031=-F2F2/10000.  
 A032=-DEL2/10.  
 A034 = S1/SCALE  
 A035=-WDT/200.  
 A036=-F2R3/10000.  
 A037 = S2/SCALE  
 A039=ZET1DT/100.  
 A041 = ((S2-S1)\*TFC2+(S4-S3)\*TSRO2)/(100.\*SCALE)  
 A042=ZET2DT/100.  
 A043=-LR/4800.  
 A044=PHIRD/10.  
 A045=-F2R4/10000.  
 A046 = (LQ-VP+G\*COSTHE\*COSPHI)/1000.  
 A047=ZET4DT/100.  
 A049=ZET3DT/100.  
 A051=-S4/SCALE  
 A052=-DELR/10.  
 A053 = -LQ/960.  
 A056=RPS1DT/10000.  
 A057=UDT/800.  
 A058 = (DELR\*(P2+Q2))/40.  
 A059 = -VQ\*RO/4000.  
 A060=RPS2DT/10000.  
 A061 = -(SUMSI/AMS)/1000.  
 A062= SINPHI  
 A063=-WQ/80.

```

*      A064 USE AS HG AMP IN SINPHI CKT
      A066 = (LR-WP-G*CCSTHE*SINPHI)/1000.
      A067=CCSTHE
      A068=-WP/200.
      A069 = TFO2*(PCT+QR)*BETA/1000.
      A071 = -(A*(S1+S2))/(100.*SCALE)
      A072=CCSPHI
*      A074 USE AS HG AMP IN COSPHI CKT
      A076=RPS EDT/10000.
      A077=-SIN THE
      A078=-CCSTHE*CCSPHI
      A081=-PDT/12.
      A082 = S4/SCALE
      A083 = -(QC*SINPHI)/0.8
      A084=SIN THE
      A086 = (B*(S3+S4))/(100.*SCALE)
      A087 = WQ/80.
      A088= -(RO*COSPHI)/4.
*      A089 USE AS HG AMP IN CCSTHE CKT
      A090=-F2F1/10000.
      A091 = (TSRC2*(S2-S4))/(100.*SCALE)
      A092=WP/1000.
      A093 = (CO*COSPHI)/0.8
      A096= -4.*THEDT*BETA
      A098= -(RO*SINPHI)/4.
      A101=-GDT/2.
      A103=-PSIDT/2.
      A104 = S3/SCALE
      A106 = (VR-WQ-G*SIN THE)/1000.
      A108 = (PSIDT*SIN THE)/2.
      A109=WCT/200.
      A111 = (TFO2*(S1-S2))/(100.*SCALE)
      A112= -(PR-QDT)/8.
      A113 = ((P2+Q2)*DEL1)/40.
      A114 = -(A*(PR-QDT)+WCT)/200.
      A116=-RDT /20.
*      A117=0.0 FOR SCLID REAR AXLE
      A117=0.0
      A118 = ((P2+Q2)*DEL2)/40.
      A119 = (E*(PR-QDT)-WCT)/200.
      D000=-GDT /0.8*BETA
      D005=-LDT/1200.*BETA
      D007=-PDT *BETA/2.
      D010=-VDT/1000.*BETA
      D012=-RDT *BETA/4.
      D015= -WCT*BETA/100.
      D020= -4.*THEDT*BETA
      D025=1.5*PHIDT*BETA
      D027= -PSIDT*BETA/4.
      D040=-PHIRC*BETA/1.

```

D050=DEL1DD/1000.\*BETA  
 D055=-DEL1DT/10.\*BETA  
 D070=DEL2DD/1000.\*BETA  
 D075=-DEL2DT/10.\*BETA  
 D080=DELRDD/1000.\*BETA  
 D085=-DELRDT/10.\*BETA  
 D095=PFIRDD/10.\*BETA  
 D100=KPS1DT/1000.\*BETA  
 D105=RPS2DT/1000.\*BETA  
 D110=RPS3DT/1000.\*BETA  
 D115=RPS4DT/1000.\*BETA

\*

SCALED DAC'S  
 DA00 = -DAC00/50.  
 DA01 = DAC01/100.  
 DA02 = -DAC02/50.  
 DA03 = -DAC03/625.  
 DA04 = DAC04/.04  
 DA05 = DAC05/.4  
 DA06 = -DAC06/2.  
 DA07 = -DAC07/1.  
 DA08=DACC8\*SCALE/.8  
 DA09 = DAC09/.003  
 DA10 = DAC10/.25  
 DA11 = DAC11/.25  
 DA12 = -DAC12/1.25  
 DA13 = -DAC13/.1  
 DA14=DAC14\*SCALE/.2  
 DA15 = -DAC15/1.25  
 DA16 = -DAC16/.01  
 DA17 = DAC17/1.25  
 DA20 =-DAC20/1000.  
 DA21 =-DAC21/1000.  
 DA22 =-DAC22/1000.  
 DA23 =-DAC23/1000.  
 DA26 = DAC26/400.  
 DA27 = DAC27/1000.  
 DA28 = DAC28/1000.  
 DA29 = DAC29/28.  
 DA30 = DAC30/10.  
 DA31 = DAC31/10.  
 DA32 = -DAC32/20000.  
 DA33 = -DAC33/20000.  
 DA34 = -DAC34/20000.  
 DA35 = -DAC35/20000.  
 DA37 = DAC37/10000.  
 DA38 = DAC38/10000.  
 DA39 = DAC39/10000.  
 DA40 = DAC40/10000.  
 DA41 = DAC41\*BETA/10000.  
 DA42 = DAC42\*BETA/10000.

```

DA43 = DAC43*BETA/10000.
DA44 = DAC44*BETA/100.0
IF(IAXLE.NE.0) GO TO 910
AC04 = -DELF/10.
A009 = -(PHIF/1. -CELF/10.)
A014 = PHIFD/10.
A029 = 0.0
A032 = -PHIF/1.
A041 = ((S2-S1)*TSFO2+(S4-S3)*TSRO2)/(100.*SCALE)
A050 = -DELFDT/100.
A055 = DELF/10.
A069 = 0.0
A070 = -PHIFD/10.
AC75 = PHIF/1.
A111 = (TSFO2*(S1-S2))/(100.*SCALE)
A113 = ((P2+Q2)*DELF)/40.
A118 = ((P2+Q2)*PHIF)/4.
C050 = DELFDD/1000.*BETA
C055 = -DELFDT/10.*BETA
C070 = PHIFDD/10.*BETA
C075 = -PHIFD*BETA
CA42 = DAC42*BETA/100.
GC TO 10000
910 IF(IAXLE.NE.2) GOTC 10000
A017 = -(DEL4-DEL3)/10.
A019 = ALXRL3/1000.
A024 = -DEL4/10.
A028 = DEL4*(P2+Q2)/40.
A040 = DEL4/10.
A041 = ((S2-S1)*TFC2+(S4-S3)*TRO2)/(100.*SCALE)
A044 = DEL4DT/100.
A052 = -DEL3/10.
A058 = DEL3*(P2+Q2)/40.
A080 = -DEL3DT/100.
A085 = DEL3/10.
A091 = (TRO2*(S3-S4))/(100.*SCALE)
A095 = -DEL4DT/100.
A117 = (PDT+QR)*TRO2/1000.*BETA
C040 = -DEL4DT/10.*BETA
C080 = DEL3DD/1000.*BETA
C085 = -DEL3DT/10.*BETA
C095 = DEL4DD/1000.*BETA
CA44 = DAC44*BETA/10000.
10000 CCNTINLE
* 680 TRUNKS
T040=ZET1DT/100.
T041=ZET2DT/100.
T042= (Q2-R2)/4.
T043=ZET4DT/100.
T053=ZET3DT/100.

```

T054=P/2.  
 T055=Q/.8  
 T056=R/4.  
 T057=-PDT/12.  
 T058=-RDT/20.  
 T059=-CDT/2.  
 T070=(PR-QDT)/8.  
 T071= PR/8.  
 T072=(R2-P2)/4.  
 T073=(P2+R2)/4.  
 T074=(P2+Q2)/4.  
 T075=(C2+R2)/4.  
 T076= FG/10.  
 T077=(FG-0.0 )/10.  
 T078= -(QR+PDT)/8.  
 T079=(CR-0.0 )/8.  
 T080=-F3F1/1000.  
 T082=-F3R3/1000.  
 T083=-F3R4/1000.  
 T088=-F3F2/1000.

TERMINAL

DUMMY=DEBUG(1.,0.)

END

PARAM IAXLE = 1  
 PARAM AKT1=1295.,AKT2=1295.,AKT3=1295.,AKT4=1295.  
 PARAM RF=151000.,RR=0.0  
 PARAM TSF=0.C,TSR=43.,TF=61.5,TR=61.  
 PARAM HFC=3.,HRC=2.5,ZF=9.35,ZR=9.35  
 PARAM CFP=36.,CRP=50.,A=48.,B=61.  
 PARAM AMS=8.13,AMUF=.484,AMLR=.789  
 PARAM AKF=100.2,AKR3=114.,AKR4=114.  
 PARAM IF=3.3,IR=600.,SCALE=2000.  
 PARAM AIX=2940.,AIY=14700.,AIZ=22500.,AIXZ=230.  
 PARAM F3F1=15.2,F3F2=22.5,F3R3=152.2,F3R4=48.6  
 INCON SFZS= -100.

END

PARAM IAXLE = 2  
 PARAM AKT1=746.,AKT2=746.,AKT3=956.,AKT4=956.  
 PARAM RR=28300.,TSR=50.,TF=53.8,TR=51.5  
 PARAM HFC=2.4,HRC=3.4,ZF=10.8,ZR=11.2  
 PARAM CFP=35.,CRP=40.,A=55.9,B=39.9  
 PARAM AMS=5.5,AMUF=0.36,AMLR=C.57  
 PARAM AKF=101.1,AKR3=115.,AKR4=115.  
 PARAM IR=800.,RF=93000.,SCALE=1000.  
 PARAM AIX=2060.,AIY=9927.,AIZ=9385.,AIXZ=C.0  
 PARAM F3R3=30.,F3R4=42.  
 INCON ANTI1=384.6,ANTI2=384.6,ANTI3=623.7,ANTI4=623.7,SFZS=-400.

END

STOP

\*\*\* OSL/91 SIMULATION DATA \*\*\*

TITLE NEW VEHICLE FRUE = 91  
 PARAM IAXL = C  
 PARAM AKT1=1250.,AKT2=1250.,AKT3=1250.,AKT4=1250.  
 PARAM RF=-24200.,RR=-69000.  
 PARAM TSF=32.25,TSR=43.25,TF=57.3,TK=57.5  
 PARAM FFC=63,FKC=2.22,ZF=16.,ZL=15.8  
 PARAM CFP=71.,CRP=60.,A=49.61,R=60.25  
 PARAM AMS=7.2,AMUF=.527,AMUR=.8PH  
 PARAM AKF=700.,AKR3=210.,AKR4=210.  
 PARAM IF=458.,IR=455.,SCALE=200.  
 PARAM AIX=7330.,AIY=2574C.,AIZ=29700.,AIXZ=250.  
 PARAM F3F1=8C.,F3F2=23.,F3R1=152.2,F3R4=45.  
 PARAM OMCNIF=0.,OMCNIR=0  
 PARAM GEE=386.4  
 PARAM BETA=.25  
 PARAM CTIN=.005  
 INCLA UC=704., VC=1., WO=5.  
 INCCN PD=.04., JU= .027, RO=.62  
 INCCN THEO=-.00209.,PHIC=-.003, PSI0=.002  
 INCCN DEL1=.387, DEL101=10.  
 INCCN DEL2=.0.866, DEL201=15.  
 INCCN DEL3=.200,DEL4=.300,DEL3CT=5.,DELCT=7.  
 INCCN DELF=.6,DELFO1=25.,PHIF=.02,PHIFO=.6  
 INCCN SNPHIF=-163.  
 INCCN DELRDT=20., PHIRC=.55  
 INCCN DELR=.6, PHIR=.01895  
 INCCN ANTI1=874.,ANTI2=874.,ANTI3=692.,ANTI4=692.  
 INCCN FYU1=-33.45,FYU2=33.45,FYU3=-10.,FYU4=10.  
 INCCN SFU1=-20.,SFU2=30.,SFZ5=-109C.  
 INCCN FZU1=-572.,FZU2=-572.,FZU3=-844.,FZU4=-844.  
 INCCN SNPHIU=-111.,SNTHEU=-274.,SNPSIU=-755.,SNPHIR=-163.  
 INCCN RPS1=57.01, RPS2=57.01, RPS3=56.55, RPS4=56.55  
 CNTL TSTART=C.,FINTIM=.002,DEL1=.001  
 EN

\*\*\*OSL MESSAGE 2C\*\*\* NO OUTPUT REQUESTED...WARNING ONLY.

OSL/91 SIMULATION TIME= 0.0 SECONDS.

OEBUG OUTPUT, BLOCK 3 AT TIME= 0.2000E-02

TIME	2.0000E-03	DEL1	1.0000E-03	DELMIN	0.0	DELMAX	7.2370E 75	TSTART	0.0	FINTIM	2.0000E-03
CLKTIM	0.0	NALARM	0.0	DELS	0.0	DELINX	7.2370E 75	DELAOC	7.2370E 75	DEL40T	7.2370E 75
DELS1F	7.2370E 75	DELMRK	7.2370E 75	TAXLE	0.0	DELX	1.2500E 03	AKT2	1.2500E 03	AKT3	1.2500E 03
AKT4	1.2500E 01	RF	-2.4200E 04	RR	-6.5000E 04	AKT1	3.2250E 01	TSK	4.3250E 01	TF	5.7300E 01
TR	5.7500E 01	HFC	6.3000E-01	PRC	2.2200E 00	ZF	1.6010E 01	ZK	1.5800E 01	CFP	7.3000E 01
CRP	6.0000E 01	A	4.9610E 01	B	6.0150E 01	AMS	7.3000E 00	AMUF	5.3700E-01	AMUR	8.8800E-01
AKF	7.0000E 02	AKR3	2.1000E 02	AKR4	2.1000E 02	IF	4.9800E 02	IR	4.5900E 02	SCALE	2.0000E 03
AIX	7.3300E 03	AIX	2.5740E 04	AIZ	2.5700E 04	AIXZ	0.0	F3F1	8.0000E 01	F3F2	2.3000E 01
F3R3	1.5220E 02	F3K4	4.9000E 01	OMCNIF	0.0	OMCNIR	0.0	GEE	3.8640E 02	HETA	2.5000E-01
CTIN	5.0000E-03	UO	7.0460E 02	VO	1.3000E 01	WO	5.0000E 00	PO	4.0000E-02	CO	3.7000E-02
RC	2.0000E-02	THEO	-2.0900E-03	PHI0	-3.0000E-03	PSI0	2.0000E-03	DELI	3.8300E-01	DEL10T	1.0000E 01
DEL2	8.6600E-01	DEL2DT	1.5000E 01	DEL3	2.0000E-01	DEL4	3.0000E-01	DEL30T	5.0000E 00	DEL40T	7.0000E 00
DEL3	8.0000E-01	CELFO1	2.5000E 01	PHIF	2.0000E-02	PHI0	6.0000E-01	SNPHIF	-1.6300E 02	DELRO1	2.0000E 01
PHIRD	5.5000E-01	DELR	6.0000E-01	PHIR	1.8950E-02	ANTI1	8.7400E 02	ANTI2	8.7400E 02	ANTI3	6.9200E 02
ANTI4	6.9200E 02	FYU1	-3.3450E 01	FYU2	3.3450E 01	FYU3	-1.0000E 01	FYU4	1.0000E 01	SFXU	-2.0000E 01
SFYU	3.0000E 01	SFZ5	-1.0900E 03	FZU1	-9.7200E 02	FZU2	-5.7200E 02	FZU3	-8.4400E 02	FZU4	-8.4400E 02
SNPHIU	-1.1100E 02	SNTHEU	-2.7400E 02	SNPSIU	-7.5500E 02	SNPHIR	-1.6300E 02	RPS1	5.7010E 01	RPS2	5.7010E 01
RPS3	5.6550E 01	RPS4	5.6550E 01	RPS200	0.0	RPS100	0.0	RPS400	0.0	RPS300	0.0
ZZ0001	0.0	P	4.0000E-02	C	3.7000E-02	K	2.0000E-02	U	7.0460E 02	V	1.3000E 01



W	SINTHE	THE	PHI	PSI	CDSTHE	SINPHI	
PR	5.0000E-03	CO5PHI	F2	Q2	K2	QR	-3.0000E-C3
PC	-2.0500E-04	WP	VR	WQ	UR	UW	7.4000E-C4
G	8.0000E-04	VP	TFO2	TRQ2	TSFQ2	TSRQ2	2.6048E 01
GAM4	1.4800E-03	SM	GAM1	ZZ0002	GAM2	GAM3	2.1625E 01
A1P	3.8640E 02	CAM5	GAM6	GAM7	GAM8	GAM9	3.0314E C1
A1ZP	0.0	A1P6	A1ZP	A1XZP	A1YXZP	A1YXZP	1.7917E 02
DAC05	5.0361E 02	LAC00	DAC01	OAC02	OAC03	DAC04	2.6244E 04
DAC11	3.6202E 04	CAC05	CAC07	DAC06	DAC09	DAC10	3.8658E-C3
DAC17	1.5355E-02	CAC12	CAC13	OAC14	OAC15	DAC16	9.5261E-07
DAC27	-3.7368E-03	CAC20	CAC21	DAC22	DAC23	DAC26	-1.9728E-C4
DAC33	0.0	DAC28	CAC29	DAC30	DAC31	DAC32	-2.5258E C0
DAC40	7.6487E 00	DAC34	CAC35	DAC37	DAC38	DAC39	3.6920E C3
ZET2	3.6520E 02	ZET3	CAC42	OAC43	DAC44	ZET3D1	6.9200E 02
ZET4CT	6.9200E 02	ZET4	CAC43	ZET1CT	DAC45	ZET2F1	1.1225E 00
F2F2	4.7750E-01	F1F1	F1F2	F1R2	F1R4	F2F1	3.1894E C1
S4	8.1063E 00	F2K3	F2R4	S1	S2	S3	7.8575E 02
UCT	3.3425E 04	AUXR1	AUXR2	AUXR3	AUXR4	SUMS1	2.9758E C2
PH10T	5.7325E 02	VOT	WCT	QDT	RDT	PSID1	1.2803E 01
PH1RCC	-1.6472E 00	THEDT	FDT	DELFCDD	PH1FDD	DELDDO	1.9889E-02
DEL40D	3.69558E-02	DELPOC	CEL1CD	DELZCO	OELPDR	OELPDD	-8.2257E C2
P005	-2.6313E 01	KPSIDT	FPS2CT	RPS3CT	RPS4DT	P000	0.0
P004	5.8667E-01	P020	P023	P075	P086	P101	4.6250E-C2
Q004	5.6550E-02	F111	F114	P050	P119	Q002	5.7010E-01
Q019	5.5000E-02	Q007	Q009	Q012	Q014	Q017	6.0000E-02
A07	5.0000E-02	Q022	Q024	Q027	Q030	A005	2.0000E-02
A027	2.0000E-04	A040	A045	A050	A055	A070	5.8667E-01
A075	2.0000E-02	A080	A085	A100	A105	A110	4.5000E-03
A115	-5.6550E-03	A014	A022	A044	A048	A099	-6.0000E-03
A021	7.5545E-03	A011	A014	A017	A018	A099	-5.6550E-01
A029	-2.2538E-01	A022	A023	A024	A026	A028	6.0000E-C2
A036	0.0	A030	A031	A032	A034	A035	0.0
A044	-3.1204E-02	A037	A039	A041	A042	A043	4.5906E-C6
A052	5.5000E-02	A045	A046	A047	A049	A051	-6.8450E-01
A060	-6.0000E-02	A053	A056	A057	A058	A059	-2.9333E-C3
A068	3.3203E-06	A061	A062	A063	A066	A067	-2.8664E-01
A078	-1.0000E-03	A069	A071	A072	A076	A077	-6.5000E-05
A087	5.5555E-01	A081	A082	A083	A084	A086	2.0900E-03
AC56	2.3125E-03	A088	AC09	A091	A092	A093	2.6308E-01
A108	-3.7060E-02	A098	A101	A102	A104	A106	4.6250E-02
A116	-2.0784E-05	A109	A111	A112	A113	A114	8.8257E-C4
D007	5.3365E-04	A117	A118	A119	A120	0005	5.9288E-C4
D027	-2.3043E-01	D010	C012	C015	D020	D025	3.4717E-01
0080	-1.2431E-03	C040	C050	C055	D070	D075	1.5984E-02
C115	-2.0574E-01	C085	C095	D095	O105	O110	-1.5000E-01
0A05	1.5021E-04	DA00	CA01	DA02	DA03	DA04	1.5021E-04
0A11	4.8488E-02	CA06	CA07	DA08	DA09	DA10	9.6744E-02
0A17	-1.4547E-02	CA12	CA13	DA14	DA15	DA16	3.8105E-02
0A27	3.6487E-03	CA20	CA21	DA22	DA23	DA26	1.9728E-C2
D493	-1.8460E-01	CA28	CA29	DA30	DA31	DA32	-6.3144E-01
DA40	6.9200E-02	DA34	CA35	DA37	DA38	DA39	1.8460E-01
TC41	1.5325E-01	T042	CA42	DA43	DA44	T045	6.9200E-C2
T056	5.0000E-03	T057	T043	T053	T054	T055	3.4675E-C1
TC72	-3.0000E-04	T073	T058	T075	T076	T077	4.6250E-C2
T078	-2.3052E-01	T079	T080	T082	T083	T088	1.4800E-04
ZZ0004	0.0	ZZ0004	LUMMY	0.0	0.0	0.0	-2.3000E-02

\*\*\* OSL/91 SIMULATION DATA \*\*\*

PARAM IAXLE = 1  
 PARAM AKT1=1255.,AKT2=1255.,AKI3=1295.,AKT4=1295.  
 PARAM RE=151000.,RK=0.0  
 PARAM TSF=0.0,TSR=43.,TF=61.5,TR=61.  
 PARAM HFC=3.,HRC=2.5,ZF=5.35,ZR=9.25  
 PARAM CFP=30.,CKP=50.,A=48.,B=61.  
 PARAM AMS=8.13,AMUF=.484,AMUK=.789  
 PARAM AKF=100.2,AKK3=114.,AKR4=114.  
 PARAM IF=3.3,IR=600.,SCALE=2000.  
 PARAM AIX=2940.,AIY=14700.,AIZ=22500.,AIXZ=230.  
 PARAM F3F1=1.2,F3F2=22.5,F3F3=152.2,F3R4=48.6  
 INCON SFZS= -100.  
 ENC

\*\*\*OSL MESSAGE 20\*\*\* NO OUTPUT REQUESTED...WARNING ONLY.

OSL/91 SIMULATION TIME= 0.01 SECONDS.

DEBUG OUTPUT, BLOCK 3 AT TIME= 0.2000E-02

TIME	2.0000E-03	DELTA	1.0000E-03	DELMIN	0.0	DELMAX	7.2370E 75	TSTART	0.0	7.2370E 75	FLTIM
CLKTIM	0.0	NALARM	C.0	DELS	0.0	DELINX	7.2370E 75	DELDAC	0.0	7.2370E 75	DELDAC
DELS1F	7.2370E 75	CELMRK	7.2370E 75	IAXLE	0.0	AKT1	1.2950E C3	AKT3	1.2950E 03	1.2950E 03	AKT3
AKT4	1.2950E 03	RF	1.5100E 05	RR	0.0	TSF	0.0	TSR	4.3000E 01	4.3000E 01	TF
TR	6.1000E 01	HFC	3.0000E 00	HRC	2.5000E 00	ZF	5.3500E 00	ZK	5.3500E 00	5.3500E 00	CFP
CRP	5.0000E 01	A	4.8000E 01	B	6.1000E 01	AMS	8.1300F 00	AMUF	4.8400E-01	4.8400E-01	AMUR
AKF	1.0020E 02	AKR3	1.1400E 02	AKR4	1.1400E 02	IF	3.3000E 00	IR	6.0000E 02	6.0000E 02	SCALE
AIX	2.9400E 03	AIX	1.4700E 04	AIZ	2.2500E 04	AIXZ	2.3000E C2	F3F1	1.5200E 01	1.5200E 01	F3F2
F3R3	1.5220E 02	F3R4	4.8600E 01	CMCNIF	0.0	OMCNIF	0.0	GEE	3.8640E 02	3.8640E 02	BETA
OTIN	5.0000E-03	U	7.0400E 02	VO	1.3000E 01	WC	5.0000E 00	PO	4.0000E-02	4.0000E-02	OD
RC	2.0000E-02	THEO	-2.0900E-03	PHIC	-3.0000E-03	PSIC	2.0000E-03	DEL1	3.8300E-01	3.8300E-01	DEL1DT
DEL2	8.6600E-01	DEL20T	1.5000E 01	DEL3	2.0000E-01	DEL4	3.0000E-01	DEL3DT	5.0000E 00	5.0000E 00	DEL4DT
DEL3	8.0000E-01	DEL20T	2.5000E 01	PHIF	2.0000E-02	PHIFC	6.0000E-01	SNPHIF	-1.6300E 00	-1.6300E 00	DELDRDT
PHIRC	5.5000E-01	DELR	6.0000E-01	PHIR	1.8950E-02	ANT11	8.7400E 02	ANT12	8.7400E 02	8.7400E 02	ANT13
ANTI4	6.9200E 02	FYU1	-3.3450E 01	FYU2	3.3450E 01	FYU3	-1.0000E 01	FYU4	1.0000E 01	1.0000E 01	SFXU
SFYU	3.0000E 01	SFZS	-1.0000E 02	FZU1	-9.7200E 02	FZU2	-5.7200E 02	FZU3	-8.4400E 02	-8.4400E 02	FZU4
SAPHIU	-1.1100E 02	SNTHEU	-2.7400E C2	SNPSIU	-7.5500E 02	SNPHIR	-1.6300E 02	RPS1	5.7010E 01	5.7010E 01	RPS2
RPS3	5.6550E 01	RPS4	5.6550E 01	RPS2CC	0.0	RPS1FD	0.0	RPS4DD	0.0	0.0	RPS3DD
Z20001	0.0	P	4.0000E-02	C	3.7000E-02	R	2.0000E-02	U	7.0400E 02	7.0400E 02	V
W	5.0000E 00	THE	-2.0900E-03	PHI	-3.0000E-03	PSI	2.0000E-03	COSTHE	1.0000E 00	1.0000E 00	SINPHI
SINTHE	-2.0500E-03	COSPHI	1.0000E 00	F2	1.6000E-03	Q2	1.3690E-03	R2	4.0000E-04	4.0000E-04	QR
PR	8.0000E-04	WP	2.0000E-01	VR	2.6000E-01	WQ	1.8500E-01	UR	1.4080E 01	1.4080E 01	UQ
PG	1.4800E-03	VP	5.2000E-01	TFO2	3.0750E 01	TRO2	3.0500E 01	TSFD2	0.0	0.0	TSRO2
G	3.8640E 02	SM	5.4030E C0	GAM1	-2.4857E 01	GAM2	C.0	GAM2	1.2678E C1	1.2678E C1	GAM3
GAM4	-3.5542E 00	GAM5	3.5934E 03	GAM6	4.3650E 01	GAM7	4.3530E 02	GAM8	-7.4415E 01	-7.4415E 01	GAM9
AIXP	1.2625E 02	AIYP	1.2625E 02	AIZP	5.1087E 03	AIXZF	-2.4716E 02	AIXXP	3.0663E 03	3.0663E 03	AIYYP
AIZPP	2.7609E 04	CAC0	1.3483E CC	OAC01	-2.6478E 00	OAC02	-2.6478E 00	OAC03	1.3483E 03	1.3483E 03	OAC04
OAC05	-5.5550E-03	CAC06	1.4196E-01	CAC07	-1.1722E-03	OAC08	3.2617E-C4	OAC09	8.512E-04	8.512E-04	OAC10
CAC11	-1.6670E-02	CAC12	2.9360E-C2	CAC13	-2.4242E-04	DAC14	6.4744E-05	OAC15	-6.2139E-04	-6.2139E-04	DAC16
OAC17	-1.3019E-04	CAC20	5.5710E 01	CAC21	5.5710E 01	DAC22	6.4760E 01	DAC23	6.4760E 01	6.4760E 01	DAC26
OAC27	3.3762E 00	CAC28	-1.2300E 01	CAC29	-3.8052E-02	OAC30	-1.7432E-02	OAC31	-3.0217E-02	-3.0217E-02	DAC32
OAC33	3.6920E 03	CAC34	3.1510E 03	CAC35	3.1510E 03	DAC37	8.7400E 02	DAC38	8.7400E 02	8.7400E 02	DAC39
OAC40	6.5200E 02	CAC41	-4.0301E 03	CAC42	-4.0301E 03	OAC43	-2.1394E 03	DAC44	-2.7167E-01	-2.7167E-01	ZET1
ZET2	8.6600E-01	ZET3	1.0074E C0	ZET4	1.9258E-01	ZET1CT	1.0000E 01	ZET2DT	1.5000E 01	1.5000E 01	ZET3DT
DEL4CT	8.1750E 00	F1F1	3.6000E 01	F1F2	2.1954E 01	F1R3	5.0000E C1	F1R4	5.0000E 01	5.0000E 01	F2F1
F3F2	8.6773E 01	F2R3	1.1485E 02	F2R4	1.9283E C1	AUXRL1	C.0	AUXRL2	7.0944E 02	7.0944E 02	S3
S4	5.7145E 02	AUXRL1	1.9283E C1	AUXRL2	-1.5283E 01	AUXRL3	C.0	AUXRL4	0.0	0.0	SUMS1
COT	-1.4220E 00	WOT	-1.1666E 01	WOT	9.7097E 01	QDT	5.8721E-01	ROT	-1.6655E-02	-1.6655E-02	PSIDT
PHIDT	3.9558E-02	THEOT	3.7066E-C2	PDT	4.5050E-01	DELFD0	-1.7249E 03	PHIFD0	-2.9762E 01	-2.9762E 01	DELROD

PHIRDD	-1.7703E-01	DELPOO	3.6218E-02	DELIDD	-5.7499E-02	DEL200	-1.0893E-03	DELPOF	0.0	DEL30D	0.0
DEL4CC	0.0	RPS1DT	3.3203E-02	RPS3CT	3.3203E-02	RPS3CT	6.0083E-01	RPS4DT	6.0083E-01	P000	6.6250E-C2
P005	5.8667E-01	P020	8.3600E-03	P023	5.0000E-04	P075	8.6600E-02	P086	6.0000E-02	P101	5.7010E-01
P110	5.6550E-01	P111	0.0	F114	0.0	P050	0.0	P119	0.0	Q002	1.5000E-01
Q004	5.5000E-02	Q07	1.8950E-C2	Q009	3.8300E-02	Q012	5.0000E-03	Q014	1.3000E-02	Q017	2.0000E-01
Q019	5.0000E-02	Q022	1.0000E-01	Q024	2.0000E-01	Q027	4.5000E-03	A000	4.6250E-02	A005	5.8667E-01
A007	2.0000E-02	A010	1.3000E-02	A012	5.0000E-03	A015	5.0000E-02	A020	-8.3600E-03	A025	4.5000E-03
A027	5.0000E-04	A040	1.8950E-02	A095	-5.5000E-02	A050	-1.0000E-01	A055	3.8300E-02	A070	-1.5000E-01
AC75	8.600E-02	A080	-2.0000E-01	A085	6.0000E-02	A100	-5.7010E-01	A105	-5.7010E-01	A110	-1.5000E-01
A115	-5.6550E-01	A001	5.9444E-C3	AC02	1.7775E-03	AC04	-3.8300E-02	AC08	-3.0000E-03	AC09	-4.8300E-02
AC11	7.7774E-03	A014	1.5000E-01	A016	-4.0185E-01	A017	4.1050E-02	A018	6.5000E-05	A019	0.0
A021	-3.5473E-01	A022	6.0083E-05	A023	2.6000E-04	A024	-1.8950E-02	A026	-1.8748E-01	A028	4.5966E-06
AC29	1.9283E-03	AC30	7.4504E-02	AC31	-8.6773E-03	AC32	-8.6600E-02	AC34	4.0185E-01	AC35	-4.8548E-01
AC36	-1.1465E-02	AC37	3.5472E-01	AC39	1.0000E-01	AC41	6.6301E-03	AC42	1.5000E-01	AC43	-2.9333E-03
AC44	5.5000E-02	AC45	-2.1954E-C3	AC46	4.1152E-01	AC47	8.1750E-02	AC49	3.1825E-01	AC51	-2.8572E-C1
AC52	-0.0000E-02	AC53	-2.7133E-02	AC56	3.3203E-06	AC57	-1.7775E-03	AC58	4.4555E-05	AC59	-6.5000E-05
AC60	3.3203E-06	AC61	-3.0253E-C1	AC62	-3.0000E-03	AC63	1.0000E-00	AC66	1.5639E-02	AC67	1.0000E-00
AC68	-1.0000E-03	AC69	3.4715E-03	AC71	-3.6316E-01	AC72	1.0000E-00	AC76	6.0083E-05	AC77	2.0900E-C2
AC78	-5.9555E-01	AC81	-3.7575E-02	AC82	2.8572E-01	AC83	1.3875E-04	AC84	-2.0900E-03	AC86	2.8865E-C1
AC87	2.3125E-03	AC88	-5.0000E-03	AC90	-3.8377E-03	AC91	-2.1123E-02	AC92	2.0000E-04	AC93	4.6250E-C2
AC96	-3.7060E-02	AC98	1.5000E-05	A101	-4.9361E-01	A103	-9.9445E-03	A104	1.8748E-01	A106	8.8257E-04
A108	-2.0782E-05	A109	4.8544E-01	A111	1.4493E-02	A112	1.2330E-01	A113	2.8428E-05	A114	-2.4878E-C1
A116	8.3273E-04	A117	0.0	A118	6.4279E-05	A115	-7.8634E-C1	D000	-3.0850E-01	D005	2.89624E-04
D007	-5.6362E-02	D010	2.9150E-03	D012	1.0409E-03	D015	-2.4274E-01	D020	-3.7050E-02	D025	1.4984E-C2
D027	-1.2431E-03	D040	-1.3750E-01	D050	-1.4360E-01	D055	-2.5000E-01	D070	-2.7090E-01	D075	-2.7500E-C1
D080	-2.4517E-01	D085	-5.0000E-01	D095	-4.4257E-01	D100	8.3008E-06	D105	8.3008E-06	D110	1.5021E-04
D115	1.5021E-04	CA00	-2.6966E-02	CA01	-2.6478E-02	CA02	5.2955E-02	DA03	-2.1573E-03	DA04	1.4037E-C1
CA05	-1.3987E-02	CA06	-7.0981E-02	CA07	1.1722E-03	CA08	8.1532E-C1	DA09	2.8504E-01	DA10	6.2052E-02
CA11	-6.6680E-02	CA12	-2.3488E-02	CA13	2.4242E-03	DA14	6.7448E-01	DA15	4.9711E-04	DA16	5.0178E-C2
CA17	-1.0415E-04	CA20	-5.5710E-02	CA21	-5.5710E-02	DA22	-6.4760E-02	DA23	-6.4760E-02	DA26	-5.7469E-02
CA27	3.3762E-03	CA28	-1.2300E-02	CA29	-1.3590E-03	DA30	-1.7432E-03	DA31	-3.0217E-03	DA32	-1.8460E-01
CA33	-1.8460E-01	CA34	-1.5755E-01	CA35	-1.5755E-01	DA37	8.7400E-02	DA38	8.7400E-02	DA39	6.9200E-02
CA40	6.5200E-02	CA41	-1.0007E-01	CA42	-1.0007E-01	DA43	-5.7485E-C2	DA44	-6.7517E-04	T040	1.0000E-C1
T041	1.5000E-01	T042	3.4225E-04	T043	8.1750E-02	T053	3.1825E-01	T054	2.0000E-02	T055	4.6250E-C2
T056	5.0000E-03	T057	-3.7575E-02	T058	8.3273E-04	T055	-4.5361E-01	T070	-1.2330E-01	T071	1.0000E-C1
T072	-3.0000E-04	T073	5.0000E-04	T074	7.4225E-04	T075	4.4225E-04	T076	1.4800E-04	T077	1.4800E-C4
T078	-5.6454E-02	T079	5.2500E-05	T080	-1.5200E-02	T082	-1.52220E-01	T083	-4.8600E-02	T088	-2.2500E-02
ZZ0003	C.0	ZZ0004	C.0	CUMMY	C.0						

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*** DSL/91 SIMULATION DATA ***
PARAM IAXLE = 2
PARAM AKT1=746.,AKT2=746.,AKT3=956.,AKT4=556.
PARAM RK=28300.,TSR=50.,TF=53.8,TR=51.5
PARAM PFC=2.4,PRC=3.4,ZF=10.8,ZK=11.2
PARAM CFP=35.,CKP=40.,A=55.9,B=19.9
PARAM AMS=5.5,AMUF=0.36,AMUR=C.57
PARAM AKF=101.1,AKR3=115.,AKR4=115.
PARAM IR=800.,RF=93000.,SCALE=1000.
PARAM AIX=2060.,AIY=5527.,AIZ=5385.,AIXL=C.C
PARAM F3R3=30.,F3R4=42.
INCON ANTI1=384.6,ANTI2=384.6,ANTI3=623.7,ANTI4=623.7,SFZS=-40C.
END

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\*\*\*DSL MESSAGE 20\*\*\* NO OUTFLT REQUESTED...WARNING ONLY.

DSL/91 SIMULATION TIME= 0.01 SECONDS.

CEBUG OUTPUT, BLCK 3 AT TIME= 0.2000E-02

TIME	DELTA	CELMIN	0.0	DELMAX	7.2370E 75	TSTART	0.0	FINTIM	2.0000E-03
CLRTIM	0.0	NALARM	0.0	DELINX	7.2370E 75	DELAOC	7.2370E 75	DELDAC	2.0000E-03
DELSTF	7.2370E 75	CELMRK	2.0000E 00	DELINX	7.2370E 75	DELAOC	7.4600E 02	DEL40T	7.2370E 75
AKT4	5.600E 02	RF	2.8300E 04	AKT1	0.0	AKT2	5.000E 01	AKT3	5.600E 02
TR	5.1500E 01	HFC	2.4000E 00	TSF	0.0	TSR	1.1200E 01	TF	5.3800E 01
CRP	4.000E 01	A	5.5900E 01	ZF	1.0800E 01	ZR	3.6000E-01	CFP	3.5000E 01
AKF	1.0110E 02	AKR3	1.1500E 02	AMS	5.5000E 00	AMUF	8.0000E 02	AMUR	5.7000E-01
AIX	2.0600E 03	AIX	9.3850E 03	IF	0.0	F3F1	1.5200E 01	SCALE	1.0000E 03
F3R3	3.000E-01	F3K4	4.2000E 01	AIXZ	0.0	GEE	3.8640E 02	F3F2	2.2500E 01
OTIN	5.000E-03	UO	1.3000E 01	OMCAIR	0.0	PO	4.0000E-02	BETA	2.5000E-01
RC	2.000E-02	THEO	-2.0500E-03	WO	2.000E 00	DEL1	3.8300E-01	CO	3.7000E-02
CEL2	8.6600E-01	LELZDT	1.5000E 01	PSIC	3.000E-03	DEL1D	3.8300E-01	DEL1DT	1.0000E 01
DEL3	8.000E-01	LELFDT	2.0000E-01	DEL4	3.0000E-01	DEL3DT	5.0000E 00	DEL4DT	7.0000E 00
PHRC	5.5000E-01	CELR	6.0000E-01	PHIF0	6.0000E-01	SNPHIF	-1.6300E 02	DEL4DT	2.0000E 00
ANTI4	6.2370E 02	FVU1	1.8950E-02	ANTI1	3.8460E 02	ANTI2	3.8460E 02	ANTI3	6.2370E 02
SFYU	3.000E 01	SFZ5	-3.3450E 01	FVU2	-1.0000E 01	FYU4	1.0000E 01	SFXU	-2.0000E 02
SNPHIU	-1.1100E 02	SNTHU	-4.0000E 02	FZU1	-9.7200E 02	FZU2	-8.4400E 02	FZU4	-8.4400E 02
RFS3	5.6550E 01	RFS4	-2.7400E 02	SNPSIL	-7.5500E 02	RPS1	5.7010E 01	RPS2	5.7010E 01
ZZ0001	0.0	P	5.6550E 01	RPS1DC	0.0	RPS400	0.0	RPS300	0.0
SINTHE	5.000E 00	THE	3.7000E-02	R	2.0000E-02	U	7.0400E 02	V	1.3000E 01
PR	-2.0500E-03	COSPHI	-2.0900E-03	PSI	3.0000E-03	R2	1.0000E 00	SINPHI	-3.0000E-03
PG	1.4800E-03	VP	2.0000E-01	WQ	1.6000E-03	JK	4.0000E-04	QR	7.4000E-04
G	3.8640E 02	SM	6.4300E 00	TRG2	2.6000E-01	TSF02	1.4080E 01	TSR02	2.5000E 01
AIXP	1.2174E 02	GAM5	1.3935E 03	ZZ0002	0.0	GAM2	1.0639E 01	GAM3	1.0639E 01
AIZZ	1.2056E 04	CAC00	1.2174E 02	GAM7	1.8167E 02	GAM8	-7.7775E 01	GAM9	2.3018E 02
OAC05	-1.3980E-02	CAC06	1.6546E 00	GAC01	-4.0731E-01	GAC02	1.6546E 00	GAC04	1.0049E 04
CAC11	-2.0333E-03	CAC12	1.8075E-02	DAC0E	4.5835E-04	DAC09	1.0588E-03	DAC10	0.0
DAC17	-2.5486E-04	CAC20	5.5710E 01	DAC14	9.9515E-05	DAC15	-2.5300E-03	DAC16	-2.1724E-04
DAC27	4.7642E 00	DAC28	-7.2727E 01	DAC22	6.4760E 01	DAC23	6.4760E 01	DAC26	-3.2016E 00
CAC33	3.6520E 03	CAC34	2.1510E 03	DAC30	-5.0652E-02	DAC31	-6.3237E-02	DAC32	3.6920E 03
DAC40	6.2370E 02	CAC41	-5.3834E 03	DAC33	3.8460E 02	DAC38	3.8460E 02	DAC39	6.2370E 02
ZET2	8.6600E-01	ZET3	2.0000E-01	DAC42	-2.9567E 03	DAC44	-2.9567E 03	ZET1	3.8300E-01
ZET4CT	7.0000E 00	F1F1	3.5000E 01	F1R2	3.0000E 01	F1R4	4.0000E 01	ZET3DT	5.0000E 00
F2F2	8.7553E 01	F2R3	3.5000E 01	S1	1.1120E 02	S2	2.2403E 02	S3	3.8721E 01
S4	5.0613E 02	AUXRL1	1.5519E 01	AUXRL2	-1.5519E 01	AUXRL4	-1.0670E 00	SUMSI	1.5731E 03
UOT	-2.3210E 00	WDT	-1.0217E 01	WOT	5.3175E 01	PD1	-5.9568E-02	PS1DT	1.9889E-02
PH10T	3.9958E-02	THEDT	3.7066E-02	DELFC0	-1.3580E 00	PHIFDC	-2.9762E 01	DELRDD	-9.8067E 02
PHI000	-1.7763E 01	CELPO0	3.0985E 02	DEL2DD	-3.4446E 03	DELPRD	3.9363E 02	DEL3DD	-7.3776E 02



H-2. IBM 360/91 Fortran Digital Program

This section contains the computer listing of the IBM 360/91 Fortran digital program.

H-2.1 Subroutines

H-2.1.1 MAIN

Presented here is the Fortran listing for the MAIN program. Control of the program flow is performed in this program.

```
C    VEHICLE HANDLING  MODEL C                                MAIN  10
C    MAIN PROGRAM                                           MAIN  10
C*****
C    THIS PROGRAM CONTROLS THE PROGRAM FLOW
C*****
    LOGICAL TRSL,LOGDUM
8888 CONTINUE                                               MAIN  30
    CALL OSXNTL                                           MAIN  40
    CALL USERIN                                           MAIN  50
    CALL VHTPIC                                           MAIN  60
    CALL NITIAL                                           MAIN  70
    CALL SBPG22                                           MAIN  80
    CALL NTIAL1                                           MAIN  90
    CALL POTSET                                           MAIN 100
999  CONTINUE
    CALL NTRACT (&8888,&1000,&2000,&3000)                MAIN 110
1000 CONTINUE                                               MAIN 120
    CALL VHTPIC                                           MAIN 130
    CALL NITIAL                                           MAIN 140
    CALL SBPG22                                           MAIN 150
    CALL NTIAL1                                           MAIN 160
    CALL POTSET                                           MAIN 170
    CALL NTRAT1 (&8888,&1000,&2000,&3000)                MAIN 180
2000 CONTINUE                                               MAIN 190
    LOGDUM=TRSL(00)
    CALL RTMON                                           MAIN 200
    IF (TRSL(00)) GO TO 999
    CALL CMPVAR                                           MAIN 210
    CALL NTRAT2 (&8888,&1000,&2000,&3000)                MAIN 220
3000 CONTINUE                                               MAIN 230
C
C    THE FOLLOWING STATEMENTS ARE REQUIRED FOR OVERLAY
C
    CALL RTMONT                                           OVERLAY
    CALL RACN(1,IRACNE)                                   OVERLAY
    CALL CHKIO                                           OVERLAY
    CALL WRTOFF                                          OVERLAY
    CALL RDOFF                                           OVERLAY
    STOP                                                 MAIN 240
    END                                                  MAIN 250
```

H-2.1.2 OSXNTL

Presented here is the Fortran listing for the OSXNTL sub-program. The following is performed in OSXNTL:

1. Initialization of the OS options executive which includes the reading of data cards for table and track variables, analog-to-digital and digital-to-analog converter (ADC and DAC) assignments, and all initial values for interactive variables.
2. Communication initialization with the hybrid operator's station.

```

C      SUBROUTINE OSXNTL                                OSXN  10
C      SUBROUTINE OSXNTL                                OSXN  20
C *****OSXN  30
C      OSXN  40
C      THIS SUBROUTINE INITIALIZES THE OS OPTIONS EXECUTIVE OSXN  50
C      INCLUDING THE READING OF DATA CARDS FOR TABLE AND TRACK VARIABLES OSXN  60
C      ,ADC AND DAC ASSIGNMENTS, AND ALL INITIAL OSXN  70
C      VALUES FOR INTERACTIVE VARIABLES. IT ALSO ESTABLISHES
C      COMMUNICATION INITIALIZATION WITH THE HYBRID OPERATOR'S STATION
C      OSXN  90
C *****OSXN 100
C      OSXN 110
C ***** COMMON AREAS *****OSXN 120
C      OSXN 130
C      COMMON/START/ ZDUMMY(4) OSXN 140
C      COMMON/VHTPNM/ TABVAR, INDVAR, WRDVNT OSXN 150
C      COMMON/OSTRAN/ ICT, IRT, MOPU, IFUNS, LRUNS, REALT, ITRUNS OSXN 160
C      COMMON/DACADC/ NAMDAC, NAMADC, IDAC, IADC, ADCNUM, DACNUM OSXN 170
C      COMMON/TABBS/ ITABP, ITABI, ITNAM, TABNUM OSXN 180
C      COMMON/DEVICE/KEYBD, ITTY, ICDFD, LPTR, LPNT OSXN 190
C      COMMON/OSMON/ IREALT, NNN OSXN 200
C      COMMON/IO/ DACPLA, ADCPLA, SCALDC, SCALAC OSXN 210
C      COMMON/TRACK/JIN, IKEEP, ATRACK, ISAMP, ONTIM, OPFTIM, ITRA,
1 ITRAA, ITRNA, ITRIA OSXN 230
C      COMMON/UNREAD/NAMEA, IWRDCT, INUMCT, LSTART, INDEXA,
1 FNUMA, LAST, ILOP OSXN 250
C      COMMON/FIND/ORNAME(400), NCOM, FSVAL(002), IORDER(400) OSXN 260
C      COMMON/SP7BLK/N1, N2, IPOT(120), IPOTAD(120), PARAM(400) OSXN 270
C      COMMON/TIMBLK/JJTIME, TIME, DT OSXN 280
C      OSXN 290
C *****OSXN 300
C      OSXN 310
C      REAL*8 LMNAME OSXN 320
C      REAL*8 VEHICL OSXN 330
C      REAL*8 TABVAR(9,7) OSXN 340
C      REAL*8 NAMEA(10) OSXN 350
C      REAL*8 CRNAME OSXN 360
C      REAL*8 ENDDAC, ENDADC OSXN 370
C      REAL*4 ZDUMMY OSXN 380
C      REAL*4 FNUMA(10) OSXN 390
C      REAL*4 SCALAC(48), SCALDC(48) OSXN 400
C      REAL*4 IPOT, IPOTAD OSXN 410
C      INTEGER*4 INDEXA(10) OSXN 420

```

INTEGER*4	ITABP (9) ,TABNUM, ITNAM (9)	OSXN 430
INTEGER*4	ITABI (9)	OSXN 440
INTEGER*2	WRDVNT (9)	OSXN 450
INTEGER*2	INDVAR (9,7)	OSXN 460
INTEGER*2	ITRAA (50) ,ITRNA (50) ,ITRIA (50)	OSXN 470
INTEGER*2	DACNUM, ADCNUM, DACPLA (48) ,ADCPLA (48)	OSXN 480
INTEGER*2	NAMDAC (48) ,NAMADC (48) ,IDAC (48) ,IADC (48)	OSXN 490
EQUIVALENCE	(BVALUE (1) ,ZDUMMY (1))	OSXN 500
EQUIVALENCE	(BVALUE (1) ,IVALUE (1))	OSXN 510
DATA	ENDDAC/'ENDNODAC'/'ENDADC/'ENDNOADC'/	OSXN 520
DIMENSION	ATRACK (2000)	OSXN 530
DIMENSION	BVALUE (2)	OSXN 540
DIMENSION	IVALUE (2)	OSXN 550
C		OSXN 560
C	*****	OSXN 570
C		OSXN 580
	KEYBD=5	OSXN 590
	ITTY=6	OSXN 600
	ICDRD = 1	OSXN 610
	LAST=72	OSXN 620
	LPTR =2	OSXN 630
	LPNT = 3	
	CALL TYPER2 (KEYBD,ITTY,LPNT)	OSXN 650
	CALL SETUP (ITTY,ICDRD)	OSXN 660
	IRT=0	OSXN 670
	IKEEP=0	OSXN 680
	JIN=0	OSXN 690
	TABNUM=9	OSXN 700
	MOPU=6	OSXN 710
	LRUNS=0	OSXN 720
	IRUNS=1	OSXN 730
	ICT=0	OSXN 740
	LSTART=1	OSXN 750
	ADCNUM=48	OSXN 760
	DACNUM=48	OSXN 770
	ITRUNS=0	OSXN 780
	REALT=1.	OSXN 790
	ONTIM=1000.	OSXN 800
	NNNN=0	OSXN 810
C		OSXN 820
C	THIS SECTION WRITES THE PROBLEM TITLE AND LOAD MODULE NAME	OSXN 830
C		OSXN 840
	WRITE (ITTY,11)	OSXN 850
11	FORMAT (T10,'HYBRID VEHICLE HANDLING PROGRAM')	OSXN 860
	READ (ICDRD ,101) NUM,LMNAME,VEHICL	OSXN 870
101	FORMAT (I3,A8,A8)	OSXN 880
	WRITE (ITTY,201) NUM,LMNAME,VEHICL	OSXN 890
	WRITE (LPTR,201) NUM,LMNAME,VEHICL	OSXN 900
201	FORMAT (1H0,' HYBRID COMPUTER PROB# ',I3/A8,' LOAD MODULE'/	OSXN 910
	1 A8,' VEHICLE'//)	OSXN 920
	WRITE (ITTY,301)	OSXN 930
301	FORMAT (1H0,' ENGAGE PATCH PANEL FOR TEST')	OSXN 940
	WRITE (ITTY,401)	OSXN 950
401	FORMAT (1H ,' TYPE CR WHEN READY')	OSXN 960
	READ (KEYBD,151) LL	OSXN 970
151	FORMAT (I1)	OSXN 980
C		OSXN 990
C	*****	OSXN1000
C		OSXN1010



C#####	---	THIS ROUTINE SETS UP TRACK NAME ARRAY	OSXN1020
		ITRA=0	OSXN1030
130		CALL UNIFORM(ICDRD,1)	OSXN1040
		IF(IWRDCT.EQ.0) GO TO 120	OSXN1050
		DO 110 I=1,IWRDCT	OSXN1060
		CALL FINDNM(K,J,I,&110)	OSXN1070
		IF(ITRA.GE.50) WRITE(ITTY,401C) ORNAME(J)	OSXN1080
		IF(ITRA.GE.50) GO TO 110	OSXN1090
4010		FORMAT(1H,'ERROR TRACK TABLE EXCEEDED, LAST NAME WAS',A6)	OSXN1100
		ITRA=ITRA+1	OSXN1110
		ITRAA(ITRA)=K	OSXN1120
		ITRNA(ITRA)=J	OSXN1130
		ITRIA(ITRA)=INDEXA(I)	OSXN1140
110		CONTINUE	OSXN1150
		GO TO 130	OSXN1160
120		CONTINUE	OSXN1170
C#####	---	THIS ROUTINE SETS UP TABLE NAME ARRAY	OSXN1180
		DO 10101 JJ=1,7	OSXN1190
		CALL UNIFORM(ICDRD,1)	OSXN1200
		TABNUM=IWRDCT	OSXN1210
		DO 102 LL=1,TABNUM	OSXN1220
		TABVAR(LL,JJ) = NAMEA(LL)	OSXN1230
		INDVAR(LL,JJ) = INDEXA(LL)	OSXN1240
102		CONTINUE	OSXN1250
		WRDVNT(JJ) = TABNUM	OSXN1260
10101		CONTINUE	OSXN1270
C#####	---	THIS ROUTINE SETS UP DAC NAMES & SCALING	OSXN1280
		N = 0	OSXN1290
105		CALL UNIFORM(ICDRD,1)	OSXN1300
		IF(NAMEA(1).EQ.ENDDAC) GO TO 106	OSXN1310
		IF(ILOP.NE.LAST) WRITE(ITTY,400C)	OSXN1320
		IF(IWRDCT.NE.INUMCT) WRITE(ITTY,4002)	OSXN1330
		DO 9007 I=1,IWRDCT	OSXN1340
		CALL FINDNM(K,J,I,&105)	OSXN1350
		N = N+1	OSXN1360
		IF(N.GT.DACNUM) WRITE(ITTY,4005) NAMEA(I)	OSXN1370
4005		FORMAT(1H0,' ERROR *-DAC ARRAY > 48-* LAST VARIABLE WAS ',A8)	OSXN1380
		IF(N.GT.DACNUM) GO TO 105	OSXN1390
		NAMDAC(N) = J	OSXN1400
		DACPLA(N) = K	OSXN1410
		SCALDC(N) = FNUMA(I)	OSXN1420
		IDAC(N) = INDEXA(I)	OSXN1430
9007		CONTINUE	OSXN1440
		GO TO 105	OSXN1450
106		CONTINUE	OSXN1460
		DACNUM = N	OSXN1470
		IF(DACNUM.GE.48) DACNUM=48	OSXN1480
C#####	---	THIS ROUTINE SETS UP ADC NAMES & SCALING	OSXN1490
		N = 0	OSXN1500
108		CALL UNIFORM(ICDRD,1)	OSXN1510
		IF(NAMEA(1).EQ.ENDADC) GO TO 109	OSXN1520
		IF(ILOP.NE.LAST) WRITE(ITTY,4000)	OSXN1530
		IF(IWRDCT.NE.INUMCT) WRITE(ITTY,4002)	OSXN1540
		DO 1269 I=1,IWRDCT	OSXN1550
		CALL FINDNM(K,J,I,&108)	OSXN1560
		N = N+1	OSXN1570
		IF(N.GT.ADCNUM) WRITE(ITTY,4008) NAMEA(I)	OSXN1580
4008		FORMAT(1H0,' ERROR *-ADC ARRAY > 48-* LAST VARIABLE WAS ',A8)	OSXN1590
		IF(N.GT.ADCNUM) GO TO 108	OSXN1600

	NAMADC(N) = J	OSXN1610
	ADCPLA(N) = K	OSXN1620
	IADC(N) = INDEXA(I)	OSXN1630
	SCALAC(N) = FNUMA(I)	OSXN1640
1269	CONTINUE	OSXN1650
	GO TO 108	OSXN1660
109	CONTINUE	OSXN1670
	ADCNUM = N	OSXN1680
	IF(ADCNUM.GE.48) ADCNUM=48	OSXN1690
C#####	--- THIS ROUTINE READS IN FLOATING POINT NAMES AND VALUES ---#####	OSXN1700
90	CALL UNIFORM(ICDRD,1)	OSXN1710
	IF(IWRDCT.EQ.0) GO TO 70	OSXN1720
	IF(ILOP.NE.LAST) WRITE(ITY,4000)	OSXN1730
	IF(IWRDCT.NE.INUMCT) WRITE(ITY,4002)	OSXN1740
	DO 80 I=1,IWRDCT	OSXN1750
	CALL FINDNM(K,J,I,890)	OSXN1760
	BVALUE(K) = FNUMA(I)	OSXN1770
80	CONTINUE	OSXN1780
	GO TO 90	OSXN1790
70	CONTINUE	OSXN1800
C#####	--- THIS ROUTINE READS IN FIX POINT NAMES AND VALUES ---#####	OSXN1810
91	CALL UNIFORM(ICDRD,1)	OSXN1820
	IF(IWRDCT.EQ.0) GO TO 71	OSXN1830
	IF(ILOP.NE.LAST) WRITE(ITY,4000)	OSXN1840
	IF(IWRDCT.NE.INUMCT) WRITE(ITY,4002)	OSXN1850
	DO 81 I=1,IWRDCT	OSXN1860
	CALL FINDNM(K,J,I,891)	OSXN1870
	IVALUE(K) = IFIX(FNUMA(I))	OSXN1880
81	CONTINUE	OSXN1890
	GO TO 91	OSXN1900
71	CONTINUE	OSXN1910
4000	FORMAT(1H0,' MAXIMUM 10 PAIRS PER DATA CARD - COLUMNS 1 THRU 72')	OSXN1920
4002	FORMAT(1H0,' DATA MUST BE ENTERED IN PAIRS - NAME AND VALUE')	OSXN1930
810	CONTINUE	OSXN1940
C		OSXN1950
C	*****	OSXN1960
C	* *	OSXN1970
C	* INITIALIZATION PASS *	OSXN1980
C	* *	OSXN1990
C	*****	OSXN2000
C		OSXN2010
	DO 1701 I=1,120	OSXN2020
	IPOT(I)=100000.	OSXN2030
	IPOTAD(I)=100000.	OSXN2040
1701	CONTINUE	OSXN2050
C		OSXN2060
	CALL SACN(1,ISACNE)	OSXN2070
	CALL SAMO(1,ISAMOE)	OSXN2080
	CALL SLMO(3,ISLMOE)	OSXN2090
	CALL SLMO(1,ISLMOE)	OSXN2100
C		OSXN2110
	RETURN	OSXN2120
	END	OSXN2130

## H-2.1.3 USERIN

Presented here is the Fortran listing for the USERIN sub-program. The following is performed: Reading of data cards for vehicle functions and parameters.

```

C      SUBROUTINE USERIN                                USER  10
      SUBROUTINE USERIN                                USER  20
C*****
C      THIS SUBPROGRAM READS DATA CARDS FOR VEHICLE FUNCTIONS
C      AND PARAMETERS
C*****
      COMMON/VHTPDT/ PARMNO,VHTPAR                                USER  30
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT                USER  40
      COMMON/APL/ OPEN ,RTSW ,LDTSW ,RBSW                      USER  50
      COMMON/SPRING/ DLSUS1,DLSUS2,DLSUS3,DLSUS4,DELSF1(10),DELSF2(10),
1DELSR3(10),DELSR4(10),FDLSF1(10),FDLSF2(10),FDLSR3(10),FDLSR4(10),
1NDELF1,NDELF2,NDELR3,NDELR4
      COMMON/STRPUN/ NST,STRTM(20),STEER(20)
      COMMON/AROTBS/ TAU(40),CX(40),CY(40),CZ(40),CL(40),      AERO 120
1CM(40),CN(40),ALPHA(40),DELCX(40),NAERO,NDGX,
1XWP(20),VYWTB(20),NWP
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),        USER 110
1AFA(20),GAMP(20),NTF(20),NTR,NFA                            USER 120
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)    USER 130
      COMMON/SOLDAX/ PHIFNT(07),THEFNT(07),                    USER 140
1PSIFNT(7),PHIRR(7),THERR(7),PSIRR(7)                         USER 150
      COMMON/ALPHA/ALPH(20)                                    USER 160
      COMMON/SHOCKS/ZDBPRF(10),ZDBPLF(10),ZDBPRR(10),ZDBPLR(10),
1SAFRF(10),SAFLF(10),SAFRR(10),SAFLR(10),
2NRF,NLF,NRR,NLR,
3ZETDRF,ZETDLF,ZETDRR,ZETDLR,
4AKSRF,AKSLF,AKSRR,AKSLR,FSARF,FSALF,FSARR,FSALR
      REAL*4 VHTPAR(27,7)                                       USER 170
      INTEGER*4 PARMNO(27),NUMPRM/27/                           USER 180
      INTEGER*2 OPEN,RTSW,LDTSW,RBSW                            USER 190
          RBSW = 0                                               USER 200
          OPEN = 0                                               USER 210
      RTSW=1                                                     USER 220
      N1=295                                                     USER 230
      N2=119                                                     USER 240
3333 FORMAT(20A4)                                               USER 250
      READ(ICDRD,3333)(ALPH(I),I=1,20)                          USER 260
      READ(ICDRD,900)(PHIFNT(I),I=1,7)                          USER 270
      READ(ICDRD,900)(THEFNT(I),I=1,7)                          USER 280
      READ(ICDRD,900)(PSIFNT(I),I=1,7)                          USER 290
      READ(ICDRD,900)(PHIRR(I),I=1,7)                           USER 300
      READ(ICDRD,900)(THERR(I),I=1,7)                           USER 310
      READ(ICDRD,900)(PSIRR(I),I=1,7)                           USER 320
      NTF=1                                                       USER 330
200 READ(ICDRD,900)PBF(NTF),TQBF(NTF)                           USER 340
      IF(PBF(NTF).GE.99999.0)GO TO 210                           USER 350
      NTF=NTF+1                                                  USER 360
      GO TO 200                                                  USER 370
210 NTF=NTF-1                                                  USER 380
      NTR=1                                                       USER 390
220 READ(ICDRD,900)PBR(NTR),TQBR(NTR)                           USER 400
      IF(PBR(NTR).GE.99999.0)GO TO 230                           USER 410
      NTR=NTR+1                                                  USER 420

```

	GO TO 220	USER 430
230	NTR=NTR-1	USER 440
	NFA=1	USER 450
280	READ(ICDRD,900) GAMF(NFA),AFA(NFA)	USER 460
	IF(GAMF(NFA).GE.99999.0)GO TO 290	USER 470
	NFA=NFA+1	USER 480
	GO TO 280	USER 490
290	NFA=NFA-1	USER 500
	NWP=1	USER1050
340	READ(ICDRD,900) XWP(NWP),VYWTB(NWP)	USER1060
	IF(XWP(NWP).GE.99999.)GO TO 350	USER1070
	NWP=NWP+1	USER1080
	GO TO 340	USER1090
350	NWP=NWP-1	USER1100
	NAERO = 1	
240	READ(ICDRD,900) TAU(NAERO),CX(NAERO),CY(NAERO),CZ(NAERO),CL(NAERO)	
	1, CM(NAERO),CN(NAERO)	
	IF(TAU(NAERO).GE.99999.) GO TO 241	
	NAERO = NAERO + 1	
	GO TO 240	USER 550
241	NAERO = NAERO - 1	
	NDCX=1	USER 870
252	READ(ICDRD,900) ALPHA(NDCX),DELX(NDCX)	USER 880
	IF(ALPHA(NDCX).GE.99999.) GO TO 253	USER 890
	NDCX= NDCX+1	USER 900
	GO TO 252	USER 910
253	NDCX =NDCX-1	USER 920
C	READ IN STEER PROFILE DATA	
	NST = 1	
360	READ(ICDRD,900) STRTM(NST),STEER(NST)	
	IF(STRTM(NST).GE.99999.) GO TO 370	
	NST = NST + 1	
	GO TO 360	
370	NST = NST - 1	
	NDELF1 = 1	
300	READ(ICDRD,900) DELSF1(NDELF1) , FDLSF1(NDELF1)	
	IF(DELSF1(NDELF1).GE.99999.) GO TO 310	
	NDELF1 = NDELF1 + 1	
	GO TO 300	
310	NDELF1 = NDELF1 - 1	
	NDELF2 = 1	
301	READ(ICDRD,900) DELSF2(NDELF2) , FDLSF2(NDELF2)	
	IF(DELSF2(NDELF2).GE.99999.) GO TO 311	
	NDELF2 = NDELF2 + 1	
	GO TO 301	
311	NDELF2 = NDELF2 - 1	
	NDELR3 = 1	
302	READ(ICDRD,900) DELSR3(NDELR3) , FDLR3(NDELR3)	
	IF(DELSR3(NDELR3).GE.99999.) GO TO 312	
	NDELR3 = NDELR3 + 1	
	GO TO 302	
312	NDELR3 = NDELR3 - 1	
	NDELR4 = 1	
303	READ(ICDRD,900) DELSR4(NDELR4) , FDLR4(NDELR4)	
	IF(DELSR4(NDELR4).GE.99999.) GO TO 313	
	NDELR4 = NDELR4 + 1	
	GO TO 303	
313	NDELR4 = NDELR4 - 1	
	NRF=1	
600	READ(ICDRD,900) ZDBPRF(NRF),SAFRF(NRF)	

IF (ZDBPRF(NRF).GE.99999.) GO TO 601	
NRF=NRF+1	
GO TO 600	
601 NRF=NRF-1	
NLF=1	
602 READ(ICDRD,900) ZDBPLF(NLF),SAFLF(NLF)	
IF(ZDBPLF(NLF).GE.99999.) GO TO 603	
NLF=NLF+1	
GO TO 602	
603 NLF=NLF-1	
NRR=1	
604 READ(ICDRD,900) ZDBPRR(NRR),SAFRR(NRR)	
IF(ZDBPRR(NRR).GE.99999.) GO TO 605	
NRR=NRR+1	
GO TO 604	
605 NRR=NRR-1	
NLR=1	
606 READ(ICDRD,900) ZDBPLR(NLR),SAFLR(NLR)	
IF(ZDBPLR(NLR).GE.99999.) GO TO 607	
NLR=NLR+1	
GO TO 606	
607 NLR=NLR-1	
900 FORMAT(7E10.0)	USER1110
READ(ICDRD,100) (PARMNO(J), (VHTPAR(J,I),I=1,7),J=1,NUMPRM)	USER1120
100 FORMAT(I3,1X,7F10.3)	USER1130
ENTRY USERN2	USER1140
DO 1028 I=1,500	USER1150
READ(ICDRD,50,END=32) NOPARM,PARVAL	USER1160
50 FORMAT(I3,1X,G20.6)	USER1170
IF(NOPARM.EQ.304) GO TO 2222	USER1180
1100 PARAM(NOPARM)=PARVAL	USER1190
1028 CONTINUE	USER1200
32 WRITE(ITTY,33)	USER1210
33 FORMAT(' END OF CARDS')	USER1220
2222 CONTINUE	USER1230
RETURN	USER1240
END	USER1250

H-2.1.4 VHTPIC

Presented here is the Fortran Listing for the VHTP initialization subprogram. The appropriate elements of the PARAM array are initialized in VHTPIC for performance of the selected VHTP.

```

C      SUBROUTINE VHTPIC                                VHTP  10
      SUBROUTINE VHTPIC                                VHTP  20
C*****
C      THE APPROPRIATE ELEMENTS OF THE PARAM ARRAY ARE INITIALIZED IN
C      VHTPIC FOR PERFORMANCE OF THE SELECTED VHTP MANEUVER
C*****
      COMMON/VHTPDT/ PARMNO,VHTPAR                    VHTP  40
      COMMON/TABBS/ ITABP,ITABI,ITNAM,TABNUM          VHTP  50
      COMMON/VHTPNM/ TABVAR,INDVAR,WRDVNT            VHTP  60
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400) VHTP  70
      COMMON/UNREAD/NAMEA,IWRDCT,INUMCT,LSTART,INDEXA, VHTP  80
1  FNUMA, LAST, ILOP                                  VHTP  90
      REAL*8 NAMEA(10)                                VHTP 100
      REAL*8 TABVAR(9,7)                              VHTP 110
      REAL*4 VHTPAR(27,7)                             VHTP 120
      INTEGER*4 INDEXA(10)                            VHTP 130
      INTEGER*4 PARMNO(27),NUMPRM/27/
      INTEGER*4 ITABI(9)                               VHTP 150
      INTEGER*4 ITABP(9),TABNUM,ITNAM(9)              VHTP 160
      INTEGER*2 INDVAR(9,7)                           VHTP 170
      INTEGER*2 WRDVNT(9)                             VHTP 180
      EQUIVALENCE (SAVE,PARAM(400))
      IF(SAVE.EQ.PARAM(129)) GO TO 500                 VHTP 190
      I = IFIX(PARAM(129)) + 1                         VHTP 200
      IF(I.EQ.1) GO TO 10                              VHTP 210
      IF((I.GE.2).AND.(SAVE.NE.1)) GO TO 10           VHTP 220
C      IF I = 1 ORIGINAL DATA MUST BE RESTORED      VHTP 230
C      IF IIS NOT = 1 MUST DECIDE TO STORE DATA     VHTP 240
C      IF I NE 1 AND OLD I NE 1 DO NOT STORE        VHTP 250
      DO 20 J=1,NUMPRM                                VHTP 260
      VHTPAR(J,1) = PARAM(PARMNO(J))                  VHTP 270
20  CONTINUE                                          VHTP 280
10  CONTINUE                                          VHTP 290
      DO 30 J=1,NUMPRM                                VHTP 300
      PARAM(PARMNO(J)) = VHTPAR(J,I)                  VHTP 310
30  CONTINUE                                          VHTP 320
C      STRRAT IS THE OVERALL STEERING RATIO
      STRRAT = PARAM(42)*(PARAM(134)/PARAM(138))
      IF(PARAM(129).EQ.4) PARAM(114) = STRRAT * ((PARAM(6)+PARAM(7)))/60.
      IF(PARAM(129).EQ.5) PARAM(123) = 66. * (PARAM(6)+PARAM(7)) * STRRAT
1  / (PARAM(66)*88.)                                  VHTP 350
      IF(PARAM(129).EQ.6) PARAM(123) = STRRAT * (PARAM(6)+PARAM(7))
1  / 7.5                                               VHTP 370
C      SELECTS VARIABLES FOR TABLE OUTPUT           VHTP 380
      I=IFIX(PARAM(129))                               VHTP 390
      IF(I.EQ.0) I=7                                   VHTP 400
      TABNUM = WRDVNT(I)                              VHTP 410
      DO 40 J=1,TABNUM                                VHTP 420
      NAMEA(J) = TABVAR(J,I)                          VHTP 430
      INDEXA(J) = INDVAR(J,I)                         VHTP 440
40  CONTINUE                                          VHTP 450
      DO 100 I=1,TABNUM                               VHTP 460
      CALL FINDNM(K,J,I,&100)                         VHTP 470

```

```
ITABI (I) =INDEXA (I)
ITNAM (I) =J
ITABP (I) =K
100 CONTINUE
500 CONTINUE
SAVE = PARAM (129)
RETURN
END
```

```
VHTP 480
VHTP 490
VHTP 500
VHTP 510
VHTP 520
VHTP 530
VHTP 540
VHTP 550
```

H-2.1.5 NITIAL

Presented here is the Fortran listing for the initialization subprogram. The following is performed in NITIAL:

1. Calculation of initial conditions using input data.
2. Initialization of DAC to their time = 0 values.

```

C      SUBROUTINE NITIAL
C      SUBROUTINE NITIAL
C*****
C      THIS SUBPROGRAM CALCULATES INITIAL CONDITIONS USING INPUT DATA
C      AND INITIALIZES DIGITAL-TO-ANALOG CONVERTERS TO THEIR
C      TIME=0 VALUES
C*****
      DIMENSION NAMEX (124), NAME (289)
      COMMON/CFRC/ SL (4), SEP (4), CFCEOF (4), ARPS (4)
      COMMON/IANDG/ AIXP, AIXZP, GAM1, GAM2, GAM3, GAM4, GAM5, GAM6,
1GAM7, GAM8, GAM9, AIYP, AIZP
      COMMON/DUALS/IDULTR, NWHEEL, TIRO2, TORO2, TIRTOR, VBRZRP,
1 FXU5, FXU6, FYU5, FYU6, ALTQ5, ALTQ6, FSI3, FSI4, FSI5, FSI6, PPHIR
      COMMON/AERO/SPXS, SPYS, SFZS, SNTHES, SNPHIS, SNPSIS, APLUSB, IAERO
      COMMON/APL/ OPEN, RTSW, LDTSW, RBSW
      COMMON/DEVICE/KEYBD, ITTY, ICDRD, LPTR, LPNT
      COMMON/SPLTAX/ SPSR3, SPSR4, IAX
      COMMON/HHHH/H1, H2, H3, H4
      COMMON/ZILCH/TQMAXF, TQMAXR, AKTQF, AKTOR, TQDRF, TQDRR, IDRSW
      COMMON/CACATO/EPK1, EPK2, FEE1, FEE2, THE1, THE2
      COMMON/THINGS/TMAX1, TMAX2, TMAX3, TQRMX, TQFMX, PSIMAX, ONER
      COMMON/EES/O1, O2, O3, E4, E5, E6
      COMMON/ALPHA/ALPH (20)
      COMMON/COMBLK/ SM, CIP, CIVP, RZF, RZR, A2T, CA20, CA23, TSFO2,
1 TRO2, TFO2, TSO2, G, THRD, TWN7, R2T, RA20, RA23
      COMMON/TIMBLK/JJTIME, TIME, DT
      COMMON/EFFS/ANUM, ADEN, ANUMDT, ADENDT, ANUMO, ADENO, ANUMDO, ADENDO,
1 ANOUT, ADOUT
      COMMON/INOUT/ IN (48), DACO (48), ISW1, ISW7, IPRT
      COMMON/UVW/VC, UIN
      COMMON/XYZ/ NUMBR
      COMMON/OPSW/IHSW
      COMMON/VARS/P, Q, R, U, V, W, X, Y, Z, THE, PHI, PSI
      COMMON/SP7BLK/N1, N2, IPOT (120), IPOTAD (120), PARAM (400)
      COMMON/XBS/XB (30), NS (4, 30), DELX (4), XI (4), NNN
      COMMON/NONAME/XEND, O, EXIT2
      COMMON/NEWER/TIME25, TIME10, PSI5, PHIMAX, DSWMAX
      COMMON/CCMVAR/ AXAVE, CUVRAT, BETDMX, CURTBP, TIMDEC, JUMP, DELSTR, DEL,
1 AXI, CURVAV, ABBIV, AYMAX, RMAX, DELBET, DELPSI, BETAMX,
1 TIMBMP, GETDL, TIMIN5, TSTEP, IVHTP
      COMMON/PAUL/ D1, D2, D3, D4, SFYU, TMP, SNPHIU, SNTHEU, SNPSIU,
1 QDT, PDT, RDT, UDT, VDT, WDT, PHIDT, THEDT, PSIDT, XDT, YDT, ZDT,
1 AKK1, AKK2, THS1, THS2,
1 AMT1, AMT2, SN, SFXU, BTVDI, ETAX, ETAL,
1 ZIP (4), PHII (4),
1 U1I (4), BAMI (4), MUP (4), SAMI (4), FI (4), FXUI (4), FYUI (4), GI (4),
1 ALFI (4), BETIP (4), BETIBR (4), SLIPI (4), AM1I (4), AM2I (4), UOI (4),
1 FCI (4), FCIMAX (4), FSI (4),
1 ABI (4), BETAI (4), AMUI (4), SNI (4), RMI (4), GBI (4), FRIBR (4),

```



1	RWZI (4) , ZI (4) , FRI (4) ,	UI (4) , VI (4) , WI (4) , UGI (4) ,	430
1	VGI (4) , SINPSI (4) , PSII (4) , COSPSI (4) , UGIP (4) , PHICGI (4) , CVI (4)		440
1	ALTQ (4) , OTM (4) , SALTQ , FCTM , ROTM		450
1	AP1 , AP2 , AP3 , AP4 , AR1 , AR2 , AR3 , AR4 , ANTI1 , ANTI2 , ANTI3 , ANTI4		
1	DLIS (4) , ZIMX (4) , FBS1 , FBS2 , FBS3 , FBS4		470
1	PHIDMX		480
	COMMON/ADCOUT/ DEL1DT , DEL2DT , DEL3DT , DEL1 , DEL2 , DEL3 , PHIRD , PHIR ,		
2	DELFW1 , DELFW2 , S1P , S2P , S3P , S4P		
	COMMON/CNTROL/ EPDSW , EPSTQR , EPDSWI , EPTQRI , ALAMDA		
	COMMON/SHOCKS/ ZDBPRF (10) , ZDBPLF (10) , ZDBPRR (10) , ZDBPLR (10) ,		
1	SAFRF (10) , SAFLF (10) , SAFRR (10) , SAFLR (10) ,		
2	NRF , NLF , NRR , NLR ,		
3	ZETDRF , ZETDLF , ZETDRR , ZETDLR ,		
4	AKSRF , AKSLF , AKSRR , AKSLR , FSARF , FSALF , FSARR , FSALR		
	EQUIVALENCE (ARPS (1) , ARPS1) , (ARPS (2) , ARPS2) , (ARPS (3) , ARPS3) ,		
1	(ARPS (4) , ARPS4)		
	EQUIVALENCE		
1	(PARAM ( 1) , AMS) , (PARAM ( 2) , AMUF) , (PARAM ( 3) , AMUR) ,	NITI 390	
1	(PARAM ( 4) , ZF) , (PARAM ( 5) , ZR) , (PARAM ( 6) , A) ,	NITI 400	
1	(PARAM ( 7) , B) , (PARAM ( 8) , TF) , (PARAM ( 9) , TR) ,	NITI 410	
1	(PARAM (10) , TS) , (PARAM (11) , AIX) , (PARAM (12) , AIY) ,	NITI 420	
1	(PARAM (13) , AIZ) , (PARAM (14) , AIXZ) , (PARAM (15) , AIR) ,	NITI 430	
1	(PARAM (16) , ROOVER) , (PARAM (17) , RF) ,	NITI 440	
1	(PARAM (19) , AKF1) , (PARAM (20) , AKF2) , (PARAM (21) , AKR3) ,	MODE 890	
1	(PARAM (22) , AKR4) , (PARAM (23) , CR) , (PARAM (24) , RR) ,	MODE 910	
1	(PARAM (25) , CF1P) , (PARAM (26) , CF2P) , (PARAM (27) , CR3P) ,	MODE 900	
1	(PARAM (28) , CR4P) , (PARAM (30) , AKRS) ,	MODE 920	
1	(PARAM (31) , RW) , (PARAM (33) , OT) ,	NITI 500	
1	(PARAM (34) , CA0) , (PARAM (35) , CA1) , (PARAM (36) , CA2) ,	NITI 510	
1	(PARAM (37) , CA3) , (PARAM (38) , CA4) , (PARAM (39) , TIR ) ,	NITI 520	
1	(PARAM (44) , AKDL) , (PARAM (41) , AKSC) , (PARAM (42) , ANG) ,	NITI 530	
1	(PARAM (43) , WG) , (PARAM (40) , TOR ) , (PARAM (45) , AKSL) ,	NITI 540	
	EQUIVALENCE	NITI 550	
1	(PARAM (46) , ANL1) , (PARAM (47) , AIFW) , (PARAM (48) , AIF) ,	NITI 560	
1	(PARAM (49) , AIWF) , (PARAM (50) , AIWR) , (PARAM (51) , AID) ,	NITI 570	
1	(PARAM (52) , ARBR) , (PARAM (53) , TSF ) , (PARAM (54) , AKFS) ,	NITI 580	
1	(PARAM (55) , PTBR) , (PARAM (56) , YSA1) , (PARAM (57) , YSA2) ,	NITI 590	
1	(PARAM (58) , YHS1) , (PARAM (59) , YHS2) , (PARAM (60) , AKD) ,	NITI 600	
1	(PARAM (61) , AIDF) , (PARAM (62) , ARFBR) , (PARAM (63) , PIN) ,	NITI 610	
1	(PARAM (64) , QIN) , (PARAM (65) , RIN) , (PARAM (66) , UIZ) ,	NITI 620	
1	(PARAM (67) , VIN) , (PARAM (68) , WIN) , (PARAM (69) , XIN) ,	NITI 630	
1	(PARAM (70) , YIN) , (PARAM (71) , ZIN) , (PARAM (72) , THEIN) ,	NITI 640	
1	(PARAM (73) , PHIIN) , (PARAM (74) , PSIIN) , (PARAM (75) , DTIN) ,	NITI 650	
1	(PARAM (76) , TEND) , (PARAM (77) , AKT1) , (PARAM (78) , AKT2) ,	NITI 660	
1	(PARAM (79) , AKT3) , (PARAM (80) , AKT4) , (PARAM (81) , RPS1) ,	NITI 670	
1	(PARAM (82) , RPS2) , (PARAM (83) , RPS3) , (PARAM (84) , RPS4) ,	NITI 680	
1	(PARAM (85) , B1) , (PARAM (86) , B2) , (PARAM (87) , B3) ,	NITI 690	
	EQUIVALENCE	NITI 700	
1	(PARAM (88) , B4) , (PARAM ( 89) , DEL1DN) , (PARAM ( 90) , DEL2DN) ,	NITI 710	
1	(PARAM ( 91) , DEL3DN) , (PARAM ( 92) , DELFIN) , (PARAM ( 93) , DELRIN) ,	NITI 720	
1	(PARAM ( 94) , DEL3IN) , (PARAM ( 95) , PHIDN) , (PARAM (96) , PHIRN) ,	NITI 730	
1	(PARAM ( 97) , DFW1IN) , (PARAM ( 98) , DFW2IN) , (PARAM ( 99) , U1PIN) ,	NITI 740	
1	(PARAM (100) , U2PIN) , (PARAM (101) , U3PIN) , (PARAM (102) , U4PIN) ,	NITI 750	
1	(PARAM (103) , S1PIN) , (PARAM (104) , S2PIN) , (PARAM (105) , S3PIN) ,	NITI 760	
1	(PARAM (106) , S4PIN) , (PARAM (107) , PPRT) , (PARAM (109) , RWSF) ,	NITI 770	
1	(PARAM (110) , TQMAX) , (PARAM (111) , AKTQ) , (PARAM (112) , VCIN) ,	NITI 780	
1	(PARAM (113) , SWMT) , (PARAM (114) , DSWCM) , (PARAM (115) , TST) ,	NITI 790	
1	(PARAM (116) , DSLP) , (PARAM (117) , CGAM) , (PARAM (118) , CS) ,	NITI 800	
1	(PARAM (119) , TORBR) , (PARAM (120) , TQFBR) ,	NITI 810	
1	(PARAM (121) , PFL) , (PARAM (122) , TTD) , (PARAM (123) , DSW) ,	NITI 820	
1	(PARAM (124) , TSW) ,	NITI 830	

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EQUIVALENCE
1 (PARAM (130), AMCR), (PARAM (131), ESP), (PARAM (132), AKSL1), NITI 840
1 (PARAM (133), AKSL2), (PARAM (134), AA1), (PARAM (135), AA2), NITI 850
1 (PARAM (136), CCR), (PARAM (137), CFCR), (PARAM (138), AP), NITI 860
1 (PARAM (139), EP1), (PARAM (140), EP2), (PARAM (141), ERR1), NITI 870
1 (PARAM (142), ERR2), NITI 880
1 (PARAM (143), AML1), (PARAM (144), AML2), (PARAM (145), RRM), NITI 890
1 (PARAM (146), RWR) NITI 900
EQUIVALENCE NITI 910
1 (PARAM (284), HFC), (PARAM (285), HRC) NITI 920
EQUIVALENCE NITI 930
1 (PARAM (290), ROT), (PARAM (291), RA0), (PARAM (292), RA1), NITI 940
1 (PARAM (293), RA2), (PARAM (294), RA3), (PARAM (295), RA4) NITI 950
EQUIVALENCE (NAME (172), NAMEX (1)) NITI 960
EQUIVALENCE (PARAM (351), IOUT (1)) NITI 1080
EQUIVALENCE (PHIFD, DEL2DT), (PHIF, DEL2) NITI 1090
EQUIVALENCE (PHIRD, DEL4DT), (PHIR, DEL4) NITI 1100
DATA NAME/' MS', ' MUF', ' MUR', ' ZF', ' ZR', ' A', ' B', ' TF', NITI 1110
1 ' TR', ' TSR', ' IX', ' IY', ' IZ', ' IXZ', ' IR', ' ROOR', ' RF', NITI 111
1 ' STOP', ' AKF1', ' AKF2', ' AKR3', ' AKR4', ' ALS', ' RR', ' CF1P', ' CF2P', NITI 1130
1 ' CR3P', ' CR4P', ' ZBAS', ' KRS', ' RW', ' SCAL', ' POT', ' AO', ' A1', NITI 1140
1 ' A2', ' A3', ' A4', ' TIR', ' TOR', ' KSC', ' NG', ' TSD', ' DSLM', NITI 1150
1 ' TFT', ' DSW2', ' IFW', ' IF', ' IWF', ' IWR', ' IDR', ' ARR', ' TSP', NITI 1160
1 ' KFS', ' PT', ' YSA1', ' YSA2', ' PHS1', ' PHS2', ' CTSW', ' IDP', ' ARF', NITI 1170
1 ' P-IN', ' Q-IN', ' R-IN', ' U-IN', ' V-IN', ' W-IN', ' X-IN', ' Y-IN', ' Z-IN', NITI 1180
1 ' THIN', ' PHIN', ' PSIN', ' DT', ' TN', ' KT1', ' KT2', ' KT3', ' KT4', NITI 1190
1 ' RPS1', ' RPS2', ' RPS3', ' RPS4', ' B1', ' B2', ' B3', ' B4', ' D1DT', NITI 1200
1 ' D2DT', ' D3DT', ' DELF', ' DELR', ' DEL3', ' PHDT', ' PHIR', ' DFW1', ' DFW2', NITI 1210
1 ' U1PR', ' U2PR', ' U3PR', ' U4PR', ' S1PR', ' S2PR', ' S3PR', ' S4PR', ' PPRT', NITI 1220
1 ' FREQ', ' TQMX', ' KTQ', ' VC', ' MTSW', ' DSWM', ' TST', ' DSLP', NITI 1230
1 ' CGAM', ' CS', ' TQR', ' TQF', ' PFL', ' TTD', ' DSW1', ' ISW5', NITI 1240
1 ' SW15', NITI 1250
1 ' VTPS', ' VHTP', ' AMCR', ' ESP', ' KSL1', ' KSL2', ' AA1', ' AA2', NITI 1260
1 ' CCR', ' CFCR', ' AP', ' EP1', ' EP2', ' AERO', ' VYW', ' OMXW', ' OMZW', NITI 1270
1 ' RHOA', ' CYP', ' CYR', ' CZAL', ' CZQ', ' CLP', ' CLR', ' CMAL', ' CMQ', NITI 1280
1 ' CNP', ' CNR', ' SF', ' VLEN', ' REWV', ' SNT', ' SNS0', ' SNS1', NITI 1290
DATA NAMEX NITI 1300
1 /' SNSW', ' DIST', ' PL', ' TSCP', ' SCSW', ' NITI 1310
1 ' SI1', ' SI2', ' SI3', ' SI4', ' SARF', ' SALF', ' SARR', NITI 1320
1 ' SALR', ' MTQB', ' DCSW', ' LDF', ' LDRF', ' EK1', ' EK2', NITI 1330
1 ' BMPL', ' BMPS', ' BMPH', ' XB', ' APF1', ' APF2', ' APR1', ' APR2', ' MUSF', NITI 1340
1 ' MUSR', ' BCON', ' FCSW', ' S1F', ' S1R', ' KLR', ' KOTF', ' KOTR', NITI 1350
1 ' FEE1', ' FEE2', ' THE1', ' THE2', ' ALMC', NITI 136
1 ' H1', ' H2', ' LAMD', NITI 1370
1 ' PS01', ' PS02', ' BR1', ' BR2', ' BR3', ' BR4', NITI 1380
1 ' KCF', ' KCR', ' KSR', ' RB1', ' RB2', ' RB3', ' RB4', ' AFK1', ' AFK2', NITI 1390
1 ' AFK3', ' ARK1', ' ARK2', ' ARK3', ' OFC0', ' OFC1', ' OFC2', ' OFC3', ' ORC0', NITI 1400
1 ' ORC1', ' ORC2', ' ORC3', ' CP0F', ' CP1F', ' CP2F', ' CP0R', ' CP1R', ' CP2R', NITI 1410
1 ' CR0F', ' CR1F', ' CR2F', ' CR0R', ' CR1R', ' CR2R', ' STSW', ' MMSW', ' BMPN', NITI 1420
1 ' TQB0', ' TQB1', ' HFC', ' HRC', ' DRSW', NITI 143
1 ' AXLE', ' DUAL', ' TIRE', ' ROT', ' RAO', ' RA1', ' RA2', ' RA3', ' RA4', NITI 1440
EQUIVALENCE (COMPVR (1), AXAVE) NITI 1450
DIMENSION COMPVR (17) NITI 1460
DATA RAD/0.1745329E-1/ NITI 1470
DATA MPHIPS/17.6/ NITI 1480
REAL*4 MPHIPS NITI 1490
REAL*4 IOUT (48), IN, SCALAC (48), SCALDC (48) NITI 1500
INTEGER*2 RTSW, RBSW, LDTSW, OPEN, OPDN NITI 1520
960 FORMAT ('1 PARAMETER VALUES - MODEL C - ', 20A4, / NITI 1530
1 (' ', 5(I4, 3X, A4, '=' , G12.5, ', ')) NITI 1540

```

C	VHTP COMPARISON VARIABLE INITIALIZATION	NITI1550
	DO 21 I=1,19	NITI1560
	COMPVR(I) = 0.	NITI1570
21	CONTINUE	NITI1580
	TSTEP = DTIN	NITI1590
	NUMBR = 0	NITI1600
	DO 20 I=1,4	NITI1610
	DELX(I) = 0.	NITI1620
20	CONTINUE	NITI1630
	IVHTP = PARAM(129) + .5	NITI1640
	IAERO = PARAM(141) + 0.5	NITI1650
	IDRSW = PARAM(286) + 0.5	NITI1660
	IAX=PARAM(287)+0.5	NITI1670
C	DUAL TIRES ON SOLID REAR AXLE	NITI1680
C	IDULTR = 0, NO DUALS	NITI1690
C	= 1, DUALS	NITI1700
	IDULTR = PARAM(288) + 0.5	NITI1710
C	NWHEEL = 4, SINGLE REAR TIRES	NITI1720
C	= 6, DUAL REAR TIRES	NITI1730
C	= 10, DOUBLE DUAL REAR TIRES	NITI1740
	NWHEEL = PARAM(289) + 0.5	NITI1750
	AKSRF=PARAM(186)	
	AKSLF=PARAM(187)	
	AKSRB=PARAM(188)	
	AKSLB=PARAM(189)	
	TQFMAX=-1.E20	NITI1760
	TQRM MAX=-1.E20	NITI1770
	BTVMAX=-1.E20	NITI1840
	EPSK1=PARAM(196)*RAD	NITI1860
	EPSK2=PARAM(197)*RAD	NITI1870
	FEE1=PARAM(219)*RAD	NITI1880
	FEE2=PARAM(220)*RAD	NITI1890
	THE1=PARAM(221)*RAD	NITI1900
	THE2=PARAM(222)*RAD	NITI1910
	PSIMAX=-1.E20	NITI1920
	PSIM=PSIN *RAD	NITI1930
	XEND=TEND	NITI1940
	EXIT2 = PARAM(18)*MPHIPS	
	TIME25=0.0	NITI1960
	TIME10=0.0	NITI1970
	ANUMO=0.0	NITI2040
	ADENO=0.0	NITI2050
	RMAX=-1.E20	NITI2060
	PSI5=0.0	NITI2070
	DSWMAX=-1.E20	NITI2080
	PHIMAX=-1.E20	NITI2090
	ETAMAX=-1.E20	NITI2100
	ISW7=1	NITI2110
	THRD=1.0/3.0	NITI2120
	TWN7=1.0/27.0	NITI2130
	TOO=0.0	NITI2140
	G=386.4	NITI2150
	APLUSB = A + B	NITI2160
	H1=RW- (AMUF+B*AMS/(A+B))*G/(2.*AKT1)	NITI2170
	H2=RW- (AMUF+B*AMS/(A+B))*G/(2.*AKT2)	NITI2180
	H3=RW- (AMUR+A*AMS/(A+B))*G/(2.*AKT3)	NITI2190
	H4=RW- (AMUR+A*AMS/(A+B))*G/(2.*AKT4)	NITI2200
	IF (IDULTR.NE.1) GO TO 25	NITI2210
	H3 = RW - (AMUR+A*AMS / (A+B)) *G/ (4.*AKT3)	NITI2220
	H4 = H3	NITI2230

25	CONTINUE	NITI2240
	RWZ1A = RW - H1	
	RWZ2A = RW - H2	
	RWZ3A = RW - H3	
	RWZ4A = RW - H4	
	TSO2=TS/2.0	NITI2250
	TSFO2 = TSF/2.	NITI2260
	TFO2=TF*0.5	NITI2270
	TIRO2 = TIR/2.	NITI2280
	TORO2 = TOR/2.	NITI2290
	TRO2=TR*0.5	NITI2300
	IF (IDULTR.EQ.1) TRO2 = (TORC2+TIRO2)*0.5	NITI2310
	TIRTOR= 0.25*(TIR-TOR)	NITI2320
	SPSR3=(TAN(2.0*HFC/TF))*2.0/AMUF	NITI2330
	SPSR4=(TAN(2.0*HRC/TR))*2.0/AMUR	NITI2340
	SM=AMS+AMUF+AMUR	NITI2350
	UIN=UIZ*MPHIPS	NITI2360
	VC=VCIN*MPHIPS	NITI2370
	ZIN=(B*(H1+ZF)+A*(H3+ZR))/(A+B)*(-1.) + PARAM(29)	
	THEIN=(H1-H3+ZF-ZR)/(A+B)/RAD	NITI2390
	ARPS1 = UIN/H1	
	ARPS2 = UIN/H2	
	ARPS3 = UIN/H3	NITI2400
	ARPS4 = UIN/H4	NITI2410
	GO TO (31,32),IAX	NITI2440
30	AIZP = AMUF*A*A + AMUR*B*B + AIF + AIR	NITI2450
	GO TO 33	NITI2460
31	AIZP = AMUF*(A*A + TFO2**2) + AMUR*B*B + AIR	NITI2470
	GO TO 33	NITI2480
32	AIZP = AMUF*(A*A + TFO2**2) + AMUR*(B*B + TRO2**2)	NITI2490
33	CONTINUE	NITI2500
	GAM1=AMUF*A-AMUR*B	NITI2520
	AIZBR=AIZP +AIZ	NITI2570
	CIP=B*AMS*G/(AMUF*(A+B))+G	NITI2680
	CIVP=A*AMS*G/(AMUR*(A+B))+G	NITI2690
	TQMAXR=TQMAX*ARBR*0.5	NITI2700
	TQMAXF=TQMAX*ARFBR*0.5	NITI2710
	AKTQR=AKTQ*ARBR*0.5	NITI2720
	AKTQF=AKTQ*ARFBR*0.5	NITI2730
	RZF=RW+ZF	NITI2740
	RZR=RW+ZR	NITI2750
	CA23=CA2*CA3	NITI2760
	A2T= OT*CA2	NITI2770
	CA20=CA0*CA2	NITI2780
	RA23=RA2*RA3	NITI2790
	R2T=ROT*RA2	NITI2800
	RA20=RA0*RA2	NITI2810
	DEL1DT=DEL1DN	NITI2880
	DEL2DT=DEL2DN	NITI2890
	DEL3DT=DEL3DN	NITI2900
	DEL1=0.0	NITI2910
	DEL2=0.0	NITI2920
	DEL3=DEL3IN	NITI2930
	PHIRD=PHIDN*RAD	NITI2940
	PHIR=PHIRN*RAD	NITI2950
	DELFW1=DFW1IN*RAD	NITI2960
	DELFW2=DFW2IN*RAD	NITI2970
	U1P=U1PIN	NITI2980
	U2P=U2PIN	NITI2990
	U3P=U3PIN	NITI3000

U4P=U4PIN	NITI 3040
S1P=S1PIN	NITI 3050
S2P=S2PIN	NITI 3100
S3P=S3PIN	NITI 3120
S4P=S4PIN	NITI 3140
P=PIN*RAD	NITI 3160
Q=QIN*RAD	NITI 3180
R=RIN*RAD	NITI 3200
U=UIN	NITI 3220
V=VIN	NITI 3240
W=WIN	NITI 3260
X=XIN	NITI 3280
Y=YIN	NITI 3300
Z=ZIN	NITI 3320
THE=THEIN*RAD	
PHI=PHIIN*RAD	
PSI=PSIIN*RAD	
UDT=0.0	
VDT=0.0	
WDT =0.	
PDT =0.	
QDT =0.	
RDT=0.0	
THEDT =0.	
PHIDT = 0.	
PSIDT =0.	
BTVDT =0.	
XDT =0.	
YDT =0.	
ZDT =0.	
ZETDRF=0.0	
ZETDLF=0.0	
ZETDRR=0.0	
ZETDLR=0.0	
EPDSWI = 0.	
EPTQRI = 0.	
TIME=0.0	
JJTIME=0	
DT=0.0	
998 FORMAT ('0',8E15.6)	NITI 3340
IHSW=0	NITI 3350
XB (1)=PARAM (201)	NITI 3360
NBMP=PARAM (277)+0.5	NITI 3370
IF (NBMP.LT.2)GO TO 4321	NITI 3380
DO 5432 I=2,NBMP	NITI 3390
XB (I)=XB (I-1)+PARAM (199)	NITI 3400
5432 CONTINUE	NITI 3410
4321 CONTINUE	NITI 3420
CALL SSRM (11,IRLERR)	NITI 3430
RETURN	NITI 3440
ENTRY NTIAL1	NITI 3450
CALL LBDAPP (00,47,DACO,ILBERR)	NITI 3460
CALL TLDA	NITI 3470
CALL STCO (0,ISTCOE)	NITI 3480
DT=DTIN	NITI 3490
ISW1=0	NITI 3500
ISW7=0	
IF (PPRT.NE.0.0) WRITE (LPTR,960) (ALPH (I),I=1,20), ((K,NAME (K),	NITI 3520
1 PARAM (K)),K=1,N1)	NITI 3530
940 FORMAT (10G12.5)	NITI 3540
RETURN	NITI 3550
END	NITI 3560
	NITI 3570
	NITI 3580
	NITI 3590

H-2.1.6 POTSET

Presented here is the Fortran listing for the potentiometer setting calculation subprogram. The following is performed in POTSET:

1. Calculation of parameters used in the potentiometer equations.
2. Calculation of potentiometer settings.

C	SUBROUTINE POTSET		
	SUBROUTINE POTSET	POTS	20
C	*****		
C	THIS SUBPROGRAM CALCULATES PARAMETERS USED IN THE POTENTIOMETER		
C	EQUATIONS AND POTENTIOMETER SETTINGS		
C	*****		
	COMMON/DUALS/IDULTR,NWHEEL,TIRO2,TORO2,TIRTOR,VBRZRP,	POTS	40
1	FXU5,FXU6,FYU5,FYU6,ALTQ5,ALTQ6,FSI3,FSI4,FSI5,FSI6,PPHIR	POTS	50
	COMMON/ZILCH/TQMAXF,TQMAXR,AKTQF,AKTQR,TQDRF,TQDRR,IDRSW	POTS	60
	COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT	POTS	70
	COMMON/HHHH/H1,H2,H3,H4	POTS	80
	COMMON/SPLTAX/SPSR3,SPSR4,IAX	POTS	90
	COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI		
	COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,	POTS	120
1	ANOUT,ADOUT	POTS	130
	COMMON/COMBLK/SM,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,TSFO2,		
1	TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23		
	COMMON/TIMBLK/JJTIME,TIME,DT	POTS	190
	COMMON/UVW/VC,UIN	POTS	200
	COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)	POTS	210
	COMMON/ADCOUT/DEL1DT,DEL2DT,DEL3DT,DEL1,DEL2,DEL3,PHIRD,PHIR,		
2	DELFW1,DELFW2,S1P,S2P,S3P,S4P		
	REAL*4 IOUT(48)	POTS	220
	REAL*4 IPOT,IPOTAD	POTS	230
	EQUIVALENCE	POTS	240
1	(PARAM(1),AMS) , (PARAM(2),AMUF) , (PARAM(3),AMUR) ,	POTS	250
1	(PARAM(4),ZF) , (PARAM(5),ZR) , (PARAM(6),A) ,	POTS	260
1	(PARAM(7),B) , (PARAM(8),TF) , (PARAM(9),TR) ,	POTS	270
1	(PARAM(10),TS) , (PARAM(11),AIX) , (PARAM(12),AIY) ,	POTS	280
1	(PARAM(13),AIZ) , (PARAM(14),AIXZ) , (PARAM(15),AIR) ,	POTS	290
1	(PARAM(16),CF) , (PARAM(17),RF) ,	POTS	300
1	(PARAM(19),AKF1) , (PARAM(20),AKF2) , (PARAM(21),AKR3) ,	MODE	890
1	(PARAM(22),AKR4) , (PARAM(23),CR) , (PARAM(24),RR) ,	MODE	910
1	(PARAM(25),CF1P) , (PARAM(26),CF2P) , (PARAM(27),CR3P) ,	MODE	900
1	(PARAM(28),CR4P) , (PARAM(30),AKRS) ,	MODE	920
1	(PARAM(31),RW) , (PARAM(32),SCALE) , (PARAM(33),OT) ,		
1	(PARAM(34),CA0) , (PARAM(35),CA1) , (PARAM(36),CA2) ,	POTS	360
1	(PARAM(37),CA3) , (PARAM(38),CA4) , (PARAM(39),TIR) ,	POTS	370
1	(PARAM(44),AKDL) , (PARAM(41),AKSC) , (PARAM(42),ANG) ,	POTS	380
1	(PARAM(43),WG) , (PARAM(40),TOR) , (PARAM(45),AKSL) ,	POTS	390
	EQUIVALENCE	POTS	400
1	(PARAM(46),ANL1) , (PARAM(47),AIFW) , (PARAM(48),AIF) ,	POTS	410
1	(PARAM(49),AIWF) , (PARAM(50),AIWR) , (PARAM(51),AID) ,	POTS	420
1	(PARAM(52),ARBR) , (PARAM(53),TSF) , (PARAM(54),AKFS) ,	POTS	430
1	(PARAM(55),PTBR) , (PARAM(56),YSA1) , (PARAM(57),YSA2) ,	POTS	440

1	(PARAM(58),YHS1)	, (PARAM(59),YHS2)	, (PARAM(60),AKD)	, POTS 450
1	(PARAM(61),AIDF)	, (PARAM(62),ARFBR)	, (PARAM(63),PIN)	, POTS 460
1	(PARAM(64),QIN)	, (PARAM(65),RIN)	, (PARAM(66),UIZ)	, POTS 470
1	(PARAM(67),VIN)	, (PARAM(68),WIN)	, (PARAM(69),XIN)	, POTS 480
1	(PARAM(70),YIN)	, (PARAM(71),ZIN)	, (PARAM(72),THEIN)	, POTS 490
1	(PARAM(73),PHIIN)	, (PARAM(74),PSIIN)	, (PARAM(75),DTIN)	, POTS 500
1	(PARAM(76),TEND)	, (PARAM(77),AKT1)	, (PARAM(78),AKT2)	, POTS 510
1	(PARAM(79),AKT3)	, (PARAM(80),AKT4)	, (PARAM(81),RPS1)	, POTS 520
1	(PARAM(82),RPS2)	, (PARAM(83),RPS3)	, (PARAM(84),RPS4)	, POTS 530
1	(PARAM(85),B1)	, (PARAM(86),B2)	, (PARAM(87),B3)	, POTS 540
	EQUIVALENCE			POTS 550
1	(PARAM(88),B4)	, (PARAM(89),DEL1DN)	, (PARAM(90),DEL2DN)	, POTS 560
1	(PARAM(91),DEL3DN)	, (PARAM(92),DELFIN)	, (PARAM(93),DELRIN)	, POTS 570
1	(PARAM(94),DEL3IN)	, (PARAM(95),PHIDN)	, (PARAM(96),PHIRN)	, POTS 580
1	(PARAM(97),DFW1IN)	, (PARAM(98),DFW2IN)	, (PARAM(99),U1PIN)	, POTS 590
1	(PARAM(100),U2PIN)	, (PARAM(101),U3PIN)	, (PARAM(102),U4PIN)	, POTS 600
1	(PARAM(103),S1PIN)	, (PARAM(104),S2PIN)	, (PARAM(105),S3PIN)	, POTS 610
1	(PARAM(106),S4PIN)	, (PARAM(107),PPRT)	, (PARAM(109),RWSF)	, POTS 620
1	(PARAM(110),TQMAX)	, (PARAM(111),AKTQ)	, (PARAM(112),VCIN)	, POTS 630
1	(PARAM(113),SWMT)	, (PARAM(114),DSWCM)	, (PARAM(115),TST)	, POTS 640
1	(PARAM(116),DSLPL)	, (PARAM(117),CGAM)	, (PARAM(118),CS)	, POTS 650
1	(PARAM(119),TQRBR)	, (PARAM(120),TQFBR)		, POTS 660
1	(PARAM(121),PFL)	, (PARAM(122),TTD)	, (PARAM(123),DSW)	, POTS 670
1	(PARAM(124),TSW)			, POTS 680
	EQUIVALENCE			POTS 690
1	(PARAM(130),AMCR)	, (PARAM(131),ESP)	, (PARAM(132),AKSL1)	, POTS 700
1	(PARAM(133),AKSL2)	, (PARAM(134),AA1)	, (PARAM(135),AA2)	, POTS 710
1	(PARAM(136),CCR)	, (PARAM(137),CPCR)	, (PARAM(138),AP)	, POTS 720
1	(PARAM(139),EP1)	, (PARAM(140),EP2)	, (PARAM(141),ERR1)	, POTS 730
1	(PARAM(142),ERR2)			, POTS 740
1	(PARAM(143),AML1)	, (PARAM(144),AML2)	, (PARAM(145),RRIM)	, POTS 750
1	(PARAM(146),RWR)			, POTS 760
	EQUIVALENCE			POTS 770
1	(PARAM(223),CR1C)	, (PARAM(224),CR1T)	, (PARAM(225),CR2C)	, POTS 780
1	(PARAM(226),CR2T)	, (PARAM(227),CR3C)	, (PARAM(228),CR3T)	, POTS 790
1	(PARAM(229),CR4C)	, (PARAM(230),CR4T)	, (PARAM(231),AH1)	, POTS 800
1	(PARAM(232),AH2)	, (PARAM(233),ALAMBD)		
	EQUIVALENCE			POTS 830
1	(PARAM(284),HFC)	, (PARAM(285),HRC)		, POTS 840
	EQUIVALENCE			POTS 850
1	(PARAM(290),ROT)	, (PARAM(291),RA0)	, (PARAM(292),RA1)	, POTS 860
1	(PARAM(293),RA2)	, (PARAM(294),RA3)	, (PARAM(295),RA4)	, POTS 870
	EQUIVALENCE (PARAM(351),IOU(1))			
C	N1, N2 EQUATED TO THEIR VALUES IN MAIN			POTS1000
	HUN=0.01			POTS1010
	TOU=0.001			POTS1020
	AIBR=AIWR+AID*ARBR**2*0.25			POTS1030
	AIBRP=AIBR-AIWR			POTS1040
	AIFBR = AIWF + AIDF*ARFBR*2 * 0.25			POTS1050
	AIFBRP = AIFBR - AIWF			POTS1060
	RPS1=UIN/H1			POTS1070
	RPS2=UIN/H2			POTS1080
	RPS3=UIN/H3			POTS1090
	RPS4=UIN/H4			POTS1100
	CALL SSRM(01,IRLERR)			POTS1880
	IF(RF.GE.0) CALL SSRP(01,IRLERR)			POTS1890
	CALL SSRM(08,IRLERR)			POTS1920
	IF(RR.GE.0) CALL SSRP(08,IRLERR)			
	CALL SSRM(13,IRLERR)			

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IF (THE.GE.0.) CALL SSRF (13,IRLERR)
SFSF=SCALE/10000.
IPOT (01) =. 2
IPOT (02) =G/400.
IPOT (05) =U/1200.
IPOT (06) =. 25*PARAM (175)
IPOT (07) =2./3.*PARAM (175)
IPOT (08) =. 6*PARAM (175)
IPOT (09) = . 7
IPOT (12) =PARAM (175) * . 15
IPOT (13) =. 4
IPOT (14) =. 5*PARAM (175)
IPOT (16) =TOU*CF1P*. 1
IPOT (17) =. 2*PARAM (175)
IPOT (19) =. 2*TOU*CF1P
IPOT (20) = 4. * (ABS (THE) )
IPOT (21) =. 3*PARAM (175)
IPOT (22) =TOU*CF2P*. 1
IPOT (23) =PSI/4.
IPOT (24) =. 2*TOU*CF2P
IPOT (27) =TOU*CR3P*. 1
IPOT (28) = . 5*PARAM (175)
IPOT (29) =. 2*TOU*CR3P
IPOT (38) =HUN*PARAM (175) *4.
IPOT (49) =TOU*CR4P*. 1
IPOT (50) =AIBRP/AIBR
IPOT (51) =PARAM (175)
IPOT (52) =. 2*PARAM (175)
IPOT (54) =. 2*TOU*CR4P
IPOT (55) =. 2
IPOT (57) =PARAM (175)
IPOT (58) =8.*A/2000.
IPOT (60) =100./AKF1
IPOT (61) =100.*AMS/SCALE
IPOT (62) =100./AKR3
IPOT (63) =SFSF
IPOT (64) =SFSF
IPOT (65) =SFSF
IPOT (68) =100./AKR4
IPOT (69) =SFSF
IPOT (72) =57. 3/ (1. 5*200.)
IPOT (73) =PARAM (175)
IPOT (77) =HUN*PARAM (175) *4.
IPOT (78) =8.*B/2000.
IPOT (79) =57. 3/ (4.*200.)
IPOT (84) =. 2*PARAM (175)
IPOT (85) =PARAM (175)
IPOT (87) =IPOT (57)
IPOT (88) =10./A
IPOT (89) =10./B
IPOT (90) =0.
IPOT (91) =0.
IPOT (96) =1./ (1. 6*11.*PARAM (175) )
IPOT (100) =PARAM (175)
IPOT (101) =HUN*RPS1
IPOT (103) =TOU*G
IPOT (104) =. 96
IPOT (105) =PARAM (175)
IPOT (106) = 100./AKF2
IPOT (108) =. 3*PARAM (175)
IPOT (110) =HUN*RPS3

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IPOT (111) = .8
IPOT (112) = .08
IPOT (113) = G*TOU
IPOT (114) = .15
IPOT (115) = .48
IPOT (117) = .2
IPOT (118) = G*TOU
IPOT (119) = IPOT (50)
C***** SPLIT FRONT AXLE LOGIC PCR 680 *****
CALL SSCL(02,IRLERR)
    CALL SSRM(00,IRLERR)
    CALL SSRP(03,IRLERR)
    CALL SSRP(07,IRLERR)
IPOT (03) = ZF*TOU*PARAM (175) *4.
IPOT (04) = (HUN*(ABS(RF))/(TF*TF)) *.1
IPOT (18) = 20./TF
IPOT (31) = 2.*SCALE*PARAM (175)/(10000.*AMUF)
IPOT (32) = 0.
IPOT (33) = 8.*TF/4000.*PARAM (175) *2.
IPOT (34) = 0.0
IPOT (37) = HUN*PARAM (175) *4.
IPOT (39) = 0.
IPOT (41) = IPOT (03)
IPOT (43) = 8.*TF*PARAM (175)/4000.*2.
IPOT (44) = 0.
IPOT (47) = 0.
IPOT (48) = 2.*SCALE*PARAM (175)/(10000.*AMUF)
IPOT (56) = 0.
IPOT (59) = 0.
IPOT (66) = 0.
IPOT (67) = 0.
IPOT (70) = .2*PARAM (175)
IPOT (74) = PARAM (175)
IPOT (76) = PARAM (175)
IPOT (107) = .9999
IPOT (109) = .9999
IPOT (116) = .9999
IF (IAX.NE.0) GO TO 1024
C ***** SOLID FRONT AXLE LOGIC FOR 680 *****
C CONTROL LINE #02 USED WITH INTEGRATOR A70
CALL RSCL(02,IRLERR)
    CALL SSRP(00,IRLERR)
    CALL SSRM(03,IRLERR)
    CALL SSRM(07,IRLERR)
IPOT (03) = 0.
IPOT (04) = 0.0
IPOT (18) = 20./TSF
IPOT (31) = TSFO2*SCALE*PARAM (175)/(100.*AIF)
IPOT (32) = TSFO2*SCALE*PARAM (175)/(100.*AIF)
IPOT (33) = 0.0
IPOT (34) = .4*PARAM (175) *2.
IPOT (37) = .25*PARAM (175)/10.*16.
IPOT (39) = .25*(ABS(RF))/(10000.*TSF) *4.
IPOT (41) = ZF*TOU*PARAM (175) *4.
IPOT (43) = 0.
IPOT (44) = IPOT (39)
IPOT (47) = HUN*TSFO2
IPOT (48) = SCALE*PARAM (175)/(10000.*AMUF)
IPOT (56) = SCALE*PARAM (175)/(10000.*AMUF)
IPOT (59) = IPOT (47)

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IPOT (66) = TSFO2*.01
IPOT (67) =IPOT (66)
IPOT (70) =0.
IPOT (74) =0.
IPOT (76) =PARAM (175)
IPOT (107) =0.
IPOT (109) =0.
IPOT (116) =0.
1024 CONTINUE
IF (IAX.EQ.2) GO TO 1021
C *****SOLID REAR AXLE LOGIC FOR 680 *****
C CONTROL LINE #01 USED WITH INTEGRATOR A95
CALL RSCL(01,IRLERR)
    CALL SSRM (09,IRLERR)
    CALL SSRP (10,IRLERR)
    CALL SSRM (14,IRLERR)
IPOT (26) = (ABS (RR) /TS) *.0001
IPOT (30) =20./TS
IPOT (35) = (HUN*TSO2)
IPOT (36) = (TSO2) *.01
IPOT (42) =PARAM (175)
IPOT (45) =IPOT (36)
IPOT (46) =IPOT (35)
IPOT (53) =IPOT (26)
IPOT (71) =0.
IPOT (80) =ZR*TOU*PARAM (175) *4.
IPOT (81) =SCALE*PARAM (175) / (10000.*AMUR)
IPOT (82) =0.
IPOT (83) =SCALE*PARAM (175) / (10000.*AMUR)
IPOT (92) =0.0
IPOT (93) =TSO2*SCALE*PARAM (175) / (100.*AIR)
IPOT (94) =TSO2*SCALE*PARAM (175) / (100.*AIR)
IPOT (95) =.4*PARAM (175) *2.
IPOT (97) =0.0
IPOT (98) =0.0
IPOT (99) =0.0
IPOT (102) =.05*PARAM (175) *8.
IF (IAX.EQ.0) GO TO 1028
IPOT (107) =.9999
IPOT (109) =.9999
IPOT (116) =.9999
1028 CONTINUE
GO TO 1022
1021 CONTINUE
C ***** SPLIT REAR AXLE LOGIC FOR 680 *****
CALL SSCL(01,IRLERR)
    CALL SSRM (10,IRLERR)
    CALL SSRP (09,IRLERR)
    CALL SSRP (14,IRLERR)
IPOT (26) =0.
IPOT (30) =20./TR
IPOT (35) =0.
IPOT (36) =0.
IPOT (42) =PARAM (175)
IPOT (45) =0.
IPOT (46) =0.
IPOT (53) =0.
IPOT (71) = (ABS (RR) ) / (1000.*TR**2)
IPOT (80) =ZR*TOU*PARAM (175) *4.
IPOT (81) =0.0

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```

IPOT (82) =8.*TR*PARAM (175)/4000.*2.
IPOT (83) =2.*SCALE*PARAM (175)/(10000.*AMUR)
IPOT (92) =IPOT (80)
IPOT (93) =2.*SCALE*PARAM (175)/(10000.*AMUR)
IPOT (94) =0.
IPOT (95) =0.0
IPOT (97) =8.*TR/4000.*PARAM (175)*2.
IPOT (98) =PARAM (175)
IPOT (99) =.2*PARAM (175)
IPOT (102) =HUN*PARAM (175)*4.
IPOT (107) =.9999
IPOT (109) =.9999
IPOT (116) =.9999
1022 CONTINUE
C ***   IDR SW=0, REAR WHEEL DRIVE
C ****  IDR SW=1, FOUR WHEEL DRIVE
        IF (IDRSW.NE.1) GO TO 1025
        IPOT (90) =AIFBRP/AIFBR
        IPOT (91) =IPOT (90)
1025 CONTINUE
C       FOUR WHEEL IND SUSPENSION
        COMCON = PARAM (175)**2*(.008+.5*PARAM (75)/PARAM (175))/100.
        IPOT (10) = (PARAM (77)/PARAM (2))*COMCON*PARAM (176)*2.
        IPOT (11) = (PARAM (78)/PARAM (2))*COMCON*PARAM (176)*2.*0.5
        IPOT (15) = (PARAM (79)/PARAM (3))*COMCON*PARAM (176)*2.
        IPOT (25) = (PARAM (80)/PARAM (3))*COMCON*PARAM (176)*2.*0.5
        IF (IAX.EQ.2) GO TO 500
C       IND FRONT, SOLID REAR
        IPOT (15) = ((PARAM (79)+PARAM (80))/PARAM (3))*COMCON*PARAM (176)
        IPOT (25) = ((PARAM (79)+PARAM (80))*TRO2**2*COMCON*PARAM (176))
1 /PARAM (15)*5.
        IF (IAX.EQ.1) GO TO 500
C       SOLID FRONT AND REAR
        IPOT (10) = ((PARAM (77)+PARAM (78))/PARAM (2))*COMCON*PARAM (176)
        IPOT (11) = ((PARAM (77)+PARAM (78))*TFO2**2*COMCON*PARAM (176))
1 /PARAM (48)*5.
500 CONTINUE
      RETURN
      END

```

H-2.1.7 MODEL

Presented here is the Fortran listing for the mathematical model subprogram. The following is performed in MODEL:

1. Reading of the ADC variables.
2. Computation of simulation time.
3. Calculation of digital model equations.
4. Data preparation for output of the DAC variables.
5. Detection, limiting, and flagging of ADC and DAC variable overloads.
6. Collection of TRACK data for output at the end of a run.

C	SUBROUTINE MODEL	10
	SUBROUTINE MODEL	20
C	*****	30
C	THIS SUBPROGRAM PERFORMS THE FOLLOWING :	40
C	1) READING OF THE ANALOG-TO-DIGITAL (ADC) CONVERTER VARIABLES	50
C	2) COMPUTION OF SIMULATION TIME	60
C	3) CALCULATION OF DIGITAL MODEL EQUATIONS	70
C	4) DATA PREPARATION FOR OUTPUT ON THE DIGITAL-TO-ANALOG (D/A)	80
C	CONVERTERS	90
C	5) DETECTION, LIMITING, AND FLAGGING OF ADC AND D/A VARIABLE	100
C	OVERLOADS	110
C	6) COLLECTION OF TRACK DATA FOR OUTPUT AT THE END OF RUN	120
C	*****	130
	COMMON/START/ ZDUMMY (4)	140
	COMMON/IANDG/ AIXP, AIXZP, GAM1, GAM2, GAM3, GAM4, GAM5, GAM6,	
	1GAM7, GAM8, GAM9, AIYP, AIZP	
	COMMON/CFRC/ SL (4), SEP (4), CFCEOF (4), ARPS (4)	
	COMMON/TOM/ COSABG (3, 4), COABGH (3, 4), COSAC (4), COSBC (4), COSAR (4),	
	1COSBR (4), COSGR (4), PSIP (4), HCOG (4), T (3, 3), XYZDOT (3)	
	2, SINPHI (4), COSPHI (4)	
	COMMON/FANDM/ FRXU (4), FRYU (4), FRZU (4), FCXU (4), FCYU (4), FCZU (4),	
	1FSXU (4), FSYU (4), PSZU (4), FRIP (4), H (4), SNPHIP, SNPHIR, FZUI (4)	
	COMMON/EMON/IERDAC (10), TERDAC (10), IDACK, IENDR (20)	150
	COMMON/ERMON2/ IERADC (10), TERADC (10), IADCK	160
	COMMON/DACADC/ NAMDAC, NAMADC, IDAC, IADC, ADCNUM, DACNUM	170
	COMMON/AERO/SFXS, SFYS, SFZS, SNTHS, SNPHIS, SNPSIS, APLUSB, IAERO	180
	COMMON/DULVAR/Z3ID, Z4ID, Z5OD, Z6OD,	190
1	F3RID, F4RID, F5ROD, F6ROD,	200
1	U3ID, U4ID, U5OD, U6CD,	210
1	V3ID, V4ID, V5OD, V6CD,	220
1	W3ID, W4ID, W5OD, W6OD,	230
1	UG3ID, UG4ID, UG5OD, UG6OD,	240
1	VG3ID, VG4ID, VG5OD, VG6OD,	250
1	UG3IDP, UG4IDP, UG5ODP, UG6ODP,	260
1	S3ID, S4ID, S5OD, S6OD,	270
1	CF3ID, CF4ID, CF5OD, CF6OD,	280

1	AMUI3,AMUI4,AMUI5,AMUI6,	290
1	ALTQ3P,ALTQ4P,	300
1	OTM3P,OTM4P,OTM5,OTM6	310
	COMMON/DUALS/IDULTR,NWHEEL,TI RO2,TORO2,TIRTOR,VBRZRP,	320
1	FYU5,FYU6,FYU5,FYU6,ALTQ5,ALTQ6,FSI3,FSI4,FSI5,FSI6,PPHIR	330
	COMMON/FAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,	340
	1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,	350
1	AKK1,AKK2,	360
	1AMT1,AMT2,SN,SFXU,BTVD1,ETAX,ETAL,	370
1	ZIP(4),PHII(4),	380
1	UII(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),	390
1	ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),UOI(4),	400
1	FCI(4),FCIMAX(4),FSI(4),	410
1	ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),	420
1	RWZI(4),ZI(4),FRI(4),	430
1	UUI(4),VI(4),WI(4),UGI(4),	440
	VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)	450
1	ALTQ(4),OTM(4),SALTQ,FOTM,ROTM	460
1	AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4	470
1	DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4	480
1	PHIDMX	490
	COMMON/APL/ OPEN ,RTSW ,LDTSW ,RBSW	500
	COMMON/SPLTAX/ SPSR3,SPSR4, IAX	510
	COMMON/SOLDAX/ PHIFNT(07),THEFNT(07),	520
1	PSIFNT(7),PHIRR(7),THERR(7),PSIRR(7)	530
	COMMON/EXTRA/ PSI3S,PSI4S,BTV,AYSTI	540
	COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMX,TQFMX,PSIMAX,ONER	550
	COMMON/CACATO/EPSK1,EPSK2,FEE1,FEE2,THE1,THE2	560
	COMMON/DELS/DELSWC	570
	COMMON/XYZ/NUMBR	580
	COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,	590
1	ANOUT,ADOUT	600
	COMMON/XBS/XB(30),NS(4,30),DELX(4),XI(4),NNN	610
	COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI	620
	COMMON/UVW/VC,UIN	650
	COMMON/EES/O1,O2,O3,E4,E5,E6	660
	COMMON/ZILCH/TQMAXF,TQMAXR,AKTQF,AKTOR,TQDRF,TQDRR,IDRSW	670
	COMMON/INOUT/ IN(48),DACO(48),ISW1,ISW7,IPT	
	COMMON/COMBLK/ SM,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,TSFO2,	
1	TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23	
	COMMON/SWITCH/ ISW	740
	COMMON/OPSW/IHSW	750
	COMMON/SP7BLK/N1,N2,IPCT(120),IPOTAD(120),PARAM(400)	760
	COMMON/ADCOUT/ DEL1DT,DEL2DT,DEL3DT,DEL1,DEL2,DEL3,PHIRD,PHIR,	
2	DELFW1,DELFW2,S1P,S2P,S3P,S4P	
	COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX	770
	COMMON/NONAME/XEND,O,EXIT2	780
	COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,	790
1	AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,	800
1	TIMBMP,GETDL,TIMIN5,	810
	TSTEP, IVHTP	820
	COMMON/TIMBLK/JJTIME,TIME,DT	830
	COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT	840
	COMMON/TRACK/JIN,IKEEP,ATRACK,I SAMP,ONTIM,OFFTIM,ITRA,	850
1	ITRAA,ITRNA,ITRIA	860
	COMMON/IO/DACPLA,ADCPIA,SCALDC,SCALAC	870
	COMMON/SPRING/ DLSUS1,DLSUS2,DISUS3,DLSUS4,DELSF1(10),DELSF2(10),	880
1	DELSR3(10),DELSR4(10),FDLSF1(10),FDLSF2(10),FDLSR3(10),FDLSR4(10),	890
1	NDEL F1,NDEL F2,NDEL R3,NDEL R4	
	COMMON/BRAKE/TQFBL,TQRBL	
	COMMON/SHOCKS/ZDBPRF(10),ZDBPLF(10),ZDBPRR(10),ZDBPLR(10),	
1	SAFRF(10),SAFLF(10),SAFRR(10),SAFLR(10),	

2	NRF, NLF, NRR, NLR,		
3	ZETDRF, ZETDLF, ZETDRR, ZETDLR,		
4	AKSRF, AKSLF, AKSFR, AKSLR, FSARF, FSALF, FSARR, FSALR		
	REAL*4 ZDUMMY		900
	EQUIVALENCE (BVALUE (1), ZDUMMY (1))		910
	EQUIVALENCE (APF (1), APF1), (AER (1), APR1), (MUS (1), MUSF),		920
1	(APF (2), APF2), (APR (2), APR2), (MUS (2), MUSR)		930
	EQUIVALENCE		940
1	(PARAM ( 1), AMS) , (PARAM ( 2), AMUF) , (PARAM ( 3), AMUR) ,		950
1	(PARAM ( 4), ZF) , (PARAM ( 5), ZR) , (PARAM ( 6), A) ,		960
1	(PARAM ( 7), B) , (PARAM ( 8), TF) , (PARAM ( 9), TR) ,		970
1	(PARAM (10), TS) , (PARAM (11), AIX) , (PARAM (12), AIY) ,		980
1	(PARAM (13), AIZ) , (PARAM (14), AIXZ) , (PARAM (15), AIR) ,		990
1	(PARAM (16), CF) , (PARAM (17), RF) ,		1000
1	(PARAM (19), AKF1) , (PARAM (20), AKF2) , (PARAM (21), AKR3) ,		1010
1	(PARAM (22), AKR4) , (PARAM (23), CR) , (PARAM (24), RR) ,		1020
1	(PARAM (25), CF1P) , (PARAM (26), CF2P) , (PARAM (27), CR3P) ,		1030
1	(PARAM (28), CR4P) , (PARAM (30), AKRS) ,		1040
1	(PARAM (31), RW) , (PARAM (32), SCALE) , (PARAM (33), OT) ,		
1	(PARAM (34), CA0) , (PARAM (35), CA1) , (PARAM (36), CA2) ,		1060
1	(PARAM (37), CA3) , (PARAM (38), CA4) , (PARAM (39), TIR ) ,		1070
1	(PARAM (44), LAFT) , (PARAM (41), AKSC) , (PARAM (42), ANG) ,		1080
1	(PARAM (43), LAFC) , (PARAM (40), TOR ) , (PARAM (45), LARC) ,		1090
	EQUIVALENCE		1100
1	(PARAM (46), LART) , (PARAM (47), AIFW) , (PARAM (48), AIF) ,		1110
1	(PARAM (49), AIWF) , (PARAM (50), AIWR) , (PARAM (51), AID) ,		1120
1	(PARAM (52), ARBR) , (PARAM (53), TSF ) , (PARAM (54), AKFS) ,		1130
1	(PARAM (55), PTBR) , (PARAM (56), YSA1) , (PARAM (57), YSA2) ,		1140
1	(PARAM (58), YHS1) , (PARAM (59), YHS2) , (PARAM (60), AKD) ,		1150
1	(PARAM (61), AIDF) , (PARAM (62), ARFBR) , (PARAM (63), PIN) ,		1160
1	(PARAM (64), QIN) , (PARAM (65), RIN) , (PARAM (66), UIZ) ,		1170
1	(PARAM (67), VIN) , (PARAM (68), WIN) , (PARAM (69), XIN) ,		1180
1	(PARAM (70), YIN) , (PARAM (71), ZIN) , (PARAM (72), THEIN) ,		1190
1	(PARAM (73), PHIIN) , (PARAM (74), PSIIN) , (PARAM (75), DTIN) ,		1200
1	(PARAM (76), TEND) , (PARAM (77), AKT1) , (PARAM (78), AKT2) ,		1210
1	(PARAM (79), AKT3) , (PARAM (80), AKT4) , (PARAM (81), RPS1) ,		1220
1	(PARAM (82), RPS2) , (PARAM (83), RPS3) , (PARAM (84), RPS4) ,		1230
1	(PARAM (85), B1) , (PARAM (86), B2) , (PARAM (87), B3) ,		1240
	EQUIVALENCE		1250
1	(PARAM (88), B4) , (PARAM ( 89), DEL1DN) , (PARAM ( 90), DEL2DN) ,		1260
1	(PARAM ( 91), DEL3DN) , (PARAM ( 92), DELFIN) , (PARAM ( 93), DELRN) ,		1270
1	(PARAM ( 94), DEL3IN) , (PARAM ( 95), PHIDN) , (PARAM (96), PHIEN) ,		1280
1	(PARAM ( 97), DFW1IN) , (PARAM ( 98), DFW2IN) , (PARAM ( 99), U1PIN) ,		1290
1	(PARAM (100), U2PIN) , (PARAM (101), U3PIN) , (PARAM (102), U4PIN) ,		1300
1	(PARAM (103), S1PIN) , (PARAM (104), S2PIN) , (PARAM (105), S3PIN) ,		1310
1	(PARAM (106), S4PIN) , (PARAM (107), PPRT) , (PARAM (108), FREQ) ,		1320
1	(PARAM (110), TQMAX) , (PARAM (111), AKTQ) , (PARAM (112), VCIN) ,		1330
1	(PARAM (113), SWMT) , (PARAM (114), DSWCM) , (PARAM (115), TST) ,		1340
1	(PARAM (116), DSLP) , (PARAM (117), CGAM) , (PARAM (118), CS) ,		1350
1	(PARAM (119), TQRBR) , (PARAM (120), TQFBR) ,		1360
1	(PARAM (121), PFL) , (PARAM (122), TTD) , (PARAM (123), DSW) ,		1370
1	(PARAM (124), TSW) ,		1380
	EQUIVALENCE		1390
1	(PARAM (130), AMCR) , (PARAM (131), ESP) , (PARAM (132), AKSL1) ,		1400
1	(PARAM (133), AKSL2) , (PARAM (134), AA1) , (PARAM (135), AA2) ,		1410
1	(PARAM (136), CCR) , (PARAM (137), CFCR) , (PARAM (138), AP) ,		1420
1	(PARAM (139), EP1) , (PARAM (140), EP2) ,		1430
1	(PARAM (169), SNT) , (PARAM (170), SNS0) , (PARAM (171), SNS1) ,		1440
1	(PARAM (182), SII (1)) ,		1450
	EQUIVALENCE (PARAM (202), APF (1)) , (PARAM (204), APR (1)) ,		1460
1	(PARAM (206), MUS (1)) ,		1470

EQUIVALENCE (AKLR,PARAM (212)), (KOTF,PARAM (213)), (KOTR,PARAM (214))	
EQUIVALENCE	1480
1 (PARAM (223),CR1C), (PARAM (224),CR1T), (PARAM (225),CR2C),	1490
1 (PARAM (226),CR2T), (PARAM (227),CR3C), (PARAM (228),CR3T),	1500
1 (PARAM (229),CR4C), (PARAM (230),CR4T), (PARAM (231),AH1),	1510
1 (PARAM (232),AH2), (PARAM (233),ALAMBD)	1520
1 (PARAM (242),AKCF), (PARAM (243),AKCR), (PARAM (244),AKSR)	1530
EQUIVALENCE (PARAM (236),PSO1), (PARAM (237),PSO2)	
EQUIVALENCE (PARAM (245),RB (1)), (PARAM (249),TFK (1)),	1540
1 (PARAM (252),TRK (1)),	1550
1 (PARAM (255),OFC0), (PARAM (256),OFC1), (PARAM (257),OFC2),	1560
1 (PARAM (258),OFC3), (PARAM (262),ORC3),	1570
1 (PARAM (259),ORC0), (PARAM (260),ORC1), (PARAM (261),ORC2)	1580
EQUIVALENCE (PARAM (263),CPOF), (PARAM (264),CP1F),	1590
1 (PARAM (265),CP2F), (PARAM (266),CPOR), (PARAM (267),CP1R),	1600
1 (PARAM (268),CP2R), (PARAM (269),CROF), (PARAM (270),CR1F),	1610
1 (PARAM (271),CR2F), (PARAM (272),CROF), (PARAM (273),CR1R),	1620
1 (PARAM (274),CR2R)	1630
EQUIVALENCE (RB (1),RB1), (RB (2),RB2)	1640
EQUIVALENCE (RB (3),RB3), (RB (4),RB4)	1650
EQUIVALENCE (TFK (1),AFK1), (TRK (1),ARK1)	1660
EQUIVALENCE (TFK (2),AFK2), (TRK (2),ARK2)	1670
EQUIVALENCE (TFK (3),AFK3), (TRK (3),ARK3)	1680
EQUIVALENCE	1690
1 (PARAM (284),HFC), (PARAM (285),HRC),	1700
1 (PARAM (290),ROT), (PARAM (291),RA0), (PARAM (292),RA1),	1710
1 (PARAM (293),RA2), (PARAM (294),RA3), (PARAM (295),RA4)	1720
EQUIVALENCE (PARAM (351),IOUT (1))	
EQUIVALENCE (RWZI (1),RWZ1), (ZI (1),Z1), (FRI (1),FR1), (AKTI (1),AKT1),	1840
1 (RWZI (2),RWZ2), (ZI (2),Z2), (FRI (2),FR2), (AKTI (2),AKT2),	1850
1 (RWZI (3),RWZ3), (ZI (3),Z3), (FRI (3),FR3), (AKTI (3),AKT3),	1860
1 (RWZI (4),RWZ4), (ZI (4),Z4), (FRI (4),FR4), (AKTI (4),AKT4),	1870
1 (UI (1),U1), (VI (1),V1), (WI (1),W1), (UGI (1),UG1), (VGI (1),VG1),	1880
1 (UI (2),U2), (VI (2),V2), (WI (2),W2), (UGI (2),UG2), (VGI (2),VG2),	1890
1 (UI (3),U3), (VI (3),V3), (WI (3),W3), (UGI (3),UG3), (VGI (3),VG3),	1900
1 (UI (4),U4), (VI (4),V4), (WI (4),W4), (UGI (4),UG4), (VGI (4),VG4),	1910
1 (SINPSI (1),SINPS1), (PSII (1),PSI1), (COSPSI (1),COSPS1), (UGIP (1),UG1P	1920
1), (PHICGI (1),PHICG1), (CVI (1),CV1), (ABI (1),AB1), (BETAI (1),BETA1),	1930
1 (SINPSI (2),SINPS2), (PSII (2),PSI2), (COSPSI (2),COSPS2), (UGIP (2),UG2P	1940
1), (PHICGI (2),PHICG2), (CVI (2),CV2), (ABI (2),AB2), (BETAI (2),BETA2),	1950
1 (SINPSI (3),SINPS3), (PSII (3),PSI3), (COSPSI (3),COSPS3), (UGIP (3),UG3P	1960
1), (PHICGI (3),PHICG3), (CVI (3),CV3), (ABI (3),AB3), (BETAI (3),BETA3),	1970
1 (SINPSI (4),SINPS4), (PSII (4),PSI4), (COSPSI (4),COSPS4), (UGIP (4),UG4P	1980
1), (PHICGI (4),PHICG4), (CVI (4),CV4), (ABI (4),AB4), (BETAI (4),BETA4)	1990
EQUIVALENCE (AMUI (1),AMU1), (SNI (1),SN1), (RMI (1),RM1), (GBI (1),GB1),	2000
1 (AMUI (2),AMU2), (SNI (2),SN2), (RMI (2),RM2), (GBI (2),GB2),	2010
1 (AMUI (3),AMU3), (SNI (3),SN3), (RMI (3),RM3), (GBI (3),GB3),	2020
1 (AMUI (4),AMU4), (SNI (4),SN4), (RMI (4),RM4), (GBI (4),GB4),	2030
1 (FRIBR (1),FR1BR), (ALFI (1),ALF1), (BETIP (1),BET1P), (BETIBR (1),BET1BR	2040
1), (SLIPI (1),SLIP1), (AM1I (1),AM11), (AM2I (1),AM21), (UOI (1),UO1),	2050
1 (FRIBR (2),FR2BR), (ALFI (2),ALF2), (BETIP (2),BET2P), (BETIBR (2),BET2BR	2060
1), (SLIPI (2),SLIP2), (AM1I (2),AM12), (AM2I (2),AM22), (UOI (2),UO2),	2070
1 (FRIBR (3),FR3BR), (ALFI (3),ALF3), (BETIP (3),BET3P), (BETIBR (3),BET3BR	2080
1), (SLIPI (3),SLIP3), (AM1I (3),AM13), (AM2I (3),AM23), (UOI (3),UO3),	2090
1 (FRIBR (4),FR4BR), (ALFI (4),ALF4), (BETIP (4),BET4P), (BETIBR (4),BET4BR	2100
1), (SLIPI (4),SLIP4), (AM1I (4),AM14), (AM2I (4),AM24), (UOI (4),UO4),	2110
1 (U1I (1),U11), (BAMI (1),EAM1), (SII (1),SI1), (SAMI (1),SAM1), (FI (1),F1)	2120
1,	2130
1 (U1I (2),U12), (BAMI (2),EAM2), (SII (2),SI2), (SAMI (2),SAM2), (FI (2),F2)	2140
1,	2150

1	(U1I (3) , U13) , (BAMI (3) , BAM3) , (SII (3) , SI3) , (SAMI (3) , SAM3) , (FI (3) , F3)	2160
1		2170
1	(U1I (4) , U14) , (BAMI (4) , BAM4) , (SII (4) , SI4) , (SAMI (4) , SAM4) , (FI (4) , F4)	2180
	EQUIVALENCE (FXUI (1) , FXU1) , (FYUI (1) , FYU1) , (GI (1) , G1) , (FCI (1) , FC1) ,	2190
1	(FXUI (2) , FXU2) , (FYUI (2) , FYU2) , (GI (2) , G2) , (FCI (2) , FC2) ,	2200
1	(FXUI (3) , FXU3) , (FYUI (3) , FYU3) , (GI (3) , G3) , (FCI (3) , FC3) ,	2210
1	(FXUI (4) , FXU4) , (FYUI (4) , FYU4) , (GI (4) , G4) , (FCI (4) , FC4) ,	2220
1	(FCIMAX (1) , FC1MAX) , (FSI (1) , FS1) ,	2230
1	(FCIMAX (2) , FC2MAX) , (FSI (2) , FS2) ,	2240
1	(FCIMAX (3) , FC3MAX) , (FSI (3) , FS3) ,	2250
1	(FCIMAX (4) , FC4MAX) , (FSI (4) , FS4)	2260
	EQUIVALENCE (ZIP (1) , Z1P) , (PHII (1) , PHI1) ,	2270
1	(ZIP (2) , Z2P) , (PHII (2) , PHI2) ,	2280
1	(ZIP (3) , Z3P) , (PHII (3) , PHI3) ,	2290
1	(ZIP (4) , Z4P) , (PHII (4) , PHI4)	2300
	EQUIVALENCE (DL1S , DLIS (1)) , (DL2S , DLIS (2)) , (DL3S , DLIS (3))	2310
1	(DL4S , DLIS (4))	2320
	EQUIVALENCE (PHIFD , DEL2DT) , (PHIF , DEL2)	2330
	EQUIVALENCE (PHIRD , DEL4DT) , (PHIR , DEL4)	2340
	EQUIVALENCE (DLSUSI (1) , DLSUS1) , (DLSUSI (2) , DLSUS2) ,	2350
1	(DLSUSI (3) , DLSUS3) , (DLSUSI (4) , DLSUS4)	2360
	EQUIVALENCE (FZUI (1) , FZU1) , (FZUI (2) , FZU2) ,	
1	(FZUI (3) , FZU3) , (FZUI (4) , FZU4)	
	EQUIVALENCE (VARZRP , VERZRP)	
	EQUIVALENCE (FEE1 , FEE (1)) , (FEE2 , FEE (2))	LFRI 530
	REAL*4 KOTF , KOTR	
	REAL*4 FEE (2)	LFRI 540
	DATA RAD/0.1745329E-1/	2370
	DATA MPHIPS/17.6/	2380
	REAL*4 MPHIPS	2390
	REAL*4 MUP , MUS (2) , RE (4) , TFK (3) , TRK (3) , SII (4) , APF (2) , APR (2)	2400
	REAL*4 LAFc , LAFT , LARC , IART	2410
	REAL*4 AKTI (4)	2420
	REAL*4 ATRACK (2000)	2430
	INTEGER*2 ITRAA (50) , ITRNA (50) , ITRIA (50) , DACPLA (48) , ADCPLA (48)	2440
	INTEGER*2 NAMDAC (48) , NAMADC (48) , IDAC (48) , IADC (48) , ADCNUM , DACNUM	2450
	REAL*4 IOUT (48) , IN , SCALAC (48) , SCALDC (48)	2460
	REAL*4 DLSUSI (4) , PCGI (4) , SNFSIP (4)	
	REAL*4 BVALUE (2)	2470
	INTEGER*2 RTSW , RBSW , LDTSW , OPEN	2490
C	*****	2500
C	USE A/D READ VALUES	2510
C	CHECK FOR A/D OVER RANGE	2520
C	*****	2530
	DO 10100 I=1,ADCNUM	2540
	SADCO = IN (I)	2550
	IN (I) = AMAX1 (-.9998 , (AMIN1 (.9998 , IN (I))) )	2560
	IF (SADCO.EQ. IN (I)) GC TO 10105	2570
	IADCK = IADCK+1	2580
	IF (IADCK.GE.10) IADCK = 10	2590
	IERADC (IADCK) = I	2600
	TERADC (IADCK) = TIME	2610
10105	CONTINUE	2620
	BVALUE (ADCPLA (I)) = IN (I) * SCALAC (I)	2630
10100	CONTINUE	2640
	IHSW=1	2650
	TIME=FLOAT (JJTIME) * DT	2660
	JJTIME=JJTIME+1	2670
	ENTRY SBPG22	2680



ISW=1	2690
IF (TIME.GT.0.) GO TO 6	2700
DO 5 K=1,4	2710
FSI (K) = 0.	2720
ALTQ (K) = 0.	2730
ZIMX (K) = 100.	2740
5 CONTINUE	2750
PHIDMX = 0.	2760
CONVRT = 1./MPHIPS	2770
C AERODYNAMIC INITIALIZATION VARIABLES	2780
SPXS =0.	2790
SFYS =0.	2800
SFZS =0.	2810
SNTHES=0.	2820
SNPHIS =0.	2830
SNPSIS=0.	2840
C DUAL TIRE INITIALIZATION VARIABLES	2850
ALTQ5=0.0	2860
ALTQ6=0.0	2870
FSI3=0.0	2880
FSI4=0.0	2890
FSI5=0.0	2900
FSI6=0.0	2910
FXU5=0.0	2920
FXU6=0.0	2930
FYU5=0.0	2940
FYU6=0.0	2950
SNPHIF=0.0	
SNPHIR=0.0	
SFSF = PARAM (32) /10000.	
NBMP=PARAM (277) +0.5	2960
C STOPPING DISTANCE INITIALIZATION	
ANUM=0.0	
ANUMDT=0.0	
6 CONTINUE	2970
C FUNCTION: PSIFNT-COEFFICIENTS TO A POLYNOMIAL FIT OF FRONT WHEEL	C 2980
C TOE-IN AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)	C 2990
C	C 3000
C INPUTS: PSIFNT- (DEGREES/INCH)	C 3010
C DELI- (INCHES)	3020
C *****	3030
C INCREASING THE SPRUNG MASS OVER THAT FOR WHICH THE STATIC WHEEL	3040
C DEFLECTION IS MEASURED, YIELDS A DELFIN AND A DELRIN WHICH	3050
C IS A NEGATIVE NUMBER	3060
C *****	3070
C DELFIN AND DELRIN REPRESENT A CHANGE IN STATIC DISPLACEMENT	3080
C OF THE FRONT AND REAR WHEELS DUE TO LOAD CONFIGURATIONS	3090
C OUTPUTS: POLY- (DEGREES)	C 3100
C	C 3110
C DLIS (I=1,2,3,4) IS THE SUSPENSION DEFLECTION RELATIVE	3120
C TO THE UNLOADED POSITION FOR WHEEL I	3130
C SUSPENSION TIME DELAY COMPENSATION	
DEL1=DEL1+PARAM (341) *DEL1DT	
DEL2=DEL2+PARAM (342) *DEL2DT	
DEL3=DEL3+PARAM (343) *DEL3DT	
PHIR=PHIR+PARAM (344) *PHIRD	
DL1S = DEL1 + DELFIN	3140
DL2S = DEL2 + DELFIN	3150
DL3S = DEL3 + DELRIN	3160
DL4S = DEL4 + DELRIN	3170

	DLSUS1=DL1S	3180
	DLSUS2=DL2S	3190
	DLSUS3=DL3S	3200
	DLSUS4=DL4S	3210
C	IAX = 0 SOLID FRONT AND REAR SUSPENSIONS	3220
C	= 1 INDEPENDENT FRONT AND SOLID REAR SUSPENSIONS	3230
C	= 2 INDEPENDENT FRONT AND REAR SUSPENSIONS	3240
	IF (IAX.EQ.0) DL1S = DL1S + TFO2*PHIF	3250
	IF (IAX.EQ.0) DL2S = DEL1 + DELFIN - TFO2*PHIF	3260
	IF (IAX.LE.1) DL3S = DL3S + TRO2*PHIR	3270
	IF (IAX.LE.1) DL4S = DEL3 + DELRIN - TRO2*PHIR	3280
C	SUSPENSION DEFLECTIONS FOR SPRING FORCES	3290
	IF (IAX.EQ.0) DLSUS1 = DLSUS1 + TSF*PHIF/2.	3300
	IF (IAX.EQ.0) DLSUS2 = DEL1 + DELFIN - TSF*PHIF/2.	3310
	IF (IAX.LE.1) DLSUS3=DLSUS3+TSO2*PHIR	3320
	IF (IAX.LE.1) DLSUS4 = DEL3 + DELRIN -TSO2*PHIR	3330
C	INDEPENDENT FRONT & SOLID REAR	
	PSI1=DELFW1+ (POLY (DL1S,PSIFNT)) *RAD+EPSK1	3340
	PSI2=DELFW2- (POLY (DL2S,PSIFNT)) *RAD+EPSK2	3350
	PSI3S = AKRS*PHIR	3360
	1 + AKLR*FSI (3)	
	PSI4S = AKRS*PHIR	3370
	1 + AKLR*FSI (4)	
C		C 3380
C	FUNCTION: PHIFNT-COEFFICIENTS TO A POLYNOMIAL FIT OF FRONT WHEEL	C 3390
C	CAMBER AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)	C 3400
C		C 3410
C	INPUTS: PHIFNT- (DEGREES/INCH)	C 3420
C	DELI- (INCHES)	C 3430
C		C 3440
C	OUTPUTS: POLY- (DEGREES)	C 3450
C		C 3460
	PHIPY1 = (POLY (DL1S,PHIFNT)) *RAD	
	PHIPY2 = (POLY (DL2S,PHIFNT)) *RAD	
	PHISA1 = PHIPY1 - PHIFNT (1) *RAD + YHS1	
	PHISA2 = -PHIPY2 + PHIFNT (1) *RAD + YHS2	
	PHI1 = PHIPY1 + SIGN (1.,FS1) *FEE1 - PHISA1* (1. -COS (PSII (1)))	
	1 + KOTF*CTM (1)	
	PHI2 = -PHIPY2 + SIGN (1.,FS2) *FEE2 -PHISA2* (1. -COS (PSII (2)))	
	1 + KOTF*OTM (2)	
	PHI3=PHIR	3490
	PHI4=PHIR	3500
C		C 3510
C	FUNCTION: THEFNT-CASTER AS A FUNCTION OF SUSPENSION	C 3520
C	DEFLECTION (DELI)	C 3530
C		C 3540
C	INPUTS: THEFNT (DEGREES/INCH)	C 3550
C	DELI- (INCHES)	C 3560
C		C 3570
C	OUTPUT: POLY- (DEGREES)	C 3580
C		C 3590
	THS1= (POLY (DL1S,THEFNT)) *RAD+THE1	3600
	THS2= (POLY (DL2S,THEFNT)) *RAD+THE2	3610
C		C 3620
C	FUNCTION: PSIRR-COEFFICIENTS TO A POLYNOMIAL FIT OF REAR WHEEL	C 3630
C	TOE-IN AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)	C 3640
C		C 3650
C	INPUTS: PSIRR- (DEGREES/INCH)	C 3660
C	DELI- (INCHES)	C 3670
C		C 3680

C	OUTPUTS:	POLY-(DEGREES)	C	3690
C			C	3700
C			C	3710
C	FUNCTION:	PHIRR-COEFFICIENTS TO A POLYNOMIAL FIT OF REAR WHEEL	C	3720
C		CAMBER AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)	C	3730
C			C	3740
C	INPUTS:	PHIRR-(DEGREES/INCH)	C	3750
C		DELI-(INCHES)	C	3760
C			C	3770
C	OUTPUTS:	POLY-(DEGREES)	C	3780
C			C	3790
C		INDEPENDENT REAR		
		IF (IAX.LE.1) GO TO 7843		3800
		PSI3S = POLY(DL3S,PSIRR)*RAD		3810
		1 + AKLR*FSI(3)		
		PSI4S = -POLY(DL4S,PSIRR)*RAD		3820
		1 + AKLR*FSI(4)		
		PHI3 = POLY(DL3S,PHIRR)*RAD		3830
		1 + KOTR*OTM(3)		
		PHI4 = -POLY(DL4S,PHIRR)*RAD		3840
		1 + KOTR*OTM(4)		
7843		CONTINUE		3850
		IF (IAX.NE.0.) GO TO 7844		3860
C		SOLID FRCNT		
		PSI1 = DELFW1-AKFS*PHIF+EPSK1		3870
		PSI2 = DELFW2-AKFS*PHIF+EPSK2		3880
		PHI1 = PHIF+FEE1		3890
		PHI2 = PHIF+FEE2		3900
7844		CONTINUE		3910
		IF (IDULTR.EQ.1) ALTQ(3) = ALTQ(3)/2.		4630
		IF (IDULTR.EQ.1) ALTQ(4) = ALTQ(4)/2.		4640
		PSI3 = PSI3S+ ALTQ(3)*AKSR		4650
		PSI4 = PSI4S+ ALTQ(4)*AKSR		4660
		PHS1=YHS1+PHI1		3920
		PHS2=YHS2+PHI2		3930
C		CALCULATION OF FRONT BUMP STOP FORCES		3940
		FBS1 = XINT(DLSUS1,DELSF1,FDLSF1,NDELF1)		3950
		FBS1 = FBS1 - AKF1*DLSUS1		3960
		FBS2 = XINT(DLSUS2,DELSF2,FDLSF2,NDELF2)		3970
		FBS2 = FBS2 - AKF2*DLSUS2		3980
C		CALCULATION OF REAR BUMP STOP FORCES		3990
		FBS3 = XINT(DLSUS3,DELSR3,FDLSR3,NDELR3)		4000
		FBS3 = FBS3 - AKR3*DLSUS3		4010
		FBS4 = XINT(DLSUS4,DELSR4,FDLSR4,NDELR4)		4020
		FBS4 = FBS4 - AKR4*DLSUS4		4030
C		CALCULATION OF SHOCK ABSORBER FORCES		
		FSARF=XINT(ZETDRF,ZDBPRF,SAFRF,NRF)		
		FSARF=FSARF-AKSRF*ZETDRF		
		FSALF=XINT(ZETDLF,ZDBPIF,SAFLF,NLF)		
		FSALF=FSALF-AKSLF*ZETDLF		
		FSARR=XINT(ZETDRR,ZDBPRR,SAFRF,NRR)		
		FSARR=FSARR-AKSRR*ZETDRR		
		FSALR=XINT(ZETDLR,ZDBPIR,SAFLF,NLR)		
		FSALR=FSALR-AKSLR*ZETDLR		
		NNN=PARAM(198)/(PARAM(75)*U )+0.5		4040
C****		COOD TRANSFORMATION *****		
		CTH=COS (THE)		
		CPH=COS (PHI)		
		CPS=COS (PSI)		

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STH=SIN (THE)
SPS=SIN (PSI)
SPH=SIN (PHI)
CPHSPS=CPH*SPS
SPHCPS=SPH*CPS
CPHCPS=CPH*CPS
SPSSPH=SES*SPH
T (1, 1) =CPS*CTH
T (2, 1) =SPS*CTH
T (3, 1) =-STH
T (1, 2) =SPHCPS*STH-CPHSPS
T (2, 2) =CPHCPS+SPSSPH*STH
T (3, 2) =SPH*CTH
T (1, 3) =SPSSPH+CPHCPS*STH
T (2, 3) =CPHSPS*STH-SPHCPS
T (3, 3) =CTH*CPH
C *****
C***** COSINE OF ALPHA BETA AND GAMMA FOR SUBS R,C,ANDH*****
DO 16 K=1,4
SINPSI (K)=SIN (PSII (K))
COSPSI (K)=COS (PSII (K))
SINPHI (K)=SIN (PHII (K))
COSPHI (K)=COS (PHII (K))
16 CONTINUE
C*****COS ALPHA YWI=COSABG (1,I) ,COS BETA YWI=COSABG (2,I)
C*** COS GAMMA YWI=COSABG (3,I)
DO 22 J=1,3
DO 23 K=1,4
COSABG (J,K)=-T (J, 1) *SINPSI (K) +T (J, 2) *COSPHI (K) *COSPSI (K)
1 +T (J, 3) *SINPHI (K) *COSPSI (K)
23 CONTINUE
22 CONTINUE
DO 26 I=1,4
C2BETA = COSABG (2,I) *CCSABG (2,I)
DEN1 = SQRT (COSABG (1,I) *COSABG (1,I) + C2BETA)
COSAC (I) = COSABG (2,I) /DEN1
COSBC (I) = -COSABG (1,I) /DEN1
COSAR (I) = -COSABG (1,I) *COSABG (3,I) /DEN1
COSBR (I) = -COSABG (3,I) *COSABG (2,I) /DEN1
COSGR (I) = DEN1
SNPSIP (I) = - (T (1, 1) *CCSABG (1,I) + T (2, 1) *COSABG (2, I)) / (DEN1*CTH)
PSIP (I) = ARSIN (SNPSIP (I))
IF (PARAM (276) .LT. 0.) PSIP (I) = PSII (I)
PCGI (I) = ARSIN (COSABG (3,I))
IF (I.GT. 2) GO TO 27
PHICGI (I) = PCGI (I) + AKCF*FSI (I)
IF (IAX.EQ. 0) PHICGI (I) = PHICGI (I) + FEE (I)
GO TO 26
27 CONTINUE
PHICGI (I) = PCGI (I) + AKCR*FSI (I)
IF (PARAM (276) .EQ. 1.) PHICGI (I) = 0.
IF (PARAM (276) .EQ. 9.) PHICGI (I) = 0.
26 CONTINUE
DO 24 J=1,3
DO 25 K=1,4
COABGH (J,K) =T (1, J) *COSAR (K) +T (2, J) *COSBR (K) +T (3, J) *COSGR (K)
25 CONTINUE
24 CONTINUE
C *****
C

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C      INTEGRATION OF DERIVATIVES DONE NEXT
C
DO 15 I=1,3
XYZDOT (I)=U*T (I, 1) +V*T (I, 2) +W*T (I, 3)
15  CONTINUE
Z=Z+XYZDOT (3) *DT
X=X
Y=Y
IF (PARAM (218) .GT. 0.5) GO TO 8999
X=X+XYZDOT (1) *DT
Y=Y+XYZDOT (2) *DT
8999 CONTINUE
C*****
C***** STOPPING DISTANCE COMPUTATIONS *****
IF (TIME. LT. CGAM) GO TC 9000
ANUMDT = SQRT (U**2 + V**2)
ANUM=ANUM+ANUMDT*DT
9000 CONTINUE
C*****
C***** Z COMPUTATION *****
100 TM 1=Z+T (3, 1) *A+T (3, 3) *ZF
TM2=T (3, 2) *TFO2
Z1=TM1+TM2+T (3, 3) *DEL1 -DELX (1)
IF (IAX. EQ. 0) Z1=Z1+T (3, 3) *TFO2*PHIF
Z2=TM1-TM2+T (3, 3) *DEL2-DELX (2)
IF (IAX. EQ. 0) Z2=Z2+T (3, 3) * (-TFO2*PHIF-DEL2+DEL1)
TM 1=Z-T (3, 1) *B+T (3, 3) *ZR
TM2=T (3, 2) *TRO2
Z3=TM1+TM2+T (3, 3) *DEL3-DELX (3)
IF (IAX. LE. 1) Z3=Z3+T (3, 3) *TRO2*PHIR
Z4=TM1-TM2+T (3, 3) *DEL4-DELX (4)
IF (IAX. LE. 1) Z4=Z4+T (3, 3) * (-TRO2*PHIR-DEL4+DEL3)
*****
C      CALCULATION OF TIRE ROLLING RADIUS
DO 110 K=1,4
H(K)=-ZI (K) /COSGR (K)
IF (PARAM (276) .EQ. 2.) H (K) = -ZI (K)
IF (PARAM (276) .EQ. 5.) H (K) = -ZI (K)
IF (PARAM (276) .EQ. 9.) H (K) = -ZI (K)
IF (H (K) .GT. RW) H (K) =RW
110 CONTINUE
C*****
C      WHEEL SPIN RATE X ROLLING RADIUS
SPINH1=ARPS (1) *H (1)
SPINH2=ARPS (2) *H (2)
C *****
C
C***** COMPUTATION OF U,V, AND W FOR VARIOUS AXLES*****
C***** THIS SECTION COMPUTES THE U'S,V'S,AND W'S FOR ALL AXLE CONFIGURATIONS
TM1=U+ZF*Q
TM2=TFO2*R
TM11=U+ZR*Q
TM22=TRO2*R
VARZFP=V+A*R-ZF*P
VARZRP=V-B*R-ZR*P
PPHIR=P+PHIRD
PPHIF=P+PHIFD
WAQ=W-A*Q
WBQ=W+B*Q
IF (IAX-1) 4, 55, 56

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C**** SOLID FRONT AXLE EQUATIONS (A) *****
4  U1=TM1-TM2+Q*(TFO2*PHIF+DEL1)
   U2=TM1+TM2+Q*(-TFO2*PHIF+DEL1)
   V1=VARZFP-DEL1 *P-(TFC2*PHIF+ H(1)*COABGH(3,1))*PPHIF
   V2=VARZFP-DEL1 *P-(-TFO2*PHIF+ H(2)*COABGH(3,2))*PPHIF
   W1=WAQ+DEL1DT-(-TFO2-H(1)*COABGH(2,1))*PPHIF
   W2=WAQ+DEL1DT-(TFO2-H(2)*COABGH(2,2))*PPHIF
C**** SOLID REAR EQUATIONS (B) *****
55 U3=TM11-TM22+Q*(TRO2*PHIR+DEL3)
   U4=TM11+TM22+Q*(-TRO2*PHIR+DEL3)
   V3=VARZRP-DEL3 *P-(TRO2*PHIR+ H(3)*COABGH(3,3))*PPHIR
   V4=VARZRP-DEL3 *P-(-TRO2*PHIR+ H(4)*COABGH(3,4))*PPHIR
   W3=WBQ+DEL3DT-(-TRO2-H(3)*COABGH(2,3))*PPHIR
   W4=WBQ+DEL3DT-(TRO2-H(4)*COABGH(2,3))*PPHIR
   IF(IAX.EQ.0) GO TO 7
C**** INDEPENDENT FRONT AXLE EQUATIONS (C) *****
56 U1 = TM1-TM2 + Q*DEL1
   U2=TM1+TM2+Q*DEL2
   V1=VARZFP-(DEL1+H(1)*COABGH(3,1))*P
   V2=VARZFP-(DEL2+H(2)*COABGH(3,2))*P
   W1=WAQ+DEL1DT+(TFO2+H(1)*COABGH(2,1))*P
   W2=WAQ+DEL2DT-(TFO2-H(2)*COABGH(2,2))*P
   IF(IAX.EQ.1) GO TO 7
C**** INDEPENDENT REAR AXLE EQUATIONS (D) *****
   U3=TM11-TM22+Q*DEL3
   U4=TM11+TM22+Q*DEL4
   V3=VARZRP-(DEL3 + H(3)*COABGH(3,3))*P
   V4=VARZRP-(DEL4+H(4)*COABGH(3,4))*P
   W3=WBQ+DEL3DT+(TRO2+H(3)*COABGH(2,3))*P
   W4=WBQ+DEL4DT-(TRO2-H(4)*COABGH(2,4))*P
7  CONTINUE
C***** COSINE OF THETA XGI SIN THETA XGI BETA I PSII*****
   COTHXG=T(3,3)/SQRT(CPH*CPH+SPH*SPH*STH*STH)
   SITHXG=COTHXG*STH/T(3,3)
   DO 30 K=1,4
   VGI(K)=VI(K)*CPH-WI(K)*SPH
   UGI(K)=UI(K)*COTHXG+WI(K)*SITHXG
   IF(PARAM(276).EQ.3.) UGI(K) = UI(K) + THE*WI(K)
   IF(PARAM(276).EQ.9.) UGI(K) = UI(K) + THE*WI(K)
   CVI(K)=SQRT(UI(K)*UI(K)+VI(K)*VI(K))*CONVET
   ABI(K)=ABS(UGI(K))
   UGIP(K)=UGI(K)*COS(PSIP(K))+VGI(K)*SNPSIP(K)
   BETA I(K)=ATAN(VGI(K)/ABI(K))-SIGN(1.,UGI(K))*PSIP(K)
   SNI(K)=SNS0/SNT
   SLIPI(K) = 1.- ARPS(K)*H(K)/UGI(K)
   IF(SLIPI(K).LT.(-1.).OR.SLIPI(K).GT.1.) SLIPI(K)=SIGN(1.,SLIPI(K))
30 CONTINUE
C INTFUN IS USED FOR ROAD PATCH WITH VARYING COEFFICIENT OF FRICTION
INTFUN=PARAM(172)+0.5
IF(INTFUN.EQ.0) GO TO 3497
IF(INTFUN.NE.1) GO TO 3498
X1 = A*CPS - TFO2*SPS + X
X2 = A*CPS + TFO2*SPS + X
X3 = -B*CPS - TRO2*SPS + X
X4 = -B*CPS + TRO2*SPS + X
TEMP=PARAM(173)+PARAM(174)
TEMP=TEMP*12.0
PPPP=PARAM(173)*12.0
IF(X1.GT.PPPP .AND.X1.LE.TEMP) SN1=SNS1/SNT
IF(X2.GT.PPPP .AND.X2.LE.TEMP) SN2=SNS1/SNT

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IF (X3.GT.PPPP      .AND.X3.LE.TEMP) SN3=SNS1/SNT      4950
IF (X4.GT.PPPP      .AND.X4.LE.TEMP) SN4=SNS1/SNT      4960
GO TO 3498          4970
3497 CONTINUE      4980
YY1 = A*SPS + TFO2*CPS + Y
Y2 = A*SPS - TFO2*CPS + Y
Y3 = -B*SPS + TRO2*CPS + Y
Y4 = -B*SPS - TRO2*CPS + Y
IF (YY1.LT.0.0) SN1=SNS1/SNT      5030
IF (Y2.LT.0.0) SN2=SNS1/SNT      5040
IF (Y3.LT.0.0) SN3=SNS1/SNT      5050
IF (Y4.LT.0.0) SN4=SNS1/SNT      5060
3498 CONTINUE      5070
C**** COMPUTATION OF ROLLING RADIUS,RADIAL FORCE,AND NORMAL FORCE ***
C *** RWZI IS THE TIRE DEFLECTION *****
DO 20 K=1,4
RWZI (K) =RW-H (K)
IF (RWZI (K) .LT.ZIMX (K) ) ZIMX (K) =RWZI (K)
FRIP (K) =0.
IF (RWZI (K) .GT.0.) FRIP (K) =AKTI (K) *RWZI (K)
FRIPP=0.
IF (RWZI (K) .GT.0.) FRIPP= -FSI (K) *TAN (PHICGI (K) )
IF ((FRIP (K) + FRIPP) .IE.0.) FRIPP = 0.
FRI (K) = FRIP (K) /COS (PHICGI (K) ) + FRIPP
IF (PARAM (276) .EQ.4.) FRI (K) = FRIP (K)
IF (PARAM (276) .EQ.5.) FRI (K) = FRIP (K)
IF (PARAM (276) .EQ.9.) FRI (K) = FRIP (K)
20 CONTINUE
C CALCULATION OF SIDE FORCE FRICTION COEFF      5130
C      5140
C CALL LFRIC      5150
C      5160
C CIRCUMFERENTIAL FRICTICN COEFF CALCULATION      5170
C      5180
C CALL CFRIC      5190
C      5200
C      6410
C ***** COMPUTATION OF TIRE FORCES*****
DO 45 K=1,4
IF (PARAM (276) .NE.7.) GO TO 120
FXUI (K) = FRI (K) *THE + FCI (K) *COSPSI (K) - FSI (K) *SINPSI (K)
FYUI (K) = -FRI (K) *PHI + FCI (K) *SINPSI (K) + FSI (K) *COSPSI (K)
FZUI (K) = -FRI (K)
GO TO 45
120 CONTINUE
FRXU (K) =-FRI (K) *T (3,1)
FRYU (K) =-FRI (K) *T (3,2)
FRZU (K) =-FRI (K) *T (3,3)
FCXU (K) =FCI (K) * (T (1,1) *COSAC (K) +T (2,1) *COSBC (K) )
FCYU (K) =FCI (K) * (T (1,2) *COSAC (K) +T (2,2) *COSBC (K) )
FCZU (K) =FCI (K) * (T (1,3) *COSAC (K) +T (2,3) *COSBC (K) )
FSXU (K) =FSI (K) * (-T (1,1) *COSBC (K) +T (2,1) *COSAC (K) )
FSYU (K) =FSI (K) * (-T (1,2) *COSBC (K) +T (2,2) *COSAC (K) )
FSZU (K) =FSI (K) * (-T (1,3) *COSBC (K) +T (2,3) *COSAC (K) )
FXUI (K) =FRXU (K) +FCXU (K) +FSXU (K)
FYUI (K) =FRYU (K) +FCYU (K) +FSYU (K)
FZUI (K) =FRZU (K) +FCZU (K) +FSZU (K)
45 CONTINUE
C ALIGNING TORQUE CALCULATIONS      5210
C OVER-TURNING MOMENT CALCULATIONS      5220

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C
DO 4280 K=1,2
ALTQ (K)=AFK1*FRI (K)*FSI (K)+SIGN (1. ,FSI (K))*FSI (K)*FSI (K) *AFK2
1 +SIGN (1. ,PHICGI (K))*FRI (K)*SQRT (ABS (PHICGI (K))) *AFK3
OTM (K)=FRI (K)*(OFC1*FSI (K)+OFC2*FSI (K)*ABS (PHICGI (K)))
1 +OFC3*PHICGI (K)
IF (IDULTR.EQ.1) GO TO 4280
KK= K+2
ALTQ (KK)=ARK1*FRI (KK)*FSI (KK)+SIGN (1. ,FSI (KK))*FSI (KK)*FSI (KK)
1*ARK2
1 +SIGN (1. ,PHICGI (KK))*FRI (KK)*SQRT (ABS (PHICGI (KK))) *ARK3
OTM (KK)=FRI (KK)*(ORC1*FSI (KK)+ORC2*FSI (KK)*ABS (PHICGI (KK)))+ORC3
1 *PHICGI (KK)
4280 CONTINUE
C DUAL TIRES ON SOLID REAR AXLE
C IDULTR = 0, NC DUALS
C = 1, DUALS
C
IF (IDULTR.EQ.1) CALL DUAL
C
SALTQ=ALTQ (1)+ALTQ (2)+ALTQ (3)+AITQ (4)
FOTM=OTM (1)+OTM (2)
ROTM=OTM (3)+OTM (4)
C AERODYNAMIC FORCES AND MOMENTS - SFXS,SFYS,SFZS,SNPHIS,SNTHES,SNPSIS
C
IF (IAERO.EQ.1) CALL AERODY
C
SF XU=FXU1+FXU2+FXU3+FXU4+FXU5+FXU6+SFXS
SF YU=FYU1+FYU2+FYU3+FYU4+FYU5+FYU6+SFYS
C ***** COMPUTATION OF MOMENTS*****
ZFDEL1=ZF+DEL1
ZFDEL2=ZF+DEL2
ZRDEL3=ZR+DEL3
ZRDEL4=ZR+DEL4
TFPHIF=TFO2*PHIF
TRPHIR=TRO2*PHIR
C**** LET HCOSG (K)= H (K)*COS GAMMA*H (K)
DO 12 K=1,4
HCOSG (K)= H (K)*COABGH (3,K)
12 CONTINUE
C**** COMPUTE MOMENTS 8=SF SR 9=IF SR 10=IF IR *****
IF (IAX-1) 8,9,10
8 SNPHIU=- (FYUI (1)+FYUI (2))*ZFDEL1- (FYUI (3)+FYUI (4))*ZRDEL3
SNTHIU=FXUI (1)*(ZFDEL1+TFPHIF+HCOSG (1))
1 +FXUI (2)*(ZFDEL1-TFPHIF+HCOSG (2))
1 +FXUI (3)*(ZRDEL3+TRPHIR+HCOSG (3))
1 +FXUI (4)*(ZRDEL3-TRPHIR+HCOSG (4))
C MOMENTS ABOUT SOLID FRCNT AXLE
SNPHIF=FZUI (1)*(TFO2+ H (1)*COABGH (2,1))-FZUI (2)*(TFO2-
1 H (2)*COABGH (2,2))-FYUI (1)*(TFPHIF+HCOSG (1))+
1 FYUI (2)*(TFPHIF-HCOSG (2))+FOTM
C MOMENTS ABOUT SOLID REAR AXLE
13 SNPHIR=FZUI (3)*(TRO2+ H (3)*COABGH (2,3))-
1 FZUI (4)*(TRO2- H (4)*COABGH (2,4))
1 -FYUI (3)*(TRPHIR+HCOSG (3))
1 +FYUI (4)*(TRPHIR-HCOSG (4))+ROTM
GO TO 11
9 SNPHIU=-FYUI (1)*(ZFDEL1+HCOSG (1))-HFC
1 -FYUI (2)*(ZFDEL2+HCOSG (2))-HFC
1 - (FYUI (3)+FYUI (4))*ZRDEL3+FOTM

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    SNTHEU=FXUI (1) * (ZFDEL1+HCOSG (1)) +FXUI (2) * (ZFDEL2+HCOSG (2))
1   +FXUI (3) * (ZRDEL3+TRPHIR+HCOSG (3)) +FXUI (4) * (ZRDEL3-TRPHIR+
1   HCOSG (4))
    GO TO 13
10  SNPHIU=-FYUI (1) * (ZFDEL1+HCOSG (1) -HFC) -FYUI (2) * (ZFDEL2+HCOSG (2)
1   -HFC) -FYUI (3) * (ZRDEL3+HCOSG (3) -HRC)
1   -FYUI (4) * (ZRDEL4+HCOSG (4) -HRC)
1   +POTM+ROTM
    SNTHEU=FXUI (1) * (ZFDEL1+HCOSG (1)) +FXUI (2) * (ZFDEL2+HCOSG (2))
1   +FXUI (3) * (ZRDEL3+HCOSG (3)) +FXUI (4) * (ZRDEL4+HCOSG (4))
11  CONTINUE
    SNPSIU=FYUI (1) * (A+H (1) *COABGH (1,1)) +FYUI (2) * (A+H (2) *COABGH (1,2))
1   -FYUI (3) * (B-H (3) *COABGH (1,3)) -FYUI (4) * (B-H (4) *COABGH (1,4))
1   -FXUI (1) * (TFO2+H (1) *CABGH (2,1)) +FXUI (2) * (TFO2-H (2) *
1   COABGH (2,2)) -FYUI (3) * (TRO2+H (3) *COABGH (2,3)) +FXUI (4) * (TRO2-
1   H (4) *COABGH (2,4)) +SALTQ
    SNTHEU = SNTHEU + SNTHES
    SNPHIU = SNPHIU + SNPHIS
    SNPSIU = SNPSIU + SNPSIS
    IF (IDULTR.NE.1) GO TO 14
    SNPSIU = SNPSIU - FYU5*(B-H (3) *COABGH (1,3)) -
1   FYU6*(B-H (4) *COABGH (1,4)) + (FXU3-FXU4) * (TRO2-TIRO2) -
1   FXU5*(TORO2 + H (3) *COABGH (2,3)) + FXU6*(TORO2 - H (4) *COABGH (2,4))
    SNTHEU = SNTHEU - (FXU3-FXU4) * (TRO2-TIRO2) *PHIR +
1   FXU5*(ZRDEL3+TIRO2*PHIR + HCOSG (3)) + FXU6*(ZRDEL3-TIRO2*PHIR +
1   HCOSG (4))
    SNPHIU = SNPHIU - (FYU5+FYU6) *ZRDEL3
    SNPHIR=2.0 * (FYUI (3) * (TRO2+H (3) *COABGH (2,3))
1   -FYUI (4) * (TRO2-H (4) *COABGH (2,4)))
2   -FYUI (3) * (TIRO2*PHIR+HCOSG (3)) + FYUI (4) * (TIRO2*PHIR-HCOSG (4))
3   - FYU5*(TORO2*PHIR+HCOSG (3)) + FYU6*(TORO2*PHIR-HCOSG (4))
14  CONTINUE
C***** INERTIAS AND GAMMAS *****
ZFDL1=ZFDEL1**2
ZFDL2=ZFDEL2**2
ZRDL3=ZRDEL3**2
ZRDL4=ZRDEL4**2
GO TO (31,32), IAX
C SOLID FRONT AND REAR
AIXP=AMUF*ZFDL1+AMUR*ZRDL3 E
AIYP=AIXP
AIXZP=AMUF*A*ZFDEL1-AMUR*B*ZRDEL3 E
GAM2=AMUF*ZFDEL1+AMUR*ZRDEL3 E
GAM3=GAM2
GAM4=0. E
GAM5=AMUF*A*A+AMUR*B*B E
GAM6=2.*AMUF*DEL1DT+2.*AMUR*DEL3DT E
GAM7=2.*AMUF*DEL1DT*ZFDEL1+2.*AMUR*DEL3DT*ZRDEL3 E
GAM8=0. E
GAM9=AMUF*2.*A*DEL1DT-AMUR*2.*B*DEL3DT E
GO TO 33
31 CONTINUE
C IND FRONT SOLID REAR
AIXP=AMUF/2.*(ZFDL1+ZFDL2)+AMUR*ZRDL3 F
AIYP=AIXP
AIXZP=AMUF*A/2.*(ZFDEL1+ZFDEL2)-AMUR*B*ZRDEL3 F
GAM2=AMUF*(ZF+(DEL1 +DEL2)/2.)*AMUR*ZRDEL3 F
IF (PARAM (276).EQ.11.) GAM2= AMUF*ZF + AMUR*ZR
IF (PARAM (276).EQ.8.) GAM2 = AMUF*ZF + AMUR*ZR
GAM3=GAM2

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GAM4=AMUF*TF/4.*(DEL1 -DEL2)
GAM5=AMUF*(A*A-TFO2**2)+AMUR*B*P
GAM6=AMUF*(DEL1DT+DEL2CT)+2.*AMUR*DEL3DT
GAM7=AMUF*(ZF*(DEL1DT+DEL2DT)+DEL1 *DEL1CT+DEL2*DEL2DT)
1 +2.*AMUR*ZRDEL3*DEL3DT
GAM8=AMUF*TFO2*(DEL1DT-DEL2DT)
GAM9=AMUF*A*(DEL1DT+DEL2DT)-2.*AMUR*B*DEL3DT
IF(PARAM(276).EQ.11.) GO TO 131
IF(PARAM(276).NE.10) GC TO 130
131 CONTINUE
GAM4 = 0.
GAM5 = 0.
GAM6 = 0.
GAM7 = 0.
GAM8 = 0.
GAM9 = 0.
130 CONTINUE
GO TO 33
32 CONTINUE
C IND FRONT AND REAR
AIXP=AMUF/2.*(ZFDL1+ZFCL2)+AMUR/2.*(ZRDL3+ZRDL4)
AIYP=AIXP
AIXZP=AMUF*A/2.*(ZFDEL1+ZFDEL2)-AMUR*B/2.*(ZRDEL3+ZRDEL4)
GAM2=AMUF*(ZF+(DEL1 +DEL2)/2.)*AMUR*(ZR+(DEL3 +DEL4)/2.)
GAM3=GAM2
GAM4=AMUF*TF/4.*(DEL1 -DEL2)+AMUR*TR/4.*(DEL3 -DEL4)
GAM5=AMUF*(A*A-TFO2**2)+AMUR*(B*B-TRO2**2)
GAM6=AMUF*(DEL1DT+DEL2CT)+AMUR*(DEL3DT+DEL4DT)
GAM7=AMUF*(ZF*(DEL1DT+DEL2DT)+DEL1 *DEL1DT+DEL2*DEL2DT)
1 +AMUR*(ZR*(DEL3DT+DEL4DT)+DEL3 *DEL3DT+DEL4*DEL4DT)
GAM8=AMUF*TFO2*(DEL1DT-DEL2DT)+AMUR*TRO2*(DEL3DT-DEL4DT)
GAM9=AMUF*A*(DEL1DT+DEL2DT)-AMUR*B*(DEL3DT+DEL4DT)
33 CONTINUE
C CALCULATION OF STEER AND BRAKE COMMANDS DONE NEXT
CALL STRBRK
C
C *****
C
C IF(NBMP.EQ.0) GO TO 8499
XI(1) = X +A*CPS - TFC2*SPS
XI(2) = X +A*CPS + TFC2*SPS
XI(3) = X -B*CPS - TRO2*SPS
XI(4) = X -B*CPS + TRC2*SPS
NUMBR = NUMBR + 1
DO 8498 I=1,4
DELX(I)=GETDEL(XI,I,PARAM(200),NBMP)
GETDL = GETDL + DELX(I)
8498 CONTINUE
8499 CONTINUE
PTB1=PTBR
PTB2=PTBR
AKK1=1.0
AKK2=1.0
IF(PARAM(60).EQ.1.0) GO TO 4334
CALL PTBAK(BETA1,FR1,AKK1,PTB1)
CALL PTBAK(BETA2,FR2,AKK2,PTB2)
4334 CONTINUE
IF(SWMT.LE.0.) GO TO 4333
FXS1 = (FXU1-FZU1*THS1)*COSFS1+(FYU1+FZU1*PHISA1)*SINPS1
FXS2 = (FXU2-FZU2*THS2)*COSFS2+(FYU2+FZU2*PHISA2)*SINPS2

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6650
6660

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FYS1=(FYU1+FZU1*PHISA1)*COSPS1-(FXU1-FZU1*THS1)*SINPS1
FYS2=(FYU2+FZU2*PHISA2)*COSPS2-(FXU2-FZU2*THS2)*SINPS2
AMT1 = -(YSA1-H(1)          *PSO1)*FXS1-PTE1*COSPS1*FYS1
AMT2 = -(YSA2+H(2)         *PSO2)*FXS2-PTB2*COSPS2*FYS2
4333 CONTINUE
AMT1 = SWMT*AMT1
AMT2 = SWMT*AMT2
C CALCULATION OF ANTI PITCH AND ROLL FORCES
C FOR SOLID AXLE DEL3 IS REAR AXLE VERTICAL ROLL CENTER
C DL3S AND DL4S ARE REAR WHEEL SUSPENSION DEFLECTIONS
AP1 = (CP0F + CP1F*DL1S + CP2F*DL1S*DL1S) * FXUI(1)
AP2 = (CP0F + CP1F*DL2S + CP2F*DL2S*DL2S) * FXUI(2)
AP3 = (CP0R + CP1R*DL3S + CP2R*DL3S*DL3S) * (FXUI(3)+FXU5)
AP4 = (CP0R + CP1R*DL4S + CP2R*DL4S*DL4S) * (FXUI(4)+FXU6)
AR1 = -(CR0F + CR1F*DL1S + CR2F*DL1S*DL1S) * FYUI(1)
AR2 = (CR0F + CR1F*DL2S + CR2F*DL2S*DL2S) * FYUI(2)
AR3 = -(CR0R + CR1R*DL3S + CR2R*DL3S*DL3S) * (FYUI(3)+FYU5)
AR4 = (CR0R + CR1R*DL4S + CR2R*DL4S*DL4S) * (FYUI(4)+FYU6)
FSWF=0.5*AMS*G*B/(A+B)
FSWR=0.5*AMS*G*A/(A+B)
ANTI1=AP1+AR1-FBS1
ANTI2=AP2+AR2-FBS2
ANTI3=AP3+AR3-FBS3
ANTI4=AP4+AR4-FBS4
C *****
C SAMPLE VALUES TO CALCULATE THE COMPARISON VARIABLES
C CALL CVCALC
C *****
C PREPARATION OF VARIABLES TO BE OUTPUT ON D/A CONVERTERS
TM1=1./SM
TEMP=GAM2*TM1
IOUT(01)=-TEMP
TEMP=GAM1*TM1
IOUT(02)=TEMP
IOUT(03)=-TEMP
TEMP=GAM2*TM1
IOUT(04)=-TEMP
TM1=1./(AIX+AIXP)
TEMP=GAM3*TM1
IOUT(05)=TEMP
TEMP=(AIXZ+AIXZP)*TM1
IOUT(06)=TEMP
TEMP=GAM7*TM1
IOUT(07)=-TEMP
TEMP=GAM4*TM1
IOUT(08)=-TEMP
TEMP=SCALE*TM1
IOUT(09)=TEMP
TM1=1./(AIY+AIYP)
TEMP=GAM2*TM1
IOUT(10)=TEMP
TEMP=AIXZ*TM1
IOUT(11)=TEMP
TEMP=AIXZP*TM1
IOUT(12)=TEMP
TEMP=GAM7*TM1
IOUT(13)=-TEMP

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6880
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6950
6960
6970
6980
6990
7000

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TEMP=GAM4*TM1
IOUT(14)=-TEMP
TEMP=SCALE*TM1
IOUT(15)=TEMP
TM1=1./(AIZ+AIZP)
TEMP=(AIXZ+AIXZP)*TM1
IOUT(16)=-TEMP
TEMP=GAM1*TM1
IOUT(17)=-TEMP
TEMP=GAM4*TM1
IOUT(18)=TEMP
TM1=1./(AIWR+AID*ARBR*ARBR/4.)
TM2=1./(AIWF+AIDF*ARFBR*ARFBR/4.)
IOUT(19)=SPINH1/MPHIPS
IOUT(20)=SPINH2/MPHIPS
TEMP=FR3*H(3)*H(3)*SL(3)*TM1/UG3P
IF(IDULTR.EQ.1) TEMP=2.0*TEMP
IOUT(21)=TEMP
TEMP=FR4*H(4)*H(4)*SL(4)*TM1/UG4P
IF(IDULTR.EQ.1) TEMP=2.0*TEMP
IOUT(22)=TEMP
TEMP=FR1*H(1)*H(1)*SL(1)*TM2/UG1P
IOUT(23)=TEMP
TEMP=FR2*H(2)*H(2)*SL(2)*TM2/UG2P
IOUT(24)=TEMP
TEMP = SL(1) + SEP(1)
TEMP=(FR1*H(1)*TEMP+TQFBR)*TM2
IOUT(33)=-TEMP
TEMP = SL(2) + SEP(2)
TEMP=(FR2*H(2)*TEMP+TQFBL)*TM2
IOUT(34)=-TEMP
TEMP = SL(3) + SEP(3)
IF(IDULTR.EQ.1) TEMP=2.0*TEMP
TEMP=(FR3*H(3)*TEMP+TQBRB)*TM1
IOUT(35)=-TEMP
TEMP = SL(4) + SEP(4)
IF(IDULTR.EQ.1) TEMP=2.0*TEMP
TEMP=(FR4*H(4)*TEMP+TQRBL)*TM1
IOUT(36)=-TEMP
TEMP = (AMT2 + ALTQ(2)) / AIFW - RDT
IOUT(25) = -TEMP*PARAM(175)
TEMP=DELSWC
IOUT(26)=TEMP
TM1=1./SM
TEMP=(-GAM6*Q+SFXU)*TM1
IOUT(27)=TEMP
TEMP=(GAM6*P+SPYU)*TM1
IOUT(28)=TEMP
TEMP=(2.*(FSWF+FSWR)-SFZS)/AMS
IOUT(29)=TEMP
TEMP=(1./(AIX+AIXP))*(Q*R*(AIY-AIZ+AIXP)+SNPHIU)
IOUT(30)=TEMP
TEMP=(1./(AIY+AIYP))*(P*R*(AIZ-AIX-AIYP)+SNTHEU)
IOUT(31)=TEMP
TEMP=(1./(AIZ+AIZP))*(P*Q*(AIX-AIY-GAM5)+GAM8*Q
1 +GAM9*P+SNPSIU)
IOUT(32)=TEMP
TEMP=ANTI1
IOUT(38)=TEMP-PSARF
TEMP=ANTI2

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IOUT (39) =TEMP-PSALF
TEMP=ANTI3
IOUT (40) =TEMP-FSARR
TEMP=ANTI4
IOUT (41) =TEMP-PSAIR
C***** SPLIT FRONT AXLE *****
TM1 =2.*HFC/TF
TEMP= (2./AMUF) * (FZU1-FYU1*TM1+FSWF) *PARAM (175)
IOUT (42) =TEMP
TEMP= (2./ (1000.*AMUF) ) * (FZU2+FYU2*TM1+FSWF) *PARAM (175)
IOUT (43) =TEMP
C***** SOLID REAR AXLE *****
TEMP= (1./AMUR) * (FZU3+FZU4)
IF (IDULTR.EQ.1) TEMP = 2.0*TEMP
TEMP= (TEMP+ (2.*FSWR/AMUR) ) *PARAM (175)
IOUT (44) =TEMP
TEMP= (1./ (10.*AIR) ) * (SNPHIR) *PARAM (175)
IOUT (45) =TEMP
IF (IAX.LE.1) GO TO 7719
C***** SPLIT REAR AXLE *****
TM1 = 2.*HRC/TR
TM1 = TAN(TM1)
TEMP= (2./AMUR) * (FZU3-FYU3*TM1+FSWR) *PARAM (175)
IOUT (44) =TEMP
TEMP= (2./ (1000.*AMUR) ) * (FZU4+FYU4*TM1+FSWR) *PARAM (175)
IOUT (45) =TEMP
GO TO 7720
7719 IF (IAX.EQ.1) GO TO 7720
C***** SOLID FRONT AXLE *****
TEMP= (1./AMUF) * (FZU1+FZU2+2.*FSWF) *PARAM (175)
IOUT (42) =TEMP
TEMP= (1./ (10.*AIF) ) * (SNPHIF) *PARAM (175)
IOUT (43) =TEMP
7720 CONTINUE
TEMP = (AMT1 + ALTQ (1) ) / AIFW - RDT
IOUT (46) = -TEMP*PARAM (175)
DO 3147 I=1,48
DACO (I) =BVALUE (DACPLA (I) ) /SCALDC (I)
SDACO=DACO (I)
DACO (I) =AMAX1 (-.9995, (AMIN1 (.9995, DACO (I) ) ) )
IF (SDACO.EQ.DACO (I) ) GC TO 8317
IDACK=IDACK+1
IF (IDACK.GT.10) IDACK=10
IERDAC (IDACK) = I
TERDAC (IDACK) =TIME
8317 CONTINUE
3147 CONTINUE
C DATA COLLECTION FOR TRACK OPTICN
IF (TIME.LT. (ONTIM-.00001) ) GO TO 8185
IF (TIME.GT.OFFTIM) GO TO 8185
IKEEP=IKEEP+1
IF (IKEEP.NE.ISAMP) GO TO 8185
IKEEP=0
DO 8199 I=1,ITRA
J=ITRAA (I)
JIN=JIN+1
IF (JIN.GT.1999) JIN=1999
ATRACK (JIN) =BVALUE (J)
8199 CONTINUE
8185 CONTINUE
RETURN
END

```

```

7740
7750
7760
7770
7780
7790
7800
7810
7820
7830
7840
7850
7860
7870
7880
7890
7900
7910
7920
7930
7940
7950
7960
7970
7980
7990

```

H-2.1.8 LFRIC

Presented here is the Fortran listing for the LFRIC subprogram. The following calculations are performed in LFRIC:

1. Lateral coefficient of friction.
2. Circumferential tire force.
3. Lateral tire force.
4. Circumferential and lateral components of the tire force on the wheel.

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SUBROUTINE LFRIC                                LFR1  10
C THIS SUBROUTINE CALCULATES THE LATERAL FRICTION COEFF.      LFR1  20
C                                                              CLFR1  30
C FUNCTION:  AMUI-MAXIMUM LATERAL FRICTION COEFFICIENT        CLFR1  40
C                                                              CLFR1  50
C INPUTS:    B1- (PARAM (85)),LOAD TERM COEFFICIENT OF LATERAL FRICTION CLFR1  60
C            COEFFICIENT (1/LB)                                CLFR1  70
C            B2- (PARAM (86)),VELOCITY TERM COEFFICIENT OF LATERAL CLFR1  80
C            FRICTION COEFFICIENT (1/MPH)                     CLFR1  90
C            B3- (PARAM (87)),CONSTANT TERM (UNITY)           LFR1  100
C            B4- (PARAM (88)),QUADRATIC LOAD TERM(1/LB**2)    LFR1  110
C            FRI-RADIAL TIRE FORCE (POUNDS)                   CLFR1  120
C            CVI-VELOCITY OF VEHICLE (MPH)                   CLFR1  130
C                                                              CLFR1  140
C OUTPUT:    AMUI-MAXIMUM LATERAL FRICTION COEFFICIENT (UNITY) CLFR1  150
C                                                              CLFR1  160
COMMON/TYRTBL/ FRTBL (7),B3TEL (7),A0TBL (7)                LFR1  170
COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,      LFR1  180
1QDT,PDT, RDT, UDT,VDI,WDT,PHIDT,THEDT,PSILT,XDT,YDT,ZDT,   LFR1  190
1 AKK1,AKK2,                                     THS1,THS2,     LFR1  200
1AMT1,AMT2,SN,SPYU,BIVDT,ETAX,ETAL,                   LFR1  210
1 ZIP (4),PHII (4),                                     LFR1  220
1      U1I (4),BAMI (4),MUP (4),SAMI (4),FI (4),FXUI (4),FYUI (4),GI (4), LFR1  230
1      ALFI (4),BETIP (4),BETIBR (4),SLIPI (4),AM1I (4),AM2I (4),UOI (4), LFR1  240
1      FCI (4),PCIMAX (4),FSI (4),                     LFR1  250
1      ABI (4),BETAI (4),AMUI (4),SNI (4),RMI (4),GBI (4),FRIBR (4),     LFR1  260
1      RWZI (4),ZI (4),FRI (4),                         UI (4),VI (4),WI (4),UGI (4), LFR1  270
1      VGI (4),SINPSI (4),PSII (4),COSPSI (4),UGIP (4),PHICGI (4),CVI (4) LFR1  280
1,ALTQ (4),OTM (4),SALTQ,FCTM,ROIM                     LFR1  290
1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4 LFR1  300
1,DLIS (4),ZIMX (4),FBS1,FBS2,FBS3,FBS4                LFR1  310
1,PHIDMX                                                LFR1  320
COMMON/SP7BLK/N1,N2,IPOT (120),IPOTAD (120),PARAM (400)    LFR1  330
COMMON/COMBLK/ SM,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,TSFO2,
1      TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23
COMMON/SPLTAX/ SPSR3,SPSR4,IA X                          LFR1  390
COMMON/CACATO/EPK1,EPK2,FEE1,FEE2,THE1,THE2              LFR1  400
COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI
EQUIVALENCE                                             LFR1  430
1 (PARAM (34),CA0) , (PARAM (35),CA1) , (PARAM (36),CA2) , LFR1  440
1 (PARAM (37),CA3) , (PARAM (38),CA4) , (PARAM (39),AISW) , LFR1  450
1 (PARAM (85),B1) , (PARAM (86),B2) , (PARAM (87),B3) ,   LFR1  460

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1 (PARAM (88),B4), (PARAM ( 89),DEL1DN), (PARAM ( 90),DEL2DN), LFRI 470
1 (PARAM (242),AKCF), (PARAM (243),AKCR), (PARAM (244),AKSR) , LFRI 480
1 (PARAM (290),ROT), (PARAM (291),RA0), (PARAM (292),RA1), LFRI 490
1 (PARAM (293),RA2), (PARAM (294),RA3), (PARAM (295),RA4) LFRI 500
EQUIVALENCE (PARAM (245),RB1), (PARAM (246),RB2) LFRI 510
1, (PARAM (247),RB3), (PARAM (248),RB4) LFRI 520
IF (PARAM (209).EQ.1.) GO TO 500 LFRI 550
DO 60 K=1,2 LFRI 560
KK = K + 2 LFRI 570
AMUI (K) = (B1*FRI (K) + B2*CVI (K) + E3 + B4*FRI (K) * FRI (K) ) * SNI (K) LFRI 580
RMI (K) = FRI (K) * AMUI (K) LFRI 590
FRIBR (K) = AMIN (FRI (K) , A2T) LFRI 600
ALFI IS THE DENOMINATOR FOR THE BETA BAR CALCULATION LFRI 610
ALFI (K) = CA1*FRIBR (K) * (FRIBR (K) - CA2) - CA20 LFRI 620
IF (ALFI (K)/CA2.GE.0.) ALFI (K) = -1.0E-10 LFRI 630
BETIP (K) = CA23*(CA4-FRIBR (K) ) * FRIBR (K) * PHICGI (K) / (CA4*ALFI (K) ) LFRI 680
IF (RMI (K).EQ.0.) GO TO 610 LFRI 690
BETIBR (K) = ALFI (K) * (BETAI (K) + BETIP (K) ) / (CA2*RMI (K) ) LFRI 700
GO TO 710 LFRI 710
610 BETIBR (K) = 0. LFRI 720
710 CONTINUE LFRI 730
AMUI (KK) = (RB3 + RB1*FRI (KK) + RB2*CVI (KK) + RB4*FRI (KK) * FRI (KK) ) LFRI 740
1 *SNI (KK) LFRI 750
RMI (KK) = FRI (KK) * AMUI (KK) LFRI 760
FRIBR (KK) = AMIN (FRI (KK) , R2T) LFRI 770
ALFI (KK) = RA1*FRIBR (KK) * (FRIBR (KK) - RA2) - RA20 LFRI 780
IF (ALFI (KK)/RA2.GE.0.) ALFI (KK) = 1.0E-10 LFRI 790
BETIP (KK) = RA23*(RA4-FRIBR (KK) ) * FRIBR (KK) * PHICGI (KK) / (RA4*ALFI (KK) ) LFRI 820
IF (RMI (KK).EQ.0.) GO TO 630 LFRI 830
BETIBR (KK) = ALFI (KK) * (BETAI (KK) + BETIP (KK) ) / (RA2*RMI (KK) ) LFRI 840
GO TO 730 LFRI 850
630 BETIBR (KK) = 0. LFRI 860
730 CONTINUE LFRI 870
60 CONTINUE LFRI 880
GO TO 510 LFRI 890
500 CONTINUE LFRI 900
DO 521 K = 1,2 LFRI 910
KK = K + 2 LFRI 920
AMUI (K) = XINT (FRI (K) , FRTBL, B3TBL, 7) * SNI (K) LFRI 930
AMUI (KK) = XINT (FRI (KK) , FRTBL, B3TBL, 7) * SNI (KK) LFRI 940
ALFI (K) = -XINT (FRI (K) , FRTBL, A0TBL, 7) LFRI 950
ALFI (KK) = -XINT (FRI (KK) , FRTBL, A0TBL, 7) LFRI 960
521 CONTINUE LFRI 970
DO 520 K=1,4 LFRI 980
RMI (K) = FRI (K) * AMUI (K) LFRI 990
BETIP (K) = 0. LFRI 1030
BETIBR (K) = 0. LFRI 1040
IF (RMI (K) .EQ.0.) GO TO 530 LFRI 1050
BETIBR (K) = ALFI (K) * (BETAI (K) + BETIP (K) ) / RMI (K) LFRI 1060
530 CONTINUE LFRI 1070
520 CONTINUE LFRI 1080
510 CONTINUE LFRI 1090
DO 11 K=1,4 LFRI 1100
ABI (K) = ABS (BETIBR (K) ) LFRI 1110
IF (ABI (K) .GE.3.) GO TO 10 LFRI 1120
GBI (K) = BETIBR (K) * (1. - THRD*ABI (K) + TWN7*BETIBR (K) **2) LFRI 1130
GO TO 80 LFRI 1140
10 GBI (K) = BETIBR (K) / ABI (K) LFRI 1150
80 CONTINUE LFRI 1160

```

C		CLFRI1170
C	FUNCTION: FCSI-SIDE FORCE SHAPING AS A FUNCTION OF SLIP	CLFRI1180
C		CLFRI1190
C	INPUTS: SAMI- SIDE-SLIP ANGLE (DEGREES)	CLFRI1200
C	GAMF-SIDE FORCE SHAPING FUNCTION AS A FUNCTION OF	CLFRI1210
C	SLIP (UNITY)	CLFRI1220
C	AFA-BRAKING SLIP (UNITY)	CLFRI1230
C	NFA-NUMBER OF DATA PCINTS	CLFRI1240
C		CLFRI1250
C	OUTPUTS: FCSI-LINEARLY ITERPOLATED SIDE FORCE SHAPING FUNCTION	CLFRI1260
C		CLFRI1270
	BAMI (K) = BETAI (K) + BETIP (K)	LFRI1280
	SAMI (K) = BAMI (K) *57.29578	LFRI1290
	FI (K) = FCSI (SAMI (K) ,SLIPI (K))	LFRI1300
	XX = ABS (AMUI (K) *GBI (K))	LFRI1310
	ASNBET = ABS (SIN (BETAI (K))) *SNI (K)	LFRI1320
	GO TO (100,100,110,110) ,K	LFRI1330
100	XXX = (XX - (XX-PARAM (206) *ASNBET) *FI (K)) *SIGN (1. ,GBI (K))	LFRI1340
	GO TO 120	LFRI1350
110	XXX = (XX - (XX-PARAM (207) *ASNBET) *FI (K)) *SIGN (1. ,GBI (K))	LFRI1360
120	CONTINUE	LFRI1370
C	PARAM (306) TO (309) CIRCUM. FRICTION COEF.	LFRI1380
	FSI (K) = FRI (K) * XXX	LFRI1390
11	CONTINUE	LFRI1450
	RETURN	LFRI1460
	END	LFRI1470



H-2.1.9 CFRIC

Presented here is the Fortran listing for the CFRIC subprogram. Calculation of the circumferential friction coefficient is performed in this subprogram.

C	SUBROUTINE CFRIC	CFRI 10
	SUBROUTINE CFRIC	CFRI 20
C	*****	CFRI 30
C	THIS SUBPROGRAM CALCULATES THE CIRCUMFERENTIAL FRICTION	CFRI 40
C	COEFFICIENT	CFRI 50
C	*****	CFRI 60
C	MUP- PEAK BRAKING COEF. CF FRICTION	CFRI 70
C	MUS- SLIDING COEF. OF FRICTION	CFRI 80
C	SII- SLIP RATIO AT WHICH PEAK BRAKING	CFRI 90
C	COEF. OF FRICTION OCCURS	CFRI 100
C		CFRI 110
C	SNI- RATIO OF SIM. VEHICLE SKID NUMBER SURFACE	CFRI 120
C	TO TIRE DATA SKID NUMBER SURFACE	CFRI 130
C		CFRI 140
C	FUNCTION: AM1I-RISE SLOPE OF UXI VS. WHEEL SLIP	CFRI 150
C		CCFRI 160
C	SAMI- SLIP ANGLE (DEGREES)	CFRI 170
C	SI1- (PARAM (182), UNITY)	CCFRI 180
C	SI2- (PARAM (183), UNITY)	CCFRI 190
C	SI3- (PARAM (184), UNITY)	CCFRI 200
C	SI4- (PARAM (185), UNITY)	CFRI 210
C		CCFRI 220
C	OUTPUT: AM1I - UNITY	CFRI 230
	COMMON/CFRC/ SL (4), SEP (4), CFCOEF (4), ARPS (4)	
	COMMON/PAUL/ D1, D2, D3, D4, SFYU, TMP, SNPHIU, SNTHIU, SNPSIU,	CFRI 240
	1QDT, PDT, RDT, UDT, VDT, WDT, PHIDT, THEDT, PSIDT, XDT, YDT, ZDT,	CFRI 250
	1 AKK1, AKK2, THS1, THS2,	CFRI 260
	1AMT1, AMT2, SN, SFXU, BTVDI, ETAX, ETAL,	CFRI 270
	1 ZIP (4), PHII (4),	CFRI 280
	1 U1I (4), BAMI (4), MUP (4), SAMI (4), FI (4), FXUI (4), FYUI (4), GI (4),	CFRI 290
	1 ALFI (4), BETIP (4), BETIBR (4), SLIPI (4), AM1I (4), AM2I (4), UOI (4),	CFRI 300
	1 FCI (4), FCIMAX (4), FSI (4),	CFRI 310
	1 ABI (4), BETAI (4), AMUI (4), SNI (4), RMI (4), GBI (4), FRIBR (4),	CFRI 320
	1 RWZI (4), ZI (4), FRI (4), UI (4), VI (4), WI (4), UGI (4),	CFRI 330
	1 VGI (4), SINPSI (4), PSII (4), COSPSI (4), UGIP (4), PHICGI (4), CVI (4)	CFRI 340
	1, ALTQ (4), OTM (4), SALTQ, FOTM, ROTM	CFRI 350
	1, AP1, AP2, AP3, AP4, AR1, AR2, AR3, AR4, ANTI1, ANTI2, ANTI3, ANTI4	CFRI 360
	1, DLIS (4), ZIMX (4), FBS1, FBS2, FBS3, FBS4	CFRI 370
	1, PHIDMX	CFRI 380
	COMMON/VARS/P, Q, R, U, V, W, X, Y, Z, THE, PHI, PSI	
	COMMON/SP7BLK/N1, N2, IPOT (120), IPOTAD (120), PARAM (400)	CFRI 410
	REAL*4 MUSF, MUSR	CFRI 420
	REAL*4 MUS (2), APF (2), APR (2), IOU (48), MUP, SII (4)	CFRI 430
	EQUIVALENCE (PARAM (182), SII (1)), (PARAM (351), IOU (1))	CFRI 440
	EQUIVALENCE (PARAM (202), APF (1)), (PARAM (204), APR (1)),	CFRI 450
	1 (PARAM (206), MUS (1))	CFRI 460
	EQUIVALENCE (APF (1), APF1), (APR (1), APR1),	CFRI 470
	1 (APF (2), APF2), (APR (2), APR2)	CFRI 480
	EQUIVALENCE (BCON, PARAM (208))	CFRI 490
	DO 13 K=1, 2	CFRI 500
	KK=K+2	CFRI 510
	MUP(K) = APF1 + APF2*FRI(K)	CFRI 520
	MUSF = MUS (1) + PARAM (210)*FRI(K)	

```

MUSF = MUSF *ABS(COS(BETAI(K)))
AM1I(K) = (MUP(K)/SII(K))*(1. - BCON*ABS(SAMI(K)))
C ** MUS(1) EQUALS MUSF, MUS(2) EQUALS MUSR **
IF((AM1I(K)*SII(K).LT.MUSF) AM1I(K) = MUSF/SII(K)
IF(SLIPI(K).GT.SII(K)) GO TC 71
AM1I(K) = AM1I(K) * SNI(K)
SL(K) = AM1I(K)
SEP(K) = 0.
GO TO 72
71 CONTINUE
AM2I(K) = (MUSF - (AM1I(K)*SII(K)))/(1. - SII(K))
AM2I(K) = AM2I(K) * SNI(K)
SL(K) = AM2I(K)
C OUTPUT: U1I-VALUE OF UXI AT BRAKE SLIP = 1. (UNITY)
U1I(K) = MUSF * SNI(K)
C OUTPUT: U0I-INTERCEPT OF UXI AT BRAKE SLIP = 0 (UNITY)
U0I(K) = U1I(K) - AM2I(K)
SEP(K) = U0I(K)
72 CONTINUE
MUP(KK) = APR1 + APR2 * FRI(KK)
MUSR = MUS(2) + PARAM(211)*FRI(KK)
MUSR = MUSR *ABS(COS(BETAI(KK)))
AM1I(KK) = (MUP(KK)/SII(KK))*(1. - BCON*ABS(SAMI(KK)))
IF((AM1I(KK)*SII(KK).LT.MUSR) AM1I(KK) = MUSR/SII(KK)
IF(SLIPI(KK).GT.SII(KK)) GO TC 76
AM1I(KK) = AM1I(KK) * SNI(KK)
SL(KK) = AM1I(KK)
SEP(KK) = 0.
GO TO 77
76 CONTINUE
AM2I(KK) = (MUSR - (AM1I(KK)*SII(KK)))/(1. - SII(KK))
AM2I(KK) = AM2I(KK) * SNI(KK)
SL(KK) = AM2I(KK)
U1I(KK) = MUSR * SNI(KK)
U0I(KK) = U1I(KK) - AM2I(KK)
SEP(KK) = U0I(KK)
77 CONTINUE
13 CONTINUE
DO 10 K=1,4
CFCOEF(K) = SL(K)*SLIPI(K) + SEP(K)
FCI(K) = -CFCOEF(K)*FRI(K)
FCIMAX(K) = -FRI(K)*AM1I(K)*SII(K)
10 CONTINUE
RETURN
END

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CFRI 540
CFRI 550
CFRI 560
CFRI 570
CFRI 580
CFRI 630
CFRI 640
CFRI 650
CFRI 660
CFRI 680
CFRI 690
CFRI 700
CFRI 710
CFRI 730
CFRI 740
CFRI 760
CFRI 770
CFRI 780
CFRI 790
CFRI 820
CFRI 830
CFRI 840
CFRI 850
CFRI 870
CFRI 880
CFRI 900
CFRI 910
LPRI1440
CFRI 920
CFRI 930

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H-2.1.10 DUAL

Presented here is the Fortran listing for the DUAL tire subprogram. Calculation of dual rear tire digital model equations is performed in this subprogram.

C	SUBROUTINE DUAL	DUAL 10
	SUBROUTINE DUAL	DUAL 20
	COMMON/TYRTBL/ FRTBL (7) ,B3TBL (7) ,A0TBL (7)	
	COMMON/DULVAR/Z3ID ,Z4ID ,Z5OD ,Z6CD ,	DUAL 30
1	F3RID ,F4RID ,F5ROD ,F6ROD ,	DUAL 40
1	U3ID ,U4ID ,U5OD ,U6OD ,	DUAL 50
1	V3ID ,V4ID ,V5OD ,V6CD ,	DUAL 60
1	W3ID ,W4ID ,W5OD ,W6OD ,	DUAL 70
1	UG3ID ,UG4ID ,UG5OD ,UG6OD ,	DUAL 80
1	VG3ID ,VG4ID ,VG5OD ,VG6OD ,	DUAL 90
1	UG3IDP ,UG4IDP ,UG5ODP ,UG6ODP ,	DUAL 100
1	S3ID ,S4ID ,S5OD ,S6OD ,	DUAL 110
1	CF3ID ,CF4ID ,CF5OD ,CF6OD ,	DUAL 120
1	AMUI3 ,AMUI4 ,AMUI5 ,AMUI6 ,	DUAL 130
1	ALTQ3P ,ALTQ4P ,	DUAL 140
1	OTM3P ,OTM4P ,OTM5 ,OTM6	DUAL 150
	COMMON/DUALS/IDULTR ,NWHEEL ,TIRO2 ,TORO2 ,TIRTOR ,VBRZRP ,	DUAL 160
1	FXU5 ,FXU6 ,FYU5 ,FYU6 ,AITQ5 ,ALTQ6 ,FSI3 ,FSI4 ,FSI5 ,FSI6 ,PPHIR	DUAL 170
	COMMON/XBS/XB (30) ,NS (4 ,30) ,DELX (4) ,XI (4) ,NNN	DUAL 180
	COMMON/PAUL/ D1 ,D2 ,D3 ,D4 ,SFYU ,TMP ,SNPHIU ,SNTHEU ,SNPSIU ,	DUAL 190
1	QDT ,PDT ,RDT ,UDT ,VDT ,WDT ,PHIDT ,THEDT ,PSIDT ,XDT ,YDT ,ZDT ,	DUAL 200
1	AKK1 ,AKK2 , THS1 ,THS2 ,	DUAL 210
1	AMT1 ,AMT2 ,SN ,SFXU ,BTVDT ,ETAX ,ETAL ,	DUAL 220
1	ZIP (4) ,PHII (4) ,	DUAL 230
1	UII (4) ,BAMI (4) ,MUP (4) ,SAMI (4) ,FI (4) ,FXUI (4) ,FYUI (4) ,GI (4) ,	DUAL 240
1	ALFI (4) ,BETIP (4) ,BETIBR (4) ,SLIPI (4) ,AM1I (4) ,AM2I (4) ,UOI (4) ,	DUAL 250
1	FCI (4) ,FCIMAX (4) ,FSI (4) ,	DUAL 260
1	ABI (4) ,BETAI (4) ,AMUI (4) ,SNI (4) ,RMI (4) ,GBI (4) ,FRIBR (4) ,	DUAL 270
1	RWZI (4) ,ZI (4) ,FRI (4) , UI (4) ,VI (4) ,WI (4) ,UGI (4) ,	DUAL 280
1	VGI (4) ,SINPSI (4) ,PSII (4) ,COSPSI (4) ,UGIP (4) ,PHICGI (4) ,CVI (4)	DUAL 290
1	,ALTQ (4) ,OTM (4) ,SALTQ ,FOTM ,ROTM	DUAL 300
1	,AP1 ,AP2 ,AP3 ,AP4 ,AR1 ,AR2 ,AR3 ,AR4 ,ANTI1 ,ANTI2 ,ANTI3 ,ANTI4	DUAL 310
1	,DLIS (4) ,ZIMX (4) ,FBS1 ,FES2 ,FBS3 ,FBS4	DUAL 320
1	,PHIDMX	DUAL 330
	COMMON/VARS/ P ,Q ,R ,U ,V ,W ,X ,Y ,Z ,THE ,PHI ,PSI	
	COMMON/COMBLK/ SM ,CIP ,CIVP ,BZF ,RZR ,A2T ,CA20 ,CA23 ,TSFO2 ,	
1	TRO2 ,TFO2 ,TSO2 ,G ,THRD ,TWN7 ,R2T ,RA20 ,RA23	
	COMMON/CFRC/ SL (4) ,SEP (4) ,CFCCEF (4) ,ARPS (4)	
	COMMON/SP7BLK/N1 ,N2 ,IPOT (120) ,IPOTAD (120) ,PARAM (400)	DUAL 410
	COMMON/ADCOU/ DEL1DT ,DEL2DT ,DEL3DT ,DEL1 ,DEL2 ,DEL3 ,PHIRD ,PHIR ,	
2	DELFW1 ,DELFW2 ,S1P ,S2P ,S3P ,S4P	
	REAL*4 AKTI (4) ,IOUT (48)	DUAL 420
	EQUIVALENCE	DUAL 430
1	(PARAM (5) ,ZR) , (PARAM (7) ,B) ,	
1	(PARAM (31) ,RW) ,	DUAL 440
1	(PARAM (79) ,AKTI (3)) , (PARAM (80) ,AKTI (4)) ,	DUAL 450
1	(PARAM (245) ,RB1) , (PARAM (246) ,RB2) ,	DUAL 460
1	(PARAM (247) ,RB3) , (PARAM (248) ,RB4) ,	DUAL 470
1	(PARAM (252) ,ARK1) , (PARAM (253) ,ARK2) , (PARAM (254) ,ARK3) ,	DUAL 480
1	(PARAM (259) ,ORC0) , (PARAM (260) ,ORC1) , (PARAM (261) ,ORC2) ,	DUAL 490
1	(PARAM (262) ,ORC3) , (ARPS3 ,ARPS (3)) , (ARPS4 ,ARPS (4))	
	Z3ID=ZI (3) +TIRTOR*(PHI+PHIR)	DUAL 520
	Z4ID=ZI (4) -TIRTOR*(PHI+PHIR)	DUAL 530

Z50D=ZI (3) -TIRTOR* (PHI+PHIR)	DUAL 540
Z60D=ZI (4) +TIRTOR* (PHI+PHIR)	DUAL 550
RWZD3 = RW + Z3ID	
RWZD4 = RW + Z4ID	
RWZD5 = RW + Z50D	
RWZD6 = RW + Z60D	
F3RID = AKTI (3) *RWZD3	
F4RID = AKTI (4) *RWZD4	
F5ROD = AKTI (3) *RWZD5	
F6ROD = AKTI (4) *RWZD6	
IF (RWZD3.LE.0.) F3RID = 0.	
IF (RWZD4.LE.0.) F4RID = 0.	
IF (RWZD5.LE.0.) F5ROD = 0.	
IF (RWZD6.LE.0.) F6ROD = 0.	
U3ID=UI (3) -TIRTOR*R	DUAL 640
U4ID=UI (4) +TIRTOR*R	DUAL 650
U50D=UI (3) +TIRTOR*R	DUAL 660
U60D=UI (4) -TIRTOR*R	DUAL 670
V3ID = VBRZRP + Z3ID*PFHIR	DUAL 680
V4ID = VBRZRP + Z4ID*PFHIR	DUAL 690
V50D = VBRZRP + Z50D*PFHIR	DUAL 700
V60D = VBRZRP + Z60D*PFHIR	DUAL 710
W3ID=WI (3) +TIRTOR*PPHIR	DUAL 720
W4ID=WI (4) -TIRTOR*PPHIR	DUAL 730
W50D=WI (3) -TIRTOR*PPHIR	DUAL 740
W60D=WI (4) +TIRTOR*PPHIR	DUAL 750
UG3ID = U3ID + THE*W3ID	DUAL 760
UG4ID = U4ID + THE*W4ID	DUAL 770
UG50D = U50D + THE*W50D	DUAL 780
UG60D = U60D + THE*W60D	DUAL 790
VG3ID = V3ID - PHI*W3ID	DUAL 800
VG4ID = V4ID - PHI*W4ID	DUAL 810
VG50D = V50D - PHI*W50D	DUAL 820
VG60D = V60D - PHI*W60D	DUAL 830
UG3IDP = UG3ID*COSP SI (3) + VG3ID*SINPSI (3)	DUAL 840
UG4IDP = UG4ID*COSP SI (4) + VG4ID*SINPSI (4)	DUAL 850
UG50DP = UG50D*COSP SI (3) + VG50D*SINPSI (3)	DUAL 860
UG60DP = UG60D*COSP SI (4) + VG60D*SINPSI (4)	DUAL 870
S3ID = 1. + (ARPS3*Z3ID)/UG3IDP	DUAL 880
IF (S3ID.LT. (-1.) .OR. S3ID.GT.1.) S3ID = SIGN (1., S3ID)	DUAL 890
IF (S3ID.LE.0.0001) S3ID=0.	
S4ID = 1. + (ARPS4*Z4ID)/UG4IDP	DUAL 900
IF (S4ID.LT. (-1.) .OR. S4ID.GT.1.) S4ID = SIGN (1., S4ID)	DUAL 910
IF (S4ID.LE.0.0001) S4ID=0.	
S50D = 1. + (ARPS3*Z50D)/UG50DP	DUAL 920
IF (S50D.LT. (-1.) .OR. S50D.GT.1.) S50D = SIGN (1., S50D)	DUAL 930
IF (S50D.LE.0.0001) S50D=0.	
S60D = 1. + (ARPS4*Z60D)/UG60DP	DUAL 940
IF (S60D.LT. (-1.) .OR. S60D.GT.1.) S60D = SIGN (1., S60D)	DUAL 950
IF (S60D.LE.0.0001) S60D=0.	
CF3ID = SEP (3) + S3ID*SL (3)	
CF4ID = SEP (4) + S4ID*SL (4)	
CF50D = SEP (3) + S50D*SL (3)	
CF60D = SEP (4) + S60D*SL (4)	
IF (PARAM (209).EQ.1.) GO TO 500	
AMUI3 = (RB3 + RB1*F3RID + RB4*F3RID*F3RID) * SNI (3)	DUAL 1000
AMUI4 = (RB3 + RB1*F4RID + RB4*F4RID*F4RID) * SNI (4)	DUAL 1010
AMUI5 = (RB3 + RB1*F5ROD + RB4*F5ROD*F5ROD) * SNI (3)	DUAL 1020
AMUI6 = (RB3 + RB1*F6ROD + RB4*F6ROD*F6ROD) * SNI (4)	DUAL 1030
GO TO 510	

500 CONTINUE

AMUI3 = XINT (F3RID, FRTEL, B3TBL, 7) \*SNI (3)  
AMUI4 = XINT (F4RID, FRTEL, B3TBL, 7) \*SNI (4)  
AMUI5 = XINT (F5ROD, FRTEL, B3TBL, 7) \*SNI (3)  
AMUI6 = XINT (F6ROD, FRTEL, B3TBL, 7) \*SNI (4)

510 CONTINUE

XX3=ABS (AMUI3\*GBI (3)) DUAL1040  
XX4=ABS (AMUI4\*GBI (4)) DUAL1050  
XX5=ABS (AMUI5\*GBI (3)) DUAL1060  
XX6=ABS (AMUI6\*GBI (4)) DUAL1070  
ASNBT4=ABS (SIN (BETAI (4))) \*SNI (4)\*PARAM (207) DUAL1080  
ASNBT3=ABS (SIN (BETAI (3))) \*SNI (3)\*PARAM (207) DUAL1090  
SIGNB3=SIGN (1., GBI (3)) DUAL1100  
SIGNB4=SIGN (1., GBI (4)) DUAL1110  
XXX3=(XX3-(XX3-ASNBT3)\*FI (3)) \*SIGNB3 DUAL1120  
XXX4=(XX4-(XX4-ASNBT4)\*FI (4)) \*SIGNB4 DUAL1130  
XXX5=(XX5-(XX5-ASNBT3)\*FI (3)) \*SIGNB3 DUAL1140  
XXX6=(XX6-(XX6-ASNBT4)\*FI (4)) \*SIGNB4 DUAL1150  
FYUI (3) = F3RID\* (-PHI-CF3ID\*SINPSI (3)) + COSPSI (3)\*XXX3 DUAL1160  
FYUI (4) = F4RID\* (-PHI-CF4ID\*SINPSI (4)) + COSPSI (4)\*XXX4 DUAL1170  
FYU5 = F5ROD\* (-PHI-CF5CD\*SINPSI (3)) + COSPSI (3)\*XXX5 DUAL1180  
FYU6 = F6ROD\* (-PHI-CF6CD\*SINPSI (4)) + COSPSI (4)\*XXX6 DUAL1190  
FSI3 = F3RID\*XXX3 DUAL1200  
FSI4 = F4RID\*XXX4 DUAL1210  
FSI5 = F5ROD\*XXX5 DUAL1220  
FSI6 = F6ROD\*XXX6 DUAL1230  
FXUI (3) = F3RID\* (THE-CF3ID\*COSPSI (3)) - SINPSI (3)\*XXX3 DUAL1240  
FXUI (4) = F4RID\* (THE-CF4ID\*COSPSI (4)) - SINPSI (4)\*XXX4 DUAL1250  
FXU5 = F5ROD\* (THE-CF5CD\*COSPSI (3)) - SINPSI (3)\*XXX5 DUAL1260  
FXU6 = F6ROD\* (THE-CF6OD\*COSPSI (4)) - SINPSI (4)\*XXX6 DUAL1270  
C PHICG3=PHICG4=PHICG5=PHICG6=0.0 DUAL1280  
ALTQ3P=ARK1\*F3RID\*FSI3+SIGN (1., FSI3) \*FSI3\*FSI3\*ARK2 DUAL1290  
1 +SIGN (1., PHICGI (3)) \*F3RID\*SQR (ABS (PHICGI (3))) \*ARK3  
ALTQ4P=ARK1\*F4RID\*FSI4+SIGN (1., FSI4) \*FSI4\*FSI4\*ARK2 DUAL1300  
1 +SIGN (1., PHICGI (4)) \*F4RID\*SQR (ABS (PHICGI (4))) \*ARK3  
ALTQ5=ARK1\*F5ROD\*FSI5+SIGN (1., FSI5) \*FSI5\*FSI5\*ARK2 DUAL1310  
1 +SIGN (1., PHICGI (3)) \*F5ROD\*SQR (ABS (PHICGI (3))) \*ARK3  
ALTQ6=ARK1\*F6ROD\*FSI6+SIGN (1., FSI6) \*FSI6\*FSI6\*ARK2 DUAL1320  
1 +SIGN (1., PHICGI (4)) \*F6ROD\*SQR (ABS (PHICGI (4))) \*ARK3  
ALTQ (3) = (ALTQ3P+ALTQ5) DUAL1330  
ALTQ (4) = (ALTQ4P+ALTQ6) DUAL1340  
OTM3P=F3RID\*ORC1\*FSI3 DUAL1350  
1 + (ORC2\*FSI3\*ABS (PHICGI (3)) +ORC3\*PHICGI (3)) \*F3RID  
OTM4P=F4RID\*ORC1\*FSI4 DUAL1360  
1 + (ORC2\*FSI4\*ABS (PHICGI (4)) +ORC3\*PHICGI (4)) \*F4RID  
OTM5= F5ROD\*ORC1\*FSI5 DUAL1370  
1 + (ORC2\*FSI5\*ABS (PHICGI (3)) +ORC3\*PHICGI (3)) \*F5ROD  
OTM6= F6ROD\*ORC1\*FSI6 DUAL1380  
1 + (ORC2\*FSI6\*ABS (PHICGI (4)) +ORC3\*PHICGI (4)) \*F6ROD  
OTM (3) = (OTM3P+OTM5) DUAL1390  
OTM (4) = (OTM4P+OTM6) DUAL1400  
RETURN DUAL1410  
END DUAL1420

H-2.1.11 AERODY

Presented here is the Fortran listing for the aerodynamic subprogram. Calculation of the aerodynamic forces and moments is performed in this subprogram.

```

C      SUBROUTINE AERODY                                     & 9  1
      SUBROUTINE AERODY                                     AERO 20
C*****AERODY*****AERO 30
C      THIS SUBPROGRAM CALCULATES THE AERODYNAMIC FORCES AND MOMENTS AERO 40
C      WHICH ACT DIRECTLY ON THE SPRUNG MASS AERO 50
C*****AERODY*****AERO 60
      COMMON/SP7BLK/N1,N2,IPCT(120),IPOTAD(120),PARAM(400) AERO 70
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI AERO 80
      COMMON/AERVAR/UR,VR,WR,PBAR,QBAR,RBAR,VCW,ALPHAC,TAUC,QA,QASF, AERO 90
1      CXC,CYC,CZC,CLC,CMC,CNC,DELCCX AERO 100
      COMMON/AERO/SFYS,SFZS,SNTHES,SNPHIS,SNPSIS,APLUSB,IAERO AERO 110
      COMMON/AROTBS/TAU(40),CX(40),CY(40),CZ(40),CL(40), AERO 120
1      CM(40),CN(40),ALPHA(40),DELCCX(40),NAERO,NDCX,
1      XWP(20),VYWTB(20),NWP
      EQUIVALENCE AERO 150
1      (PARAM(142),VYW),(PARAM(143),OMXW), AERO 160
1      (PARAM(144),OMZW),(PARAM(145),RHOA),(PARAM(146),CYP), AERO 170
1      (PARAM(147),CYR),(PARAM(148),CZAL),(PARAM(149),CZQ), AERO 180
1      (PARAM(150),CLP),(PARAM(151),CLR),(PARAM(152),CMAL), AERO 190
1      (PARAM(153),CMQ),(PARAM(154),CNP),(PARAM(155),CNR), AERO 200
1      (PARAM(156),SF),(PARAM(157),VL),(PARAM(158),RWV) AERO 210
      EQUIVALENCE (PARAM(06),A),(PARAM(07),B),(PARAM(71),HCG) AERO 220
      WBL=A+B AERO 230
      DCG=A-WBL/2. AERO 240
C      CROSS WIND DISTURBANCE AERO 250
      VYW=0.0 AERO 260
      IF((X.LT.XWP(1)).OR.(X.GT.XWP(NWP)))GO TO 100 AERO 270
      VYW=XINT(X,XWP,VYWTB,NWP) AERO 280
100  CONTINUE AERO 290
      UR = U -VYW*SIN(PSI) AERO 300
      VR = V -VYW*COS(PSI) AERO 310
      WR = W AERO 320
      PBAR = (P - OMXW*COS(PSI) + OMZW*THE) * APLUSB/UR AERO 330
      QBAR = (Q + OMXW*SIN(PSI) - OMZW*PHI) * APIUSB/UR AERO 340
      RBAR = (R - OMZW) * APLUSB/UR AERO 350
      VCW = SQRT(UR*UR + VR*VR + WR*WR) AERO 360
      ALPHAC = ATAN(WR/UR) AERO 370
      TAUC = ARSIN(VR/VCW)
      IF(UR.GE.0.) GO TO 110
      IF(VR) 120,121,122
120  TAUC = TAUC -1.5708
      GO TO 110
121  TAUC = -3.14159
      GO TO 110
122  TAUC = TAUC + 1.5708
110  CONTINUE
      QA = (RHOA * VCW*VCW)/2. AERO 390
      CXC = XINT(TAUC,TAU,CX,NAERC)
      CYC = XINT(TAUC,TAU,CY,NAERC)
      CZC = XINT(TAUC,TAU,CZ,NAERC)
      CLC = XINT(TAUC,TAU,CL,NAERC)
      CMC = XINT(TAUC,TAU,CM,NAERC)

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CNC = XINT(TAUC,TAU,CN,NAERC)	
DELCXC = XINT(ALPHAC,ALPHA,DELXC,NDCX)	AERO 460
AERODYNAMIC FORCES AND MOMENTS	AERO 470
QASF = QA*SF	AERO 480
SFYS = (CXC + DELCXC) * QASF	AERO 490
SPYS = (CYC + CYP*PBAR + CYR*RBAR) * QASF	AERO 510
SFZS = (CZC + CZAL*ALPHAC + CZQ*QBAR) * QASF	AERO 520
SNPHIS=(VL*CLC+HCG*CYC)*QASF	AERO 540
SNTHES=(VL*CMC-DCG*CZC-HCG*CXC) *QASF	
SNPSIS=(VL*CNC+DCG*CYC) *QASF	AERO 560
RETURN	AERO 570
END	AERO 580

H-2.1.12 STRBRK

Presented here is the Fortran listing for the steer and brake subprogram. Calculation of the steering and braking commands is performed in this subprogram.

```

C      SUBROUTINE STRBRK                                STRB 10
      SUBROUTINE STRBRK                                STRB 20
C*****STRB 30
C      STEERING AND BRAKING CCMMANDS CALCULATED      STRB 40
C*****STRB 50
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU, STRB 60
      1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT, STRB 70
      1 AKK1,AKK2, THS1,THS2, STRB 80
      1AMT1,AMT2,SN,SFXU,BTVDT,ETAX,ETAL, STRB 90
      1 ZIP (4) ,PHII (4) , STRB 100
      1 U1I (4) ,BAMI (4) ,MUP (4) ,SAMI (4) ,FI (4) ,FXUI (4) ,FYUI (4) ,GI (4) , STRB 110
      1 ALFI (4) ,BETIP (4) ,BETIBR (4) ,SLIPI (4) ,AM1I (4) ,AM2I (4) ,UOI (4) , STRB 120
      1 FCI (4) ,FCIMAX (4) ,FSI (4) , STRB 130
      1 ABI (4) ,BETAI (4) ,AMUI (4) ,SNI (4) ,RMI (4) ,GBI (4) ,FRIBR (4) , STRB 140
      1 RWZI (4) ,ZI (4) ,PRI (4) , UI (4) ,VI (4) ,WI (4) ,UGI (4) , STRB 150
      1 VGI (4) ,SINPSI (4) ,PSII (4) ,COSPSI (4) ,UGIP (4) ,PHICGI (4) ,CVI (4) STRB 160
      1,ALTQ (4) ,OTM (4) ,SALTQ,FCIM,ROIM STRB 170
      1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4 STRB 180
      1,DLIS (4) ,ZIMX (4) ,FBS1,FBS2,FBS3,FBS4 STRB 190
      1,PHIDMX STRB 200
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMX,TQFMAX,PSIMAX,ONER STRB 230
      COMMON/DELS/DELSWC STRB 240
      COMMON/UVW/VC,UIN STRB 250
      COMMON/ZILCH/TQMAXF,TQMAXR,AKTQF,AKTQR,TQDRF,TQDRR,IDRSW STRB 260
      COMMON/TIMBLK/JJTIME,TIME,DT STRB 270
      COMMON/SP7BLK/N1,N2,IPCT (120) ,IPOTAD (120) ,PARAM (400) STRB 280
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX STRB 290
      COMMON/STRFUN/ NST,STRIM (20) ,STEER (20)
      COMMON/SPINS/ARPSDT (4) ,PF,PFR,AVRPS (4) ,AVRPSD (4) ,
      1 ARPSD (4) ,ARPSDH (4) ,HDOT (4)
      COMMON/BRAKE/TQFBL,TQREL
      COMMON/PRESS/PRF,PLF,PRR,PLR
      COMMON/CNTROL/ EPSDSW,EPSTQR,EPDSWI,EPTQRI,ALAMDA
      COMMON/TOM/ COSABG (12) ,COABGH (12) ,COSAC (4) ,COSBC (4) ,COSAR (4) ,
      1COSBR (4) ,COSGR (4) ,PSIP (4) ,HCOSG (4) ,T (9) ,XYZDOT (3)
      2 , SINPHI (4) ,COSPHI (4)
      DATA RAD/0.1745329E-1/ STRB 300
      EQUIVALENCE (PARAM (118) ,CS) , (PARAM (123) ,DSW) , (PARAM (121) ,PFL) , STRB 310
      1 (PARAM (117) ,CGAM) , (PARAM (55) ,PTBR) , (PARAM (62) ,ARFBR) , STRB 320
      1 (PARAM (122) ,TTD) , (PARAM (124) ,TSW) , (PARAM (115) ,TST) , STRB 330
      1 (PARAM (119) ,TQRER) , (PARAM (233) ,ALAMBD) STRB 340
      EQUIVALENCE (TQFBR,PARAM (120) ) , (DSWCM,PARAM (114) ) STRB 350
      EQUIVALENCE (PARAM (108) ,FREQ) STRB 360
C      PARAM (218) > .5, DRIVE TORQUE AND STEERING COMMANDS ARE
C      GENERATED FOR STEADY STATE WINDS
      IF (PARAM (218) .GT. 0.5) GO TO 8999
C      KELSEY-HAYES ANTI-LOCK SYSTEM
C      IALS = 0, DISABLE
C      = 1, ENABLE
      IALS=PARAM (23) +0.5
      DSLM=PARAM (114) /PARAM (116) STRB 370
      XTMP=PARAM (121) /PARAM (192) STRB 380

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	IF (PARAM (126) .NE.0.0) GC TO 4321	STRB 390
	IF (TIME.GT.TST) GO TO 6000	STRB 400
	DELSWC=0.0	STRB 410
	GO TO 7000	STRB 420
6000	DELSWC=(TIME-TST)*DSLM	STRB 430
	IF (ABS (DELSWC) .GT.DSWCM) DELSWC=DSWCM*SIGN (1.0,DELSWC)	STRB 440
	IF (PARAM (128) .EQ.3.0) GC TO 7000	STRB 450
	IF ( TIME.GT.4.5 ) DELSWC=DSWCM*(5.5-TIME)*SIGN (1.0,DELSWC)	STRB 460
7000	DELSWC=DELSWC*RAD	STRB 470
	PF=0.0	STRB 480
	IF (TIME.LT.TTD) GO TO 4444	STRB 490
	PF=(TIME-CGAM)*XTMP	STRB 500
	IF (PARAM (128) .EQ.1.0) GC TO 2223	STRB 510
	IF (PARAM (128) .EQ.3.0) GO TO 2223	STRB 520
2222	IF (PF.GT.PFL) PF=PFL	STRB 530
	IF (TIME.LT.CGAM) PF=0.0	STRB 540
	PFR=(TIME-CS)*XTMP	STRB 550
	IF ( TIME.GT.CS ) PF=PF*(CS-TIME)/10.	STRB 560
	IF (TIME.LT.CS) PFR=0.0	STRB 570
	IF (PFR.GT.PFL) PFR=PFL	STRB 580
	IF ( TIME.GT.CS ) PFR=PFR*(CS-TIME)/10.	STRB 590
C		CSTRB 600
C	FUNCTION: FF-FRONT WHEEL BRAKE TORQUE AS A FUNCTION OF FRONT	CSTRB 610
C	BRAKE LINE PRESSURE	CSTRB 620
C		CSTRB 630
C	INPUTS: PFR-FRONT WHEEL BRAKE LINE PRESSURE (PSI)	CSTRB 640
C	PBF-BRAKE LINE PRESSURE (PSI), ABSISSA USED IN LINEAR	CSTRB 650
C	INTERPOLATION SUBROUTINE	CSTRB 660
C	TQBF-FRONT WHEEL BRAKE TORQUE (INCH-POUNDS), ORDINATE USED	CSTRB 670
C	IN LINEAR INTERPOLATION SUBROUTINE	CSTRB 680
C		CSTRB 690
C	OUTPUTS: FF-INTERPOLATED FRONT WHEEL BRAKE TORQUE AS A FUNCTION	CSTRB 700
C	OF FRONT BRAKE LINE PRESSURE	CSTRB 710
C		CSTRB 720
C		CSTRB 740
C	FUNCTION: FR-REAR WHEEL BRAKE TORQUE AS A FUNCTION OF REAR BRAKE	CSTRB 750
C	LINE PRESSURE	CSTRB 760
C		CSTRB 770
C	INPUTS: PFR-BRAKE LINE PRESSURE (PSI)	CSTRB 780
C	PBR-BRAKE LINE PRESSURE (PSI), ABSISSA	CSTRB 790
C	TQBR-REAR WHEEL BRAKE TORQUE (INCH-POUNDS), ORDINATE	CSTRB 800
C		CSTRB 810
C	OUTPUT: FR-INTERPOLATED REAR WHEEL BRAKE TORQUE AS A FUNCTION	CSTRB 820
C	OF REAR BRAKE LINE PRESSURE	CSTRB 830
C		CSTRB 840
	IF (IALS.EQ.1) CALL KHAIS	
	TQFBR = -FF (PF)	STRB 730
	TQRBR = -FR (PFR)	STRB 850
	GO TO 2345	STRB 860
2223	PF=(TIME-CGAM)*XTMP	STRB 870
	IF (PF.GT.PFL) PF=PFL	STRB 880
	PFR=(TIME-CGAM)*XTMP	STRB 890
	IF (PFR.GT.PFL) PFR=PFL	STRB 900
	IF (IALS.EQ.1) CALL KHAIS	
	TQFBR = -FF (PF)	STRB 910
	TQRBR = -FR (PFR)	STRB 920
	IF (TIME.LE.CGAM) TQFBR=0.	STRB 930
	IF (TIME.LE.CGAM) TQRBR=0.	STRB 940
	GO TO 2345	STRB 950
C	DRIVE TORQUE CALCULATIONS	STRB 960

C	I DRSW=0, REAR WHEEL DRIVE	STRB 970
C	=1, FOUR WHEEL DRIVE	STRB 980
4444	TQFBR= 0.0	STRB 990
	TQRBR = 0.0	STRB1000
	IF (IDRSW.NE.1) GO TO 5555	STRB1010
	TQDRF=AKTQP*(VC-U)	STRB1020
	IF (TQDRF.GE.TQMAXF) TQDRF=TQMAXF	STRB1030
	TQFBR = 0.5*(1.-ALAMBD)*ARFBR*TQDRF	STRB1040
5555	TQDRR=AKTQR*(VC-U)	STRB1050
	IF (TQDRR.GE.TQMAXR) TQDRR=TQMAXR	STRB1060
	TQRBR = 0.5*ALAMBD*TQDRR	STRB1070
	GO TO 2345	STRB1080
4321	CONTINUE	STRB1090
	DELSWC=SIN(6.28*FREQ*TIME)*DSW*RAD	STRB1100
	IF (TIME.GT.0.5/FREQ)DELSWC=SIN(6.28*FREQ*TIME)*PARAM(46)*RAD	STRB1110
	IF (TIME.GT.1./FREQ)DELSWC=0.0	STRB1120
	IF ((TIME.GT.0.5/FREQ).AND.(PARAM(129).GT.5.)) DELSWC = 0.0	STRB1130
	PF=0.0	STRB1140
	TQRBR=0.0	STRB1150
	TQFBR=0.0	
	IF (TIME.LE.TST) GO TO 8000	
	DELSWC=(TIME-TST)*DSLMD	
	IF (ABS(DELSWC).GT.DSWCM) DELSWC=DSWCM*SIGN(1.0,DELSWC)	
	DSLMD=PARAM(114)/PARAM(44)	
	IF (TIME.GT.PARAM(43)) DELSWC=(TIME-PARAM(45))*DSLMD	
	IF (TIME.GT.PARAM(45)) DELSWC=0.0	
	DELSWC=DELSWC*RAD	
8000	CONTINUE	
	IF (PARAM(125).EQ.0.0)GO TO 2345	STRB1160
	IF (TIME.LE.PARAM(278).OR.TIME.GT.PARAM(279))GO TO 2345	STRB1170
	PF=(TIME-PARAM(278))*26000.0	STRB1180
	IF (PF.GT.PFL)PF=PFL	STRB1190
	PFR=(TIME-PARAM(278))*26000.0	
	IF (PFR.GT.PFL)PFR=PFL	
	IF (IALS.EQ.1) CALL KHAIS	
	TQFBR =-FF(PF)	STRB1200
	TQRBR=-FR(PFR)	
2345	CONTINUE	STRB1220
	IF (PARAM(193).NE.0.0)DELSWC=0.01745329*(PARAM(194)*Y +PARAM(195)	STRB1230
1	*YDT)	STRB1240
C	IF PRM(275) IS 1 STEER PROFILE DATA IS USED	
	IF (PARAM(275).LE.0.) GO TO 100	
	DELSWC = XINT(TIME,STRTM,STEER,NST)	
	DELSWC = DELSWC*RAD	
100	CONTINUE	
	IF (IALS.EQ.0) GO TO 200	
	TQFBR=-FF(PRF)*PARAM(238)	
	TQFBL=-FF(PLF)*PARAM(239)	
	TQRBR=-FR(PRR)*PARAM(240)	
	TQRBL=-FR(PLR)*PARAM(241)	
	IF (TIME.LE.CGAM)TQFBR=0.0	
	IF (TIME.LE.CGAM)TQFBL=0.0	
	IF (TIME.LE.CGAM)TQRBR=0.0	
	IF (TIME.LE.CGAM)TQRBL=0.0	
	GO TO 300	
8999	CONTINUE	
	EPDSW = XYZDOT(2)*COS(ALAMDA) - XYZDOT(1)*SIN(ALAMDA)	
	EPSTQR = VC-(XYZDOT(1)*COS(ALAMDA) + XYZDOT(2)*SIN(ALAMDA))	
C	VC IS INITIAL VELOCITY INPUT WITH PARAM 112 IN MPH	
	EPDSWI = EPDSWI + EPDSW*DT	

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EPTQRI = EPTQRI + EPSIQR*DT
DELSWC=- (PARAM (217) *EPDSWI + PARAM (194) *PSIDT + PARAM (195) *PSI
2 + PARAM (193) *EPSDSW) *RAD
TQRBR = (PARAM (215) *EPSTQR + PARAM (216) *EPTQRI)
TQFBR=0.
200 CONTINUE
TQFBR = TQFBR*PARAM (238)
TQFBL=TQFBR*PARAM (239)
TQRBR = TQRBR*PARAM (240)
TQRBL=TQRBR*PARAM (241)
300 CONTINUE
TEMPE=ABS (DELSWC/RAD) STRB1250
IF (TEMPE.GT. DSWMAX) DSWMAX=TEMPE STRB1260
TEMPE=ABS (TQFBR) STRB1290
IF (TEMPE.GT. TQFMAX) TQFMAX=TEMPE STRB1300
TEMPE=ABS (TQRBR) STRB1270
IF (TEMPE.GT. TQRMAX) TQRMAX=TEMPE STRB1280
RETURN STRB1310
END STRB1320

```

H-2.1.13 CVCALC

Presented here is the Fortran listing for the comparison variable subprogram. This subprogram collects data for comparison variable calculation.

C	SUBROUTINE CVCALC	3031	10
	SUBROUTINE CVCALC		CVCA 20
C	*****		CVCA 30
C	THIS SUBROUTINE COLLECTS DATA FOR COMPARISON VARIABLE CALCULATION		CVCA 40
C	*****		CVCA 50
	COMMON/EXTRA/ PSI3S,PSI4S,BTV,AYSTI		CVCA 60
	COMMON/NEWER/TIME25,TIME10,FSI5,PHIMAX,DSWMAX		CVCA 70
	COMMON/SP7BLK/N1,N2,IPCT(120),IPOTAD(120),PARAM(400)		CVCA 80
	COMMON/TIMBLK/JJTIME,TIME,DT		CVCA 90
	COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI		CVCA 100
	COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,		CVCA 110
1	AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,		CVCA 120
1	TIMBMP,GETDL,TIMIN5, TSTEP, IVHTP		CVCA 130
	COMMON/UVW/VC,UIN		CVCA 140
	COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,		CVCA 150
1	QDT,EDT, RDT,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,		CVCA 160
1	AKK1,AKK2, THS1,THS2,		CVCA 170
1	AMT1,AMT2,SN,SFXU,BTVDT,ETAX,ETAL,		CVCA 180
1	ZIP(4),PHII(4),		CVCA 190
1	UI(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),		CVCA 200
1	ALFI(4),BETIP(4),BETIBF(4),SLIPI(4),AM1I(4),AM2I(4),UOI(4),		CVCA 210
1	FCI(4),FCIMAX(4),FSI(4),		CVCA 220
1	ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIER(4),		CVCA 230
1	RWZI(4),ZI(4),FRI(4), UI(4),VI(4),WI(4),UGI(4),		CVCA 240
1	VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)		CVCA 250
1	,ALTQ(4),OTM(4),SALTQ,ECTM,BOTM		CVCA 260
1	,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4		CVCA 270
1	,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4		CVCA 280
1	,PHIDMX		CVCA 290
	COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMX,TQFMAX,PSIMAX,ONER		CVCA 300
	REAL*4 MPHIPS		CVCA 310
	DATA MPHIPS/17.6/		CVCA 320
	DATA RAD/0.1745329E-1/		CVCA 330
	EQUIVALENCE (PARAM(123),DSW),(PARAM(115),TST),(PARAM(117),CGAM)		CVCA 340
	EQUIVALENCE (PARAM(108),FREQ)		CVCA 350
C	LONGITUDINAL AND LATERAL ACCELERATION CALCULATION		CVCA 360
	ETAX = (UDT-V*R+W*Q)/386.4		CVCA 370
	ETAL = (VDT+R*U-W*P)/386.4		CVCA 380
	BTV = ATAN(V/U)		CVCA 390
	BTVDT = (U*VDT-V*UDT)/(U*U)		CVCA 400
	ONER = (R+BTVDT)/SQRT(U**2+V**2)		CVCA 410
C	COMPARISON VARIABLE DATA COLLECTION		CVCA 420
	IF(IVHTP.GT.2) GO TO 402		CVCA 430
C	COMPARISON VARIABLES FOR VHTP # 1		CVCA 440
C	AXAVE = AVERAGE LONGITUDINAL DECELERATION		CVCA 450
	IF(U.GT.(UIN-88.)) GO TO 400		CVCA 460
	AXI = AXI + ETAX		CVCA 470
	GO TO 401		CVCA 480
400	TIMIN5 = TIME		CVCA 490
401	CONTINUE		CVCA 500
	TIMDEC = TIME - TIMIN5		CVCA 510
402	CONTINUE		CVCA 520
	IF(IVHTP.NE.2) GO TO 412		CVCA 530

C	VHTP #2 COMPARISON VARIABLES	CVCA 540
C	AVERAGE PATH CURVATURE RATIO , CUVRAT	CVCA 550
C	AVERAGE LONGITUDINAL DECELERATION, AXAVE	CVCA 560
C	PEAK BODY SIDESLIP RATE, BETDMX	CVCA 570
	IF (TIME.LT.CGAM) GO TO 410	CVCA 580
	IF ( TIME.GT. (CGAM + 1.)) GO TO 411	CVCA 590
	CURVAV = CURVAV + ONER	CVCA 600
	ABBTV = ABS (BTV)	CVCA 610
	ABTVDT = ABS (BTVDT)	CVCA 620
	IF (ABBTV.GT.BETAMX) BETAMX = ABBTV	CVCA 630
	IF (ABTVDT.GT.BETDMX) BETDMX = ABTVDT	CVCA 640
	GO TO 411	CVCA 650
410	CURTBP = ONER	CVCA 660
411	CONTINUE	CVCA 670
412	CONTINUE	CVCA 680
	IF (IVHTP.NE.3) GO TO 422	CVCA 690
C	VHTP #3	CVCA 700
	IF ((GETDL.EQ.0.).AND.(JUMP.EQ.0)) GO TO 420	CVCA 710
	IF (TIME.GT. (TIMBMP + 1)) GO TO 421	CVCA 720
	JUMP = 1	CVCA 730
	CURVAV = CURVAV + ONER	CVCA 740
	ABTVDT = ABS (BTVDT)	CVCA 750
	ABBTV = ABS (BTV)	CVCA 760
	IF (ABTVDT.GT.BETDMX) BETDMX = ABTVDT	CVCA 770
	IF (ABBTV.GT.BETAMX) BETAMX = ABBTV	CVCA 780
	GO TO 421	CVCA 790
420	CURTBP = ONER	CVCA 800
	TIMBMP = TIME	CVCA 810
421	CONTINUE	CVCA 820
422	CONTINUE	CVCA 830
	IF (IVHTP.NE.4) GO TO 432	CVCA 840
C	VHTP #4 COMPARISON VARIABLES	CVCA 850
	IF (TIME.LT.TST) GO TO 430	CVCA 860
	IF (TIME.GT. (TST + 2.)) GO TO 431	CVCA 870
	CURVAV = CURVAV + ONER	CVCA 880
	ABTVDT = ABS (BTVDT)	CVCA 890
	ABBTV = ABS (BTV)	CVCA 900
	IF (ABTVDT.GT.BETDMX) BETDMX = ABTVDT	CVCA 910
	IF (ABBTV.GT.BETAMX) BETAMX = ABBTV	CVCA 920
	DELBET = BETAMX - BETA	CVCA 930
	GO TO 431	CVCA 940
430	BETA = BTV	CVCA 950
431	CONTINUE	CVCA 960
432	CONTINUE	CVCA 970
	IF (IVHTP.NE.5) GO TO 442	CVCA 980
C	VHTP #5 COMPARISON VARIABLES	CVCA 990
	IF (TIME.GT. ((1./FREQ) + 1.4)) GO TO 450	CVCA1000
	IF (DSW.GT.0) GO TO 460	CVCA1010
	DELSTR= DELSTR + ABS (Y + 144.)	CVCA1020
	GO TO 461	CVCA1030
460	CONTINUE	CVCA1040
	DELSTR=DELSTR + ABS (Y - 144.)	CVCA1050
461	CONTINUE	CVCA1060
	ABBTV = ABS (BTV)	CVCA1070
	IF (ABBTV.GT.BETAMX) BETAMX = ABBTV	CVCA1080
	DELPSI = PSI	CVCA1090
450	CONTINUE	CVCA1100
442	CONTINUE	CVCA1110
C	VHTP #6 COMPARISON VARIABLE	CVCA1120
	IF (ABS (PHIDT).GT.PHIDMX) PHIDMX = ABS (PHIDT)	CVCA1130
	IF (ABS (ETAL).GT.AYMAX) AYMAX= ABS (ETAL)	CVCA1140

```
TEMPE = ABS (R/RAD)
IF (TEMPE.GT. RMAX) RMAX=TEMPE
TEMPE = ABS (PSI)
IF (TEMPE.GT. PSIMAX) PSIMAX=TEMPE
TEMPE = ABS (PHI/RAD)
IF (TEMPE.GT. PHIMAX) PHIMAX=TEMPE
IF (U .GE. 10.0*MPHIPS) TIME10=TIME
IF (U .GE. 25.0*MPHIPS) TIME25=TIME
IF (TIME.LE. 5.0) PSI5=PSI /RAD
RETURN
END
```

```
CVCA1150
CVCA1160
CVCA1170
CVCA1180
CVCA1190
CVCA1200
CVCA1210
CVCA1220
CVCA1230
CVCA1240
CVCA1250
```

H-2.1.14 RTMON

Presented here is the Fortran listing for the real-time mode initialization subprogram. The following is performed in RTMON:

1. Initialization of order programs to perform real-time input/output.
2. Initiation of simulation runs.
3. Suspension of the simulation's OS processing until the real-time processing is completed.

```

C      SUBROUTINE RTMON                                RTMO  10
      SUBROUTINE RTMON                                RTMO  20
C*****
C      THIS SUBPROGRAM PERFORMS THE FOLLOWING:
C      1) INITIALIZATION OF ORDER PROGRAMS TO PERFORM REAL-TIME
C         INPUT/OUTPUT
C      2) INITIATION OF SIMULATION RUNS
C      3) SUSPENSION OF THE SIMULATION'S OS PROCESSING UNTIL THE
C         REAL-TIME PROCESSING IS COMPLETED
C*****
      COMMON/OSMON/ IREALT,NNNN                                RTMO  40
      COMMON/EVTRB/SAVE0,SAVE1,SAVE2
      COMMON/OSTRAN/ ICT,IRI,MOPU,IFUNS,LRUNS,REALT,ITRNS
      COMMON/APL/ OPEN ,RTSW ,LRTSW ,RBSW                                RTMO  50
      COMMON/RBBLK/ AD1RB,ICFB,OPRB,PILRB                                RTMO  60
      COMMON /RBBLK/ TCNBUF,TIMBUF,LDARB ,TDARB ,PILRB1                RTMO  70
      COMMON/RBBLK/SLRB05,RLRB05                                RTMO  80
      COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAECB,TDAECB                RTMO  90
      COMMON/ECBBLK/ AD1ECB,ICECB,OFECEB                            RTMO 100
      COMMON /ECBBLK/OSECB ,DONECB,SLECB5,RLECB5                    RTMO 110
      COMMON/INOUT/ IN(48),LACO(48),ISW1,ISW7,IPRT
C
      REAL*8          PILRB(3) ,LDARB(23) ,TCNBUF(8)                RTMO 140
      REAL*8          TIMBUF(8)                                    RTMO 150
      REAL*8          SAVE2(16) ,PILRB1(3) ,AD1RB(12)              RTMO 160
      REAL*8          OPRB(6) ,TDARB(6)                            RTMO 170
      REAL*8          SAVE0(16) ,SAVE1(16) ,ICRB(6)                RTMO 180
      REAL*8          SLRB05(6) ,RLRB05(6)                        RTMO 190
C
      REAL*4          IN                                           RTMO 200
      REAL*4          ADC2(24) ,ADC1(24)                            RTMO 210
C
      INTEGER*4       TCNECB ,TIMECB                                RTMO 230
      INTEGER*4       CONSL/01/ ,PILECB ,ADAECB ,TDAECB            RTMO 240
      INTEGER*4       IMODOP/04/ ,OPECB                            RTMO 250
      INTEGER*4       FIRST/0/,LAST/47/                            RTMO 260
      INTEGER*4       NONE/0/,AD1FCB, IMODIC/06/,ICECB             RTMO 270
      INTEGER*4       MONE/-1/ ,F1/00/ ,L1/47/                    RTMO 280
      INTEGER*4       TDAECB                                        RTMO 300
      INTEGER*4       OSECB ,DONECB                                RTMO 310
      INTEGER*4       SCL05/5/,RCL05/5/,SLECB5,RLECB5              RTMO 320
C
      INTEGER*4       SCL05/5/,RCL05/5/,SLECB5,RLECB5              RTMO 330

```

	INTEGER*2	NUMEVT/03/ ,ZERO/00/	RTMO 340
	INTEGER*2	UNIT/19/	RTMO 350
	INTEGER*2	TWO/02/	RTMO 360
	INTEGER*2	RTSW ,RBSW ,LTSW ,OPEN ,OPDN	RTMO 370
C			RTMO 380
	EQUIVALENCE	(ADC1(24) ,IN(24)) , (ADC2(1) ,IN(25))	RTMO 390
C			RTMO 400
	EXTERNAL	INIT,CART ,ENDRUN,HYBINT	RTMO 410
C			RTMO 420
	IF( RBSW.EQ.1 )	GO TO 200	RTMO 430
	CALL	BLJCB( 'J007',CSECB,NUMEVT,NONE )	RTMO 440
	CALL	DEFEP( INIT,SAVE0,ZERC,'NONE','NO' )	RTMO 450
	CALL	DEFEP( ENDRUN,SAVE1,ZERC,'NONE','NO' )	RTMO 460
	CALL	DEFEP( CART,SAVE2,ZERC,'NONE','NO' )	RTMO 470
	CALL	CRBCRB( F1,L1,ADC1,AD1RE,AD1ECB,CONSL )	RTMO 480
	CALL	TLDARB( TDARB,TDAECB,CONSL )	RTMO 490
	CALL	SSCLRB( SCL05,SIRB05,SLECB5,CONSI)	RTMO 500
	CALL	RSCLRB( RCL05,RIRB05,RLECB5,CONSL)	RTMO 510
	CALL	SAMORB( IMODIC,ICRB,ICECB,CONSL )	RTMO 520
	CALL	SAMORB( IMODOF,OPRB,OPECB,CONSL )	RTMO 530
	RBSW	= 1	RTMO 550
200	CONTINUE		RTMO 560
	IF(IREALT.EQ.0 )	GO TO 210	RTMO 570
	IF(NNNN.EQ.1)	GO TO 320	RTMO 700
	NNNN	= 1	RTMO 710
	CALL	RTOPN	RTMO 600
	CALL	RTACT( ZERO,'J007' )	RTMO 610
320	CONTINUE		RTMO 740
	CALL	DEFPR( UNIT,HYBINT,'J007' )	RTMO 630
	LDSW	= 0	RTMO 640
	OSECB	= 0	RTMO 650
	CALL	RTACT( TWO,'J007' )	RTMO 660
	CALL	WAITRT( OSECB )	RTMO 670
	CALL	WAITBU( 200 )	RTMO 680
	CALL	DEFPR( UNIT,MONE,'J007' )	RTMO 690
	GO TO	215	RTMO 700
210	CONTINUE		RTMO 710
	CALL	LBDAFP( FIRST,LAST,DACO,IERR )	RTMO 720
	CALL	TLDA	RTMO 730
	CALL	CRBCFP( F1,L1,ADC1,ICRBCE )	RTMO 740
	CALL	MODEL	RTMO 750
215	CONTINUE		RTMO 760
	RETURN		OVERLAY
	ENTRY	RTMONT	OVERLAY
	IF(IREALT.EQ.0)	GO TO 310	RTMO 960
	OSECB	= 0	OVERLAY
	CALL	HPCST( DONECB,'IN')	OVERLAY
	CALL	WAITRT( OSECB )	OVERLAY
310	CONTINUE		
	RETURN		RTMO 770
	END		RTMO 780



H-2.1.15 RTIME

Presented here is the Fortran listing of the real-time executive subprogram. The following is performed in RTIME:

1. Assignment of priority interrupt addresses to real-time events.
2. Initialization of the interval timer for computation cycle timing.
3. Execution of all real-time input/output.
4. Checks for end-of-run conditions.
5. Deactivation of real-time mode at the end of a simulation run.

```

C      SUBROUTINE RTIME                                RTIM  10
      SUBROUTINE RTIME                                RTIM  20
C*****
C      THIS SUBPROGRAM PERFORMS THE FOLLOWING:
C      1) ASSIGNMENT OF PRICRITY INTERRUPT ADDRESSES TO
C          REAL-TIME EVENTS
C      2) INITIATION OF THE INTERVAL TIMER FOR COMPUTATION CYCLE
C          TIMING
C      3) EXECUTION OF ALL REAL-TIME INPUT/OUTPUT
C      4) CHECKS FOR END-OF RUN CCNEITIONS
C      5) DEACTIVATION OF REAL-TIME MODE AT THE END OF A
C          SIMULATION RUN
C*****
COMMON/APL/ OPEN ,RTSW ,LDTSW ,RBSW                RTIM  40
COMMON/RBBLK/ AD1RB,ICFE,OPRB,PILRB                RTIM  50
COMMON /RBBLK/ TCNBUF,TIMBUF,LDARB ,TDARB ,PILRB1   RTIM  60
COMMON/RBBLK/SLRB05,RLRB05                          RTIM  70
COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAECB,TDAECB  RTIM  80
COMMON/ECBBLK/ AD1ECB,ICECB,OFECB                  RTIM  90
COMMON /ECBBLK/OSECB ,DONECB,SLECB5,RLECB5        RTIM 100
COMMON/INOUT/ IN(48) ,LACO(48) ,ISW1,ISW7,IPRT
COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI
COMMON/TIMBLK/JJTIME,TIME,DT                        RTIM 140
COMMON/SP7BLK/N1,N2,IPOI(120) ,IPOTAD(120) ,PARAM(400) RTIM 150
COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX      RTIM 160
COMMON/NONAME/XEND,O,EXIT2                          RTIM 170
COMMON/NODLY/INDXCN                                  RTIM 180
DIMENSION CSI(4) ,XBM(4) ,SLP(4)                    RTIM 190
REAL*8      BUFF(8) ,PILRB(3) ,LDARB(23) ,TCNBUF(8) RTIM 200
REAL*8      TIMBUF(8)                                RTIM 210
REAL*8 ICRB(6) ,PILRB1(3) ,AD1RB(12)                RTIM 220
REAL*8      OPRB(6) ,TDARB(6)                       RTIM 230
REAL*8      BUFF1(8)                                 RTIM 240
REAL*8      SLRB05(6) ,RLRE05(6)                     RTIM 250
C                                                    RTIM 260
REAL*4      IN                                        RTIM 270
REAL*4      ADC2(24) ,ADC1(24)
C                                                    RTIM 290

```

	INTEGER*4	TIMCAN	,TCNECB	,TIMECB		RTIM	300
	INTEGER*4	CONSL/01/	,PILECB	,ADAECB	,TDAECB	RTIM	310
	INTEGER*4		EVTREI/02/	,TIMINT/120000/		RTIM	320
	INTEGER*4	SLFCB5,RLECB5	,	FIRST/00/	,LAST/47/	RTIM	330
	INTEGER*4	OPECB,AD1ECB,ICECB				RTIM	340
	INTEGER*4	TDAECB	,STATUS			RTIM	350
	INTEGER*4	OSECB	,DONECB			RTIM	360
	INTEGER*4	PILCB1				RTIM	370
C						RTIM	380
	INTEGER*2	PILIST(2)/1,0/	,EVILST/1/			RTIM	390
	INTEGER*2	TWO /02/	,ONE/C1/			RTIM	400
	INTEGER*2	RTSW	,RBSW	,LDTSW	,OPEN	RTIM	410
C						RTIM	420
	EQUIVALENCE	(ADC1(24),IN(24))		, (ADC2(1),IN(25))		RTIM	430
	EQUIVALENCE	(PARAM(016),ROOVER)				RTIM	440
C						RTIM	450
C		EVENT 0				RTIM	460
C						RTIM	470
	ENTRY	INIT				RTIM	480
		CALL PGET( PILIST, C	, 'J007',PILRB1 )			RTIM	490
		PILECB = 0				RTIM	500
		CALL PCAN( PILIST,BUFF,PILECB )				RTIM	510
		CALL HIOCHK( PILECB )				RTIM	520
		CALL PEVT( PILIST,EVILST,'J007',PILRB )				RTIM	530
		DONECB = 0				RTIM	540
		CALL HWAIT( DONECB )				RTIM	550
		CALL PREL( PILIST,'J007',PILRB1 )				RTIM	560
		CALL HDONE( 'DN' )				RTIM	570
	CALL	HEXIT				RTIM	580
C						RTIM	590
C		EVENT 1				RTIM	600
C						RTIM	610
	ENTRY	ENDRUN				RTIM	620
		TCNECB = 0				RTIM	630
		CALL RDTIMR( TIMCAN,TCNECB,'CANC',TCNBUF )				RTIM	640
		CALL HIOCHK( TCNECB )				RTIM	650
		PILECB = 0				RTIM	660
		CALL PDAC( PILIST,BUFF,PILECB )				RTIM	670
		CALL HIOCHK( PILECB )				RTIM	680
		PILECB = 0				RTIM	690
		CALL PCAN( PILIST,BUFF,PILECB )				RTIM	700
		CALL HIOCHK( PILECB )				RTIM	710
	ICECB = 0					RTIM	720
		CALL HIREQ( ICRB )				RTIM	730
		CALL HIOCHK( ICECB )				RTIM	740
		CALL RTCAN( TWO ,STATUS )				RTIM	750
		CALL HOSPST( 'FN' )				RTIM	760
	CALL	HEXIT				RTIM	770
C						RTIM	780
C		EVENT 2				RTIM	790
C						RTIM	800
	ENTRY	CART				RTIM	810
	IF( LDTSW.EQ.1 )	GO TO 230				RTIM	820
	PILCB1 = 0					RTIM	830
	CALL PCAN(PILIST,BUFF1,PILCB1)					RTIM	840
	CALL HIOCHK(PILCB1)					RTIM	850
	PILCB1 = 0					RTIM	860
		CALL PACT( PILIST,BUFF1,PILCB1 )				RTIM	870
		CALL HIOCHK ( PILCB1 )				RTIM	880
	OPECB = 0					RTIM	890
	TIMECB = 0					RTIM	900

	CALL HIOREQ( OPRB )	RTIM 890
	TIMINT = 1.E06*DT/PARAM(175)	RTIM 860
	CALL LDTIMR( TIMINT,TIMECB,EVTRET,TIMBUF )	RTIM 870
	LDTSW = 1	RTIM 900
	GO TO 250	
230	CONTINUE	RTIM 910
	SLECB5=0	RTIM 920
	TDAECB = 0	RTIM 930
	AD1ECB = 0	RTIM 940
	CALL HIOREQ(SLRB05)	RTIM 950
	CALL HIOREQ( AD1RB )	RTIM 970
	J=0	RTIM 980
	DO 200 I=1,INDXCN	RTIM 990
	J=J+1	RTIM1000
200	CONTINUE	RTIM1010
C		
	CALL HIOCHK( AD1ECB )	RTIM1020
	CALL MODEL	RTIM1030
	ADAECB = 0	RTIM1040
	RLECB5=0	RTIM1050
	CALL LBDART( FIRST,IAST,DACC,LDARB , ADAECB,CONSL )	RTIM1060
	CALL HIOREQ( TDARB )	RTIM 960
	CALL HIOREQ(RLRB05)	RTIM1070
C	APL WILL TERMINATE REAL-TIME RUN IF EITHER	RTIM1080
C	CONDITION SHOWN BELOW IS SATISFIED	RTIM1090
	C=SQRT(U*U+V*V)	RTIM1100
	IF(U.LE.0.1)CALL RTACT(ONE,'J007')	RTIM1110
	IF(PHIMAX.GT.ROOVER) CALL RTACT(ONE,'J007')	
	IF(( ISW1.EQ.1 ).OR.( ISW7.EQ.1 )) CALL RTACT( ONE , 'J007' )	RTIM1130
	IF( TIME.LE.XEND.AND.O.GE.EXIT2 ) GO TO 250	RTIM1140
	CALL RTACT( ONE,'J007' )	RTIM1150
250	CONTINUE	RTIM1160
	CALL HEXIT	RTIM1170
	RETURN	RTIM1180
	END	RTIM1190

H-2.1.16 CMPVAR

Presented here is the Fortran listing for the performance comparison variable (PCV) calculation subprogram. The calculation and output of the PCV's are performed in CMPVAR following each simulation run.

```

C      SUBROUTINE CMPVAR                                CMPV  10
      SUBROUTINE CMPVAR                                CMPV  20
C*****
C      THE CALCULATION AND OUTPUT OF THE CV'S ARE PERFORMED IN THIS
C      SUBPROGRAM FOLLOWING EACH SIMULATION RUN
C*****
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL, CMPV  40
1      AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX, CMPV  50
1      TIMBMP,GETDL,TIMIN5, TSTEP, IVHTP
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMX,TQFMX,PSIMAX,ONER CMPV  70
      COMMON/NEWER/TIME25,TIME10,ESI5,PHIMAX,DSWMAX CMPV  80
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/SAYERS/SD,TSTOP
      COMMON/NONAME/XEND,O,EXIT2
      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO, 600
1      ANOUT,ADOUT 610
      COMMON/COMBLK/ SM,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,TSFO2,
1      TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23
      COMMON/TIMBLK/JJTIME,TIME,DT
      EQUIVALENCE(PARAM(108),FREQ)
      DATA CURV1G/.00078/ CMPV  90
      DATA LPTR/2/ CMPV 100
C      CALCULATION OF COMPARISON VARIABLELES CMPV 110
      IF(TIMDEC.EQ.0.) TIMDEC=.000000001 CMPV 120
      IF(CURTBP.EQ.0.) CURTEP=.000000001 CMPV 130
      GO TO(1,2,3,4,5,6), IVHTP CMPV 140
      AXAVE = AXI*DT/TIMDEC CMPV 150
      GO TO 10 CMPV 160
1 CONTINUE CMPV 170
      AXAVE = AXI*DT/TIMDEC CMPV 180
      AXABS=ABS(AXAVE)
      IF(TIME.LT.PARAM(117)) GO TO 10
      TSTOP=EXIT2/(AXABS*G)
      SD=(AXAVE*G*TSTOP**2)/2. + EXIT2*TSTOP + ANUM
      GO TO 10 CMPV 190
2 CONTINUE CMPV 200
      AXAVE = AXI*DT/TIMDEC CMPV 210
      AXABS=ABS(AXAVE)
      TSTOP=EXIT2/(AXABS*G)
      SD=(AXAVE*G*TSTOP**2)/2. + EXIT2*TSTOP + ANUM
      CUVRAT = CURVAV * DT/CURTBP CMPV 220
      GO TO 10 CMPV 230
3 CONTINUE CMPV 240
      CUVRAT = CURVAV * DT/CURTBP CMPV 250
      GO TO 10 CMPV 260
4 CONTINUE CMPV 270
      CUVRAT = CURVAV*.5*DT/CURV1G CMPV 280
      GO TO 10 CMPV 290
5 CONTINUE CMPV 300
      DEL = (DELSTR*DT/((1./FREQ)+1.4))/12.
6 CONTINUE CMPV 320

```

10	CONTINUE	CMPV 330
	RMAX = RMAX/57.3	CMPV 340
	WRITE(LPTR,2345) AXAVE,TIMDEC,CUVRAT,BETDMX,BETAMX,DELBET,	CMPV 350
	1AYMAX,PHIMAX,RMAX,DEL,DELPSI,DSWMAX,TQFMAX,TQRMX	CMPV 360
2345	FORMAT('0 AXAV=',F8.3,' DECL TIME=',F8.3,' AVCUR=',F8.3,' BTDMAX='	CMPV 370
	1,F8.3,' BTMAX=',F8.3,' DELBT=',F8.3/	CMPV 380
	1'OAYMAX=',F8.3,' PHIMAX=',F8.3,' RMAX=',F8.3,' LANE CHNG DEL='	CMPV 390
	1F8.3,' DELPSI=',F8.3,' MAX STEER=',F8.3/	CMPV 400
	1'OFTRQMAX=',F9.1,' RTRQMAX=',F9.1/)	CMPV 410
	RETURN	CMPV 420
	END	CMPV 430

H-2.1.17 QSTD

Presented here is the Fortran listing of the subprogram which outputs nonstandard data. The performance comparison variables are output from QSTD.

```

C      SUBROUTINE QSTD                                QSTD  10
      SUBROUTINE QSTD                                QSTD  20
C*****
C      STANDARD END OF RUN DATA IS OUTPUT FROM THIS SUBPROGRAM
C*****
      COMMON/DEVICE/KEYBD,ITTY,ICDRC,LPTR,LPNT      QSTD  40
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTEP,TIMDEC,JUMP,DELSTR,DEL, QSTD  50
1      AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX, QSTD  60
1      TIMBMP,GETDL,TIMINS, TSTEP, IVHTP          QSTD  70
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMX,TQFMAX,PSIMAX,ONER QSTD  80
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX QSTD  90
      WRITE(ITTY,2345) AXAVE,TIMDEC,CUVRAT,BETDMX,BETAMX,DELBET, QSTD 100
1AYMAX,PHIMAX,RMAX,DEL,DELPSI,DSWMAX,TQFMAX,TQRMX QSTD 110
2345 FORMAT('O AXAV=',F8.3,' DECL TIME=',F8.3,' AVCUR=',F8.3,' BTDMAX=' QSTD 120
1,F8.3,' BTMAX=',F8.3,' DELBT=',F8.3/ QSTD 130
1' AYMAX=',F8.3,' PHIMAX=',F8.3,' RMAX=',F8.3,' LANE CHNG DEL=', QSTD 140
1F8.3,' DELPSI=',F8.3,' MAX STEER=',F8.3/ QSTD 150
1' FTRQMAX=',F10.0,' RTRQMAX=',F10.0/) QSTD 160
      RETURN                                       QSTD 170
      END                                         QSTD 180

```

H-2.1.18 ERMONT

Presented here is the Fortran listing for the abnormal simulation operation subprogram. The conditions of vehicle roll-over, DAC overrange, and ADC overrange are detected by ERMONT when single-run execution is performed.

```

C      SUBROUTINE ERMONT(MOPU,ORNAME,PHIMAX)                                ERMONT 10
C      SUBROUTINE ERMONT(MOPU,CRNAME,PHIMAX)                                ERMONT 20
C*****
C      THE CONDITIONS OF VEHICLE RCLL-OVER, DIGITAL-TO-ANALOG CONVERTER
C      OVERRANGE, AND ANALOG-TO-DIGITAL OVERRANGE ARE DETECTED BY
C      THIS SUBPROGRAM WHEN SINGLE RUN EXECUTION IS PERFORMED
C*****
COMMON/EMON/IERDAC(10),TERDAC(10),IDACK,IENDR(20)                        ERMONT 40
COMMON/ERMON2/ IERADC(10),TERADC(10),IADCK                               ERMONT 50
COMMON/DACADC/ NAMDAC,NAMADC,IDAC,IADC,ADCNUM,DACNUM                     ERMONT 60
COMMON/SP7BLK/N1,N2,IPOI(120),IPOTAD(120),PARAM(400)                    R
EQUIVALENCE (PARAM(016),ROOVER)
INTEGER*2 NAMDAC(48),NAMADC(48),IDAC(48),IADC(48),ADCNUM,DACNUM        ERMONT 70
REAL*8 ORNAME(400)                                                       ERMONT 80
IF(PHIMAX.LT.ROOVER) GO TO 200
WRITE(MOPU,205) PHIMAX                                                    ERMONT 80
205 FORMAT(' VEHICLE ROLL CVER PHIMAX=',F8.2)                             ERMONT 90
200 CONTINUE                                                                ERMONT 90
IF(IDACK.LT.1) GO TO 100                                                  ERMONT 100
WRITE(MOPU,105)                                                            ERMONT 110
WRITE(MOPU,106)                                                            ERMONT 120
WRITE(MOPU,107) (TERDAC(J),CRNAME(NAMDAC(IERDAC(J))),                   ERMONT 130
1 IDAC(IERDAC(J)),J=1,IDACK)                                              ERMONT 140
105 FORMAT(' DAC OVERLOAD')                                               ERMONT 150
106 FORMAT(' TIME VAR')                                                  ERMONT 160
107 FORMAT(F8.2,2X,A6,' (' ,I4,' ') ')                                   ERMONT 170
100 CONTINUE                                                                ERMONT 180
IF(IADCK.LT.1) GO TO 300                                                  ERMONT 190
WRITE(MOPU,305)                                                            ERMONT 200
WRITE(MOPU,106)                                                            ERMONT 210
WRITE(MOPU,107) (TERADC(J),CRNAME(NAMADC(IERADC(J))),                   ERMONT 220
1 IADC(IERADC(J)),J=1,IADCK)                                             ERMONT 230
305 FORMAT(' ADC OVER RANGE')                                             ERMONT 240
300 CONTINUE                                                                ERMONT 250
RETURN                                                                    ERMONT 260
END                                                                        ERMONT 270

```

H-2.1.19 NTRACT

Presented here is the Fortran listing for the NTRACT subprogram. This subprogram is for simulation control via the interactive routines using the option command.

```

C      SUBROUTINE NTRACT (*,*,*,*)
      SUBROUTINE NTRACT (*,*,*,*)
C*****
C      THIS SUBPROGRAM IS FOR SIMULATION CONTROL VIA THE INTERACTIVE
C      ROUTINES USING THE OPTION CMMAND
C*****
C*****
C***** COMMON AREAS *****
C*****
COMMON/START/ ZDUMMY (4)
COMMON/TABBS/ ITABP,ITABI,ITNAM,TABNUM
COMMON/EMON/IERDAC (10),TERDAC (10),IDACK,IENDR (20)
COMMON/ERMON2/ IERADC (10),TERADC (10),IADC K
COMMON/NEWER/TIME25,TIME10,FSI5,PHIMAX,DSWMAX
COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT
COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAECB,TDAECB
COMMON/ECBBLK/ AD1ECE,ICECB,OPECB
COMMON /ECBBLK/OSECB ,DONECB,SLECB5,RLECB5
COMMON/OSMON/ IREALT,NNNN
COMMON/OSTRAN/ ICT,IRT,MOPU,IRUNS,LRUNS,REALT,ITRUNS
COMMON/DACADC/ NAMDAC,NAMADC,IDAC,IADC,ADCNM,DACNM
COMMON/IO/ DACPLA,ADCPLA,SCALDC,SCALAC
COMMON/TRACK/JIN,IKEEP,ATRACK,ISAMP,ONTIM,OFFTIM,ITRA,
1 ITRAA,ITRNA,ITRIA
COMMON/UNREAD/NAMEA,IWRDCT,INUMCT,LSTART,INDEXA,
1 FNUMA, LAST, ILOP
COMMON/FIND/ORNAME (400),NCOM,RSVAL (002),ICORDER (400)
COMMON/TIMBLK/JJTIME,TIME,DI
COMMON/SP7BLK/N1,N2,IPOT (120),IPOTAD (120),PARAM (400)
COMMON/OVRLAY/ OPTEST,VALMR,FINLMR,NTIME1,NTIME2,LOCAT,LOOPN
COMMON/NTCOM/ OUTNAM,UNNAM,MODENA,JDATE
COMMON/NTCOM/ IOU,MODE,DEVICE,IMODE
COMMON/PLOTA/IPLF,NP
C*****
REAL*8 NAMEA (10),RETURN
REAL*8 OPTION (20),OPTEST ,ASELT (15),REMOVE,RESET
REAL*8 BLANK
REAL*8 NMES, NTESTP, NTESTO
REAL*8 NADCL, NDAACL, NDUMP, NNPC, NPLOT, NSTD
REAL*8 NTRACK, NTM, NTIML, NTAELE
REAL*8 OUTNAM (21), NX ,NTEFM, NRESR, NIC, NADCA
REAL*8 NXM, UNNAM (3), MCDENA (4)
REAL*8 ORNAME
REAL*8 NSAMPL, NLA
REAL*8 NDACA, NMULT, CNAME, NII, NFF
REAL*8 NUOPT, NUOT1, NSTAT
REAL*8 ENDDAC, ENDADC
REAL*4 ZDUMMY
REAL*4 VALMR (20), FINLMR (20)
REAL*4 FNUMA (10)
REAL*4 SCALAC (48), SCALDC (48)

```



```

REAL*4 IPOT, IPOTAD                                NTRA 460
REAL*4 XDOWN(100), YACRCS(100)
INTEGER*4 RTSW, INDEXA(10)                        NTRA 470
INTEGER*4 ITABI(9)                                NTRA 480
INTEGER*4 DONECB, OS ECB, TIMINT                  NTRA 490
INTEGER*4 ITABP(9), TABNUM, ITNAM(9)              NTRA 500
INTEGER*2 ITRAA(50), ITRNA(50), ITRIA(50)         NTRA 510
INTEGER*2 LOCAT(20), LOOPN(20)                    NTRA 520
INTEGER*2 DEVICE(21), ICRDER, I MODE(20)          NTRA 530
INTEGER*2 DACNUM, ADCNUM, DACPLA(48), ADCPLA(48)  NTRA 540
INTEGER*2 NAMDAC(48), NAMADC(48), IDAC(48), IADC(48) NTRA 550
DIMENSION JDATE(3)                                NTRA 560
DIMENSION ATRACK(2000)                            NTRA 570
DIMENSION BVALUE(2)                                NTRA 580
DIMENSION IVALUE(2)                                NTRA 590
EQUIVALENCE (BVALUE(1), ZDUMMY(1))                NTRA 600
EQUIVALENCE (BVALUE(1), IVALUE(1))                NTRA 610
EQUIVALENCE (OPTION(1), NX), (OPTION(2), NIC), (OPTION(3), NTERM), NTRA 620
1 (OPTION(4), NADCA), (OPTION(5), NDACA), (OPTION(6), NFF), NTRA 630
2 (OPTION(7), NII), (OPTION(8), NMES), (OPTION(9), NTESTP), NTRA 640
3 (OPTION(10), NRESR), (OPTION(11), RESET), (OPTION(12), REMOVE), NTRA 650
4 (OPTION(13), NMULT), (OPTION(14), NXM), (OPTION(15), NUOPT) NTRA 660
EQUIVALENCE (ASELT(1), NTIMD), (ASELT(2), NDUMP), (ASELT(3), NSTD), NTRA 670
1 (ASELT(4), NTESTO), (ASELT(5), NLA), (ASELT(6), NTRACK), NTRA 680
2 (ASELT(7), NTABLE), (ASELT(8), NPLOT), (ASELT(9), NDACL), NTRA 690
3 (ASELT(10), NADCL), (ASELT(11), NSAMPLI), (ASELT(12), NNPC), NTRA 700
4 (ASELT(13), NTH), (ASELT(14), NSTAT), (ASELT(15), NUOT1) NTRA 710
C                                                    NTRA 720
C ***** NTRA 730
C                                                    NTRA 740
C DATA BLANK/' '/ NTRA 750
C DATA OUTNAM/'STD', 'TM', 'TABLE', 18*' '/ OVERLAY
C DATA DEVICE/2,2,3,17*0/ OVERLAY
C DATA IMODE/1,1,3,17*0/ OVERLAY
C DATA UNNAM/'L.....', 'T.....', 'B.....'/ OVERLAY
C DATA MODENA/'S.....', 'XEQ.....', 'M.....', 'A.....'/ OVERLAY
C                                                    NTRA 810
C DATA OPTION/'X', 'IC', 'TERM', 'ADCA', 'DACA', 'F', 'I', 'MES', NTRA 820
1 'TEST', 'RE-SIR', 'RESET', 'REMOVE', 'MULTI', 'XM', NTRA 830
2 'UOPT', 5*'ZZZZZZZ'/' NTRA 840
C DATA RETURN/' '/ NTRA 850
C DATA ASELT/'T+D', 'DUMP', 'STD', 'TESTO', 'LA', 'TRACK', 'TABLE', 'PLOT', NTRA 860
1 'DACL', 'ADCL', 'SAMPLE', 'PC', 'TM', 'STAT', 'UOUT1'/' NTRA 870
C 1 LOAD JDATE ARRAY NTRA 880
C 2 WRITE TIME AND DATE NTRA 890
C CALL IDATE(JDATE) NTRA 900
C CALL TIMDAT(JDATE, ITTY) NTRA 910
C                                                    NTRA 920
C ***** NTRA 930
C ***** NTRA 940
C ***** NTRA 950
C * NTRA 960
C * OPTION TEST * - ENTER A NAME FROM KEYBD (OPTTEST) NTRA 970
C * NTRA 980
C ***** NTRA 990
C NTRA 1000
C 1 IF OPTTEST IS AN OPTION KEYWORD PASS CONTROL TO OPTION EXECUTINTRA1010
C 2 IF OPTTEST IS AN OUTPUT KEYWORD PASS CONTROL TO OUTPUT ARRAY ANTRA1020
C 3 IF OPTTEST IS IN THE ANAME ARRAY WRITE ITS PRESENT AND INITIALNTRA1030
C 4 IF OPTTEST IS EQUAL TO RESET GO TO RESET ROUTINE NTRA1040
C 5 IF NONE OF THE AECVE ENVCKE ERROR MONITOR NTRA1050

```

C		NTRA1060
8749	WRITE (ITTY,8754)	NTRA1070
8754	FORMAT (1H0,'OPTION')	NTRA1080
	LRUNS=0	
	READ (KEYBD,1031) OPTTEST	NTRA1090
1031	FORMAT (1A8)	NTRA1100
8450	CONTINUE	NTRA1110
	LSTART=1	NTRA1120
	LAST=80	NTRA1130
C		NTRA1140
	DO 8756 IOR=1,20	NTRA1150
	IF (OPTION(IOR).EQ.OPTTEST) GO TO 8758	NTRA1160
8756	CONTINUE	NTRA1170
C		NTRA1180
	DO 8765 IS=1,15	NTRA1190
	IF (OPTTEST.EQ.ASELT (IS)) GO TO 720	NTRA1200
8765	CONTINUE	NTRA1210
C		NTRA1220
	WRITE (ITTY,1000)	NTRA1230
1000	FORMAT (1H0,' ERROR - OPTION NCT FOUND - RENTER ')	NTRA1240
	GO TO 8749	NTRA1250
C		NTRA1260
C	*****	NTRA1270
C		NTRA1280
C	*****	NTRA1290
C	*	NTRA1300
C	* OPTION EXECUTIVE * - CONTROL IS PASSED FROM OPTION TEST	NTRA1310
C	*	NTRA1320
C	*****	NTRA1330
8758	CONTINUE	NTRA1340
C	IF OPTTEST IS EQUAL TO:	NTRA1350
C	1 X - TRANSFER CONTROL TO EXECUTION REGION	NTRA1360
C	2 IC - TRANSFER CONTROL TO EXECUTION REGION	NTRA1370
C	3 OUTPUT - TRANSFER CONTROL TO OUTPUT ARRAY ASSEMBLER	NTRA1380
C	A) TABLE (SETUP END-OF-RUN OUTPUT)	NTRA1390
C	B) TRACK (SETUP DURING RUN DATA COLLECTION)	NTRA1400
C	C) LA (LIST ARRAY VALUES)	NTRA1410
C	D) T+D (OUTPUT TIME AND DATE)	NTRA1420
C	E) STD (STANDARD OUTPUT)	NTRA1430
C	F) DUMP (OUTPUT ALL VARIABLES)	NTRA1440
C	G) SAMPLE (SETUP FOR FEAL-TIME DATA COLLECTION)	NTRA1450
C	4 TERM - TRANSFER CCNTROL TO TERMINAL REGION	NTRA1460
C	5 ADCA - ALTER ADC ARRAY	NTRA1470
C	6 DACA - ALTER DAC ARRAY	NTRA1480
C	7 F - FLOATING POINT OPERATIONS	NTRA1490
C	8 I - INTEGER OPERATIONS	NTRA1500
C	9 MES - SEND MESSAGE TO LINE PRINTER	NTRA1510
C	10 TEST - EXECUTE TEST ROUTINE	NTRA1520
C	11 RE-STR - RESTARTS (READS IN NEW DATA)	NTRA1530
C	12 RESET - LOADS OUTPUT NAME ARRAY WITH BLANKS	NTRA1540
C	13 REMOVE - REMOVES NAMES FROM OPTION LIST	NTRA1550
C	14 MULTI - SETS UP MULTI RUN LOOP & VARIABLES	NTRA1560
C	15 XM - TRANFER CONTROL TO EXECUTION REGION FOR MULTI RUNS	NTRA1570
C	16 UOPTION - USER OWN OPTION SUBROUTINE	NTRA1580
C		NTRA1590
	IF (OPTTEST.EQ.NX) GO TO 8802	NTRA1600
	IF (OPTTEST.EQ.NIC) GO TC 8802	NTRA1610
	IF (OPTTEST.EQ.NXM) GO TO 8802	NTRA1620
	IF (OPTTEST.EQ.NTERM) GC TO 8809	NTRA1630
	IF (OPTTEST.EQ.RESET) GO TO 8230	NTRA1640
	IF (OPTTEST.EQ.REMOVE) GO TO 8234	NTRA1650

```

C          IF (OPTEST.EQ.NRESR) RETURN 1
C
C *****
C          IF (OPTEST.NE.NADCA) GO TO 500C
C ##### --- ADC ROUTINE ---#####
C          CALL ADCA (ADCNUM, NAMADC, IADC, SCALAC, ADCPLA, ITTY, KEYBD)
5000 CONTINUE
C          IF (OPTEST.NE.NII.AND.OPTEST.NE.NFF) GO TO 5010
C #####---ALTER OR READ DATA LIST ---#####
C          CALL RDWRT (OPTEST)
5010 CONTINUE
C          IF (OPTEST.NE.NDACA) GO TO 5020
C #####---DAC ROUTINE ---#####
C          CALL DACA (DACNUM, NAMDAC, IDAC, SCALDC, DACPLA, ITTY, KEYBD)
5020 CONTINUE
C          IF (OPTEST.NE.NMES) GO TO 5035
C #####--- MESSAGE ROUTINE ---#####
C          CALL MESRTN (ITTY, KEYED, RETURN, LPTR)
5035 CONTINUE
C          IF (OPTEST.NE.NMULT) GO TO 5040
C #####--- MULTI RUN ---#####
C          CALL MULTRN (ITTY, LOCAT, LOOEN, VALMR, FINLMR, ICT, IRUNS)
5040 CONTINUE
C          IF (OPTEST.NE.NTESTP) GO TO 5050
C #####--- TEST OPTION ---#####
C          CALL TESTP (KEYBD, ITTY, NCOM, ORNAME, IORDER, EVALUE, RSVAL, REALT)
5050 CONTINUE
C          IF (OPTEST.NE.NUOPT) GO TO 5070
C #####--- USER OPTION SUBROUTINE ---#####
C          WRITE (ITTY, 8764)
5070 CONTINUE
C          GO TO 8749
C
C *****
C *****
C *
C * OUTPUT ARRAY ASSEMBLER * - CALLED FROM THE OPTION TEST OR EXECUTIVE
C *
C *****
C
720 WRITE (ITTY, 700)
700 FORMAT (1H, 'UNIT, MODE')
C          CALL UNFORM (5, 1)
C          DO 705 IOU=1, 3
C          IF (UNNAM (IOU).EQ.NAMEA (1)) GO TO 710
705 CONTINUE
C          WRITE (ITTY, 715)
715 FORMAT (1H, 'FOR UNIT ENTER L (LIN PT), T (TELE), B (BOTH)')
C          GO TO 720
710 DO 725 MODE=1, 4
C          IF (MODENA (MODE).EQ.NAMEA (2)) GO TO 730
725 CONTINUE
C          WRITE (ITTY, 735)
735 FORMAT (1H, 'FOR MODE ENTER A (ALL), S (SING.), M (MULTI),
1 XEQ (EXECUTION)')
C          GO TO 720
730 CONTINUE
C

```

```

NTRA1660
NTRA1670
NTRA1680
NTRA1690
NTRA1700
NTRA1710
NTRA1720
NTRA1730
NTRA1740
NTRA1750
NTRA1760
NTRA1770
NTRA1780
NTRA1790
NTRA1800
NTRA1810
NTRA1820
NTRA1830
NTRA1840
NTRA1850
NTRA1860
NTRA1870
NTRA1880
NTRA1890
NTRA1900
NTRA1910
NTRA1920
NTRA1930
NTRA1940
NTRA1950
NTRA1960
NTRA1970
NTRA1980
NTRA1990
NTRA2000
NTRA2010
NTRA2020
NTRA2030
NTRA2040
NTRA2050
NTRA2060
NTRA2070
NTRA2080
NTRA2090
NTRA2100
NTRA2110
NTRA2120
NTRA2130
NTRA2140
NTRA2150
NTRA2160
NTRA2170
NTRA2180
NTRA2190
NTRA2200
NTRA2210
NTRA2220
NTRA2230
NTRA2240
NTRA2250

```

IF(OPTTEST.NE.NLA) GO TC 2005	NTRA2260
C #####--- ARRAY SET UP ---####	NTRA2270
CALL ARAST	NTRA2280
2005 CONTINUE	NTRA2290
IF(OPTTEST.NE.NTABLE) GC TO 2010	NTRA2300
C #####--- TABLE SET UP ---#####	NTRA2310
CALL TABLES(ITTY,KEYBD)	NTRA2320
2010 CONTINUE	NTRA2330
IF(OPTTEST.NE.NTRACK) GO TO 2020	NTRA2340
C #####--- TRACK ROUTINE ---#####	NTRA2350
CALL TRACKS(ITTY,KEYBD,DT)	NTRA2360
2020 CONTINUE	NTRA2370
IF(OPTTEST.NE.NSAMPL) GC TO 2030	NTRA2380
C #####--- REAL TIME SAMPLE SETUP SUBROUTINE ---#####	NTRA2390
WRITE(ITTY,8764)	NTRA2400
2030 CONTINUE	NTRA2410
IF(OPTTEST.NE.NPLOT) GO TO 2040	PLOT
C #####--- PREPARE DATA FOR PLOTTING ---#####	
CALL PLOTS(ITTY,KEYBD)	
2040 CONTINUE	
C #####--- SET UP OUTPUT NAME ARRAY ---#####	NTRA2420
IF(MODE.NE.2) GO TO 670	NTRA2430
OUTNAM(21)=OPTTEST	NTRA2440
DEVICE(21)=IOU	NTRA2450
GO TO 8253	NTRA2460
670 DO 741 JJ=1,20	NTRA2470
IF(OUTNAM(JJ).EQ.OPTTEST) GO TC 740	NTRA2480
741 CONTINUE	NTRA2490
DO 745 JJ=1,20	NTRA2500
IF(OUTNAM(JJ).EQ.BLANK) GO TO 740	NTRA2510
745 CONTINUE	NTRA2520
740 OUTNAM(JJ)=OPTTEST	NTRA2530
IMODE(JJ)=MODE	NTRA2540
DEVICE(JJ)=IOU	NTRA2550
GO TO 8749	NTRA2560
C #####--- REMOVE SINGLE VARIABLE ---#####	NTRA2570
8234 CONTINUE	NTRA2580
WRITE(ITTY,350)	NTRA2590
350 FORMAT(1H,'WHAT')	NTRA2600
READ(KEYBD,1031) OPTTEST	NTRA2610
DO 7350 I=1,20	NTRA2620
IF(OUTNAM(I).EQ.OPTTEST) OUTNAM(I)=BLANK	NTRA2630
7350 CONTINUE	NTRA2640
GO TO 8749	NTRA2650
C #####--- RESET OUTPUT NAME ARRAY ---#####	NTRA2660
C	NTRA2670
C LOAD OUTPUT NAME ARRAY WITH BLANKS	NTRA2680
8230 DO 8231 I=1,20	NTRA2690
OUTNAM(I)=BLANK	NTRA2700
8231 CONTINUE	NTRA2710
GO TO 8749	NTRA2720
C*****	NTRA2730
C	NTRA2740
C*****	NTRA2750
C*	NTRA2760
C* EXECUTION REGION* - CONTROL IS TRANSFERED FROM OPTION EXECUTIVE	NTRA2770
C*	NTRA2780
C*****	NTRA2790
8802 CONTINUE	NTRA2800
C 1 FILL BVALUE ARRAY WITH INITIAL CONDITIONS	NTRA2810
C 2 SET POTS	NTRA2820

```

C          3 SET DACS                                NTRA2830
C          4 EQUIVALENCE + STORE IC                 NTRA2840
C          5 IF REAL TIME IS CALLED ENTER FLAGE    NTRA2850
C          6 WRITE TIME,DATE, AND RUN NUMBER       NTRA2860
C          7 CHANGE ANALOG MODE                    NTRA2870
C *****                                          NTRA2880
C          *****                                  NTRA2890
C #####--- RUN COUNTER LOGIC ---#####          NTRA2900
C          IF(OPTTEST.EQ.NIC) GO TO 170            NTRA2910
C          LRUNS=LRUNS+1                            NTRA2920
C          ITRUNS=ITRUNS+1                          NTRA2930
C          170 CONTINUE                             NTRA2940
C          *****                                  NTRA2950
C          *                                         NTRA2960
C          *                                         NTRA2970
C #####--- FIRST MULTI RUN VARIABLE INITIALIZATION PASS ---##### NTRA2980
C          *                                         NTRA2990
C          *****                                  NTRA3000
C          IF(ICT.EQ.0.OR.OPTTEST.NE.NXM) GO TO 165 NTRA3010
C          DO 160 I=1,ICT                            NTRA3020
C          IF(LRUNS.LT.LOOPN(I)) GC TO 160          NTRA3030
C          KTEMP=LRUNS-LOOPN(I)                    NTRA3040
C          BVALUE(LOCAT(I))=VALMR(I)+FLOAT(KTEMP)*FINLMR(I) NTRA3050
C          160 CONTINUE                             NTRA3060
C          165 CONTINUE                             NTRA3070
C          *****                                  NTRA3080
C          #####--- USER INITIALIZATION SUBROUTINES NTRA3090
C          RETURN 2                                  NTRA3100
C          ENTRY NTRAT1(*,*,*,*)                   NTRA3110
C          *****                                  NTRA3120
C          *                                         NTRA3130
C #####--- SECCND PASS FOR MULTI-RUN VARIABLE REINITIALIZATION ---##### NTRA3140
C          *                                         NTRA3150
C          *****                                  NTRA3160
C          IF(ICT.EQ.0.OR.OPTTEST.NE.NXM) GO TO 155 NTRA3170
C          DO 150 I=1,ICT                            NTRA3180
C          IF(LRUNS.LT.LOOPN(I)) GO TO 150          NTRA3190
C          KTEMP=LRUNS-LOOPN(I)                    NTRA3200
C          BVALUE(LOCAT(I))=VALMR(I)+FLOAT(KTEMP)*FINLMR(I) NTRA3210
C          150 CONTINUE                             NTRA3220
C          155 CONTINUE                             NTRA3230
C          *****                                  NTRA3240
C          *****                                  NTRA3250
C          *****                                  NTRA3260
C          THIS ROUTINE SETS POTS ON 680            NTRA3270
C          *****                                  NTRA3280
C          IF(REALT.LT..5) GO TO 75                 NTRA3290
C          DO 1702 I=1,120                           NTRA3300
C          IF(IPOT(I).EQ.IPOTAD(I)) GO TC 1702      NTRA3310
C          CALL POTCHK(I,IPOT(I),3,&8152,&8152)     NTRA3320
C          IPOTAD(I)=IPOT(I)                        NTRA3330
C          1702 CONTINUE                             NTRA3340
C          75 CONTINUE                              NTRA3350
C          *****                                  NTRA3360
C          THIS CALL PLACES THE 680 IN IC          NTRA3370
C          *****                                  NTRA3380
C          CALL SAMO(6,ISAMOE)                      NTRA3390
C          IKEEP = ISAMP - 1                        NTRA3400
C          PASS = ASAMPL                            NTRA3410
C          IDACK=0                                  NTRA3420
C          IADCK = 0                                NTRA3430

```



ILA=2	NTRA4050
IF (MODE.NE.2) GO TO 555	NTRA4060
CNAME=OUTNAM (21)	NTRA4070
IF (DEVICE (21).EQ.1) IIA=1	NTRA4080
IF (DEVICE (21).EQ.2) IFR=2	NTRA4090
I=20	NTRA4100
GO TO 550	NTRA4110
555 IF (IMODE (I).EQ.4) GO TC 560	NTRA4120
IF (IMODE (I).EQ.MODE) GC TO 560	NTRA4130
GO TO 8943	NTRA4140
560 CNAME=OUTNAM (I)	NTRA4150
IF (CNAME.EQ.BLANK) GO TO 8943	NTRA4160
IF (DEVICE (I).EQ.1) IIA=1	NTRA4170
IF (DEVICE (I).EQ.2) IFR=2	NTRA4180
550 CONTINUE	NTRA4190
DO 8946 K=IFR,ILA	NTRA4200
IF (K.EQ.1) MOPU=LPTR	NTRA4210
IF (K.EQ.2) MOPU=ITTY	NTRA4220
IF (CNAME.NE.NADCL) GO TO 3000	NTRA4230
C#####--- LIST ADC ARRAY ---#####	NTRA4240
CALL LSTADC (ADCNUM, MOPU, IADC, SCALAC, NAMADC, ORNAME)	NTRA4250
GO TO 8946	NTRA4260
3000 CONTINUE	NTRA4270
IF (CNAME.NE.NDACL) GO TO 3010	NTRA4280
C#####--- LIST DAC ARRAY ---#####	NTRA4290
CALL LSTDAC (DACNUM, MOPU, IDAC, SCALDC, NAMDAC, ORNAME)	NTRA4300
GO TO 8946	NTRA4310
3010 CONTINUE	NTRA4320
IF (CNAME.NE.NDUMP) GO TO 3020	NTRA4330
C#####--- DUMP ---#####	NTRA4340
CALL DUMP (MOPU, NCOM, ICRDER, ORNAME, BVALUE)	NTRA4350
GO TO 8946	NTRA4360
3020 CONTINUE	NTRA4370
IF (CNAME.NE.NLA) GO TO 3030	NTRA4380
C#####--- LIST ARRAYS & VALUES ---#####	NTRA4390
CALL ARAWT (MOPU, BVALUE, CRNAME)	NTRA4400
GO TO 8946	NTRA4410
3030 CONTINUE	NTRA4420
IF (CNAME.NE.NNPC) GO TC 3040	NTRA4430
C#####--- SPECIAL PROGRAM END OF RUN DATA ---#####	NTRA4440
WRITE (ITTY, 8764)	NTRA4450
GO TO 8946	NTRA4460
3040 CONTINUE	NTRA4470
IF (CNAME.NE.NPLOT) GO TO 3050	NTRA4480
C#####--- PLOTTING SUBROUTINE ---#####	NTRA4490
CALL PLOTS1	
CALL PLTOUT (XDOWN, YACRCS, MOPU, NE, IPLF, JDATE, ORNAME)	
GO TO 8946	NTRA4510
3050 CONTINUE	NTRA4520
IF (CNAME.NE.NSTAT) GO TO 3060	NTRA4530
WRITE (ITTY, 8764)	NTRA4540
GO TO 8946	NTRA4550
3060 CONTINUE	NTRA4560
IF (CNAME.NE.NSTD) GO TO 3070	NTRA4570
C#####--- STANDARD OUTPUT SUBROUTINE ---#####	NTRA4580
CALL QSTD (MOPU)	NTRA4590
GO TO 8946	NTRA4600
3070 CONTINUE	NTRA4610
IF (CNAME.NE.NTABLE) GO TO 3080	NTRA4620
C#####--- TABLE OUTPUT ---#####	NTRA4630
CALL TABLEO (MOPU, ORNAME, LRUNS, ITRUNS, BVALUE)	NTRA4640

GO TO 8946	NTRA4650
3080 CONTINUE	NTRA4660
IF(CNAME.NE.NTESTO) GO TO 3085	NTRA4670
C#####---TEST VALUE OUTPUT ---#####	NTRA4680
WRITE(ITYY,8764)	NTRA4690
GO TO 8946	NTRA4700
3085 CONTINUE	NTRA4710
IF(CNAME.NE.NTIMD) GO TO 3090	NTRA4720
C#####---DATE---#####	NTRA4730
CALL TIMDAT(JDATE,MOPU)	NTRA4740
GO TO 8946	NTRA4750
3090 CONTINUE	NTRA4760
IF(CNAME.NE.NTM) GO TO 3100	NTRA4770
C#####--- ERROR MONITOR OUTPUT ---#####	NTRA4780
CALL ERMONT(MOPU,ORNAME,PHIMAX)	NTRA4790
GO TO 8946	NTRA4800
3100 CONTINUE	NTRA4810
IF(CNAME.NE.NTRACK) GO TO 3110	NTRA4820
C#####--- TRACK OUTPUT ---#####	NTRA4830
CALL TRACO(MOPU,ORNAME,DT)	NTRA4840
GO TO 8946	NTRA4850
3110 CONTINUE	NTRA4860
IF(CNAME.NE.NUOT1) GO TO 3120	NTRA4870
C#####--- USER OUTPUT OPTION 1 ---#####	NTRA4880
WRITE(ITYY,8764)	NTRA4890
GO TO 8946	NTRA4900
3120 CONTINUE	NTRA4910
8946 CONTINUE	NTRA4920
8943 CONTINUE	NTRA4930
8764 FORMAT(1HO,'THIS OPTION HAS NOT BEEN PROGRAMED YET')	NTRA4940
IF(MODE.EQ.2) GO TO 8749	NTRA4950
IF(OPTTEST.EQ.NX) GO TO 8152	NTRA4960
8150 IF(IRUNS.EQ.LRUNS) GO TO 8152	NTRA4970
GO TO 8802	NTRA4980
8152 CONTINUE	NTRA4990
LRUNS=0	NTRA5000
GO TO 8749	NTRA5010
C	NTRA5020
C*****	NTRA5030
C	NTRA5040
C *****	NTRA5050
C *	NTRA5060
C#####--- TERMINATE #####	NTRA5070
C *	NTRA5080
C *****	NTRA5090
C8809 OSECB=0	OVERLAY
8809 CONTINUE	
CALL TIMDAT(JDATE,ITYY)	NTRA5110
IF(IRT.NE.1) GO TO 5607	NTRA5120
C CALL HPOST(DONECB,'DN')	OVERLAY
C CALL WAITRT(OSECB)	OVERLAY
5607 CONTINUE	NTRA5150
WRITE(ITYY,8821)	NTRA5160
8821 FORMAT(1HO,'PROGRAM TERMINATED')	NTRA5170
C CALL RACN(1,IRACNE)	OVERLAY
C CALL CHKIO	OVERLAY
C CALL WRTOFF	OVERLAY
C CALL RDOFF	OVERLAY
RETURN 4	NTRA5220
END	NTRA5230



## H-2.2 FUNCTION

Presented here are the Fortran listings for the FUNCTION subprograms called by the MODEL subprogram. The following list details the names and uses of the functions:

Function	Use
FF	Calculation of front wheel brake torque
FR	Calculation of rear wheel brake torque
FCSI	Calculation of the wheel slip sideforce shaping function
PTBAK	Calculation of a caster trail function
GETDEL	Calculation of a rectangular bump grid for VHTP No. 3
XINT	Linear interpolation of function values among input table data points
AMIN	Selection of the minimum value between two variables
POLY	Evaluation of a fifth-order polynomial approximation to a function

```

C      FUNCTION FF(P)                                CFUN  10
      FUNCTION FF(P)                                CFUN  20
C*****
C      THIS FUNCTION CALCULATES THE FRONT WHEEL BRAKE TORQUE
C*****
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
1AFA(20),GAMF(20),NTF,NTR,NFA                        CFUN  30
      FF=XINT(P,PBF,TQBF,NTF)                        CFUN  40
      RETURN                                         CFUN  50
      END                                           CFUN  60
      END                                           CFUN  70

```

```

C      FUNCTION FR (P)                                CFUN  10
      FUNCTION FR (P)                                CFUN  20
C*****
C      THIS FUNCTION CALCULATES THE REAR WHEEL BRAKE TORQUE
C*****
      COMMON/NEWTBS/TQBF (20) ,PBF (20) ,TQBR (20) ,PBR (20) ,
1AFA (20) ,GAMF (20) ,NTF ,NTR ,NFA                                CFUN  30
      FR=XINT (F ,PBR ,TQBR ,NTR)                            CFUN  40
      RETURN                                                  CFUN  50
      END                                                    CFUN  60
                                                    CFUN  70

```

```

C      FUNCTION FCSI (GAMI ,SLPI)                     CFUN  10
      FUNCTION FCSI (GAMI ,SLPI)                     CFUN  20
C*****
C      THIS FUNCTION CALCULATES THE WHEEL-SLIP SIDE FORCE
C      SHAPING FUNCTION
C*****
      COMMON/NEWTBS/TQBF (20) ,PBF (20) ,TQBR (20) ,PBR (20) ,
1AFA (20) ,GAMF (20) ,NTF ,NTR ,NFA                                CFUN  30
      TMP=ABS (SLPI)                                         CFUN  40
      FCSI = XINT (TMP ,GAMF ,AFA ,NFA)                   CFUN  50
      RETURN                                                  CFUN  60
      END                                                    CFUN  70
                                                    CFUN  80

```

```

C      SUBROUTINE PTBAK (BET ,FRI ,AKKI ,PTBI)        PTBA  10
      SUBROUTINE PTBAK (BET ,FRI ,AKKI ,PTBI)        PTBA  20
C*****
C      THIS FUNCTION CALCULATES CASTER TRAIL
C*****
      COMMON/PTBK/AP1 ,AP2 ,AP3 ,AP4 ,AP5 ,BTC1 ,BTC2          PTBA  30
      AP5=600.                                               PTBA  40
      AKKI=AP4+FRI/AP5                                       PTBA  50
      TEMP=ABS (BET*57.29578)                                PTBA  60
      PTBI=AP1                                               PTBA  70
      IF (TEMP. LE. BTC1) RETURN                              PTBA  80
      PTBI=AP3                                               PTBA  90
      IF (TEMP. GT. BTC2) RETURN                              PTBA 100
      PTBI=AP1*(1.0- (TEMP-BTC1)*AP2)                       PTBA 110
      RETURN                                                  PTBA 120
      END                                                    PTBA 130

```

```

C      FUNCTION GETDEL (X,I,R5,NBMP)                                CFUN  10
      FUNCTION GETDEL (X,I,R5,NBMP)                                CFUN  20
C*****
C      THIS SUBROUTINE PRODUCES THE BUMPS FOR VHTP #3              CFUN  30
C*****
      COMMON/XBS/XB(30),NS(4,30),DELX(4),XI(4),NNN                 CFUN  40
      COMMON/XYZ/NUMBR                                             CFUN  50
      DIMENSION X(4)                                              CFUN  60
      GETDEL=0.0                                                  CFUN  70
      DO 10 K=1,NBMP                                             CFUN  80
      L=NBMP-K+1                                                 CFUN  90
      IF (X(I).LE.XB(L)) NS(I,I)=NUMBR+NNN                       CFUN 100
      IF (X(I).GE.XB(L).AND.NUMBR.LE.NS(I,L)) GC TO 20          CFUN 110
10    CONTINUE                                                  CFUN 120
      RETURN                                                       CFUN 130
20    GETDEL=R5                                                  CFUN 140
      RETURN                                                       CFUN 150
      END                                                         CFUN 160

```

```

C      FUNCTION XINT(ARG,ARGTE,FUN,NP)                             CFUN  10
      FUNCTION XINT(ARG,ARGTB,FUN,NP)                             CFUN  20
C*****
C      THIS FUNCTION PERFORMS LINEAR INTERPOLATION OF FUNCTION
C      VALUES BETWEEN INPUT TABLE DATA POINTS
C*****
      DIMENSION ARGTB(NP),FUN(NP)                                CFUN  40
      DO 10 I=1,NP                                               CFUN  50
      IF (ARG-ARGTB(I)) 30,20,10                                 CFUN  60
10    CONTINUE                                                  CFUN  70
      I=NP                                                       CFUN  80
30    IF (I.EQ.1) I=2                                           CFUN  90
      TEMP=(ARG-ARGTB(I-1))/(ARGTE(I)-ARGTB(I-1))              CFUN 100
      XINT=FUN(I-1)+(FUN(I)-FUN(I-1))*TEMP                       CFUN 110
      RETURN                                                       CFUN 120
20    XINT=FUN(I)                                               CFUN 130
      RETURN                                                       CFUN 140
      END                                                         CFUN 150

```

```

C      FUNCTION AMIN(X,Y)                                          CFUN  10
      FUNCTION AMIN(X,Y)                                          CFUN  20
C*****
C      THIS FUNCTION SELECTS THE MINIMUM VALUE BETWEEN TWO VARIABLES
C*****
      IF (X-Y) 1,1,2                                             CFUN  30
1     AMIN=X                                                       CFUN  40
      RETURN                                                       CFUN  50
2     AMIN=Y                                                       CFUN  60
      RETURN                                                       CFUN  70
      END                                                         CFUN  80

```

C	FUNCTION POLY(DL,TBL)	CFUN	10
	FUNCTION POLY(DL,TBL)	CFUN	20
C	*****		
C	THIS FUNCTION EVALUATES A FIFTH-ORDED POLYNOMIAL		
C	APPROXIMATION TO A FUNCTION		
C	*****		
	DIMENSION TBL(7)	CFUN	40
	TMP=TBL(7)	CFUN	50
	DO 10 I=1,6	CFUN	60
	TMP=TMP*DL+TBL(7-I)	CFUN	70
10	CONTINUE	CFUN	80
	POLY=TMP	CFUN	90
	RETURN	CFUN	100
	END	CFUN	110

H-3. Analog Computer Diagrams

The analog computer diagrams are presented in this section.

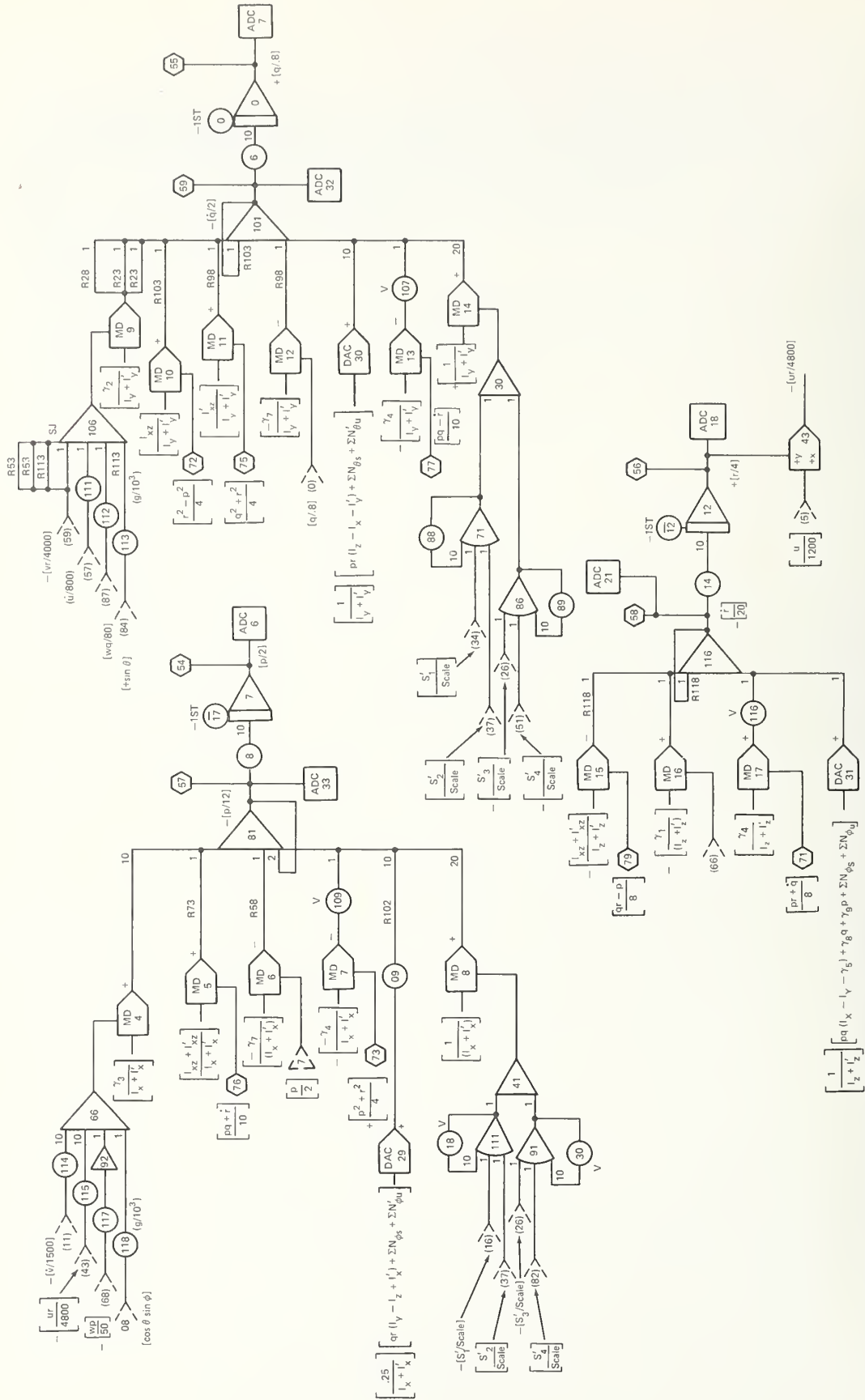


Fig. H-1 Analog Computer Diagram — Angular Accelerations and Velocities

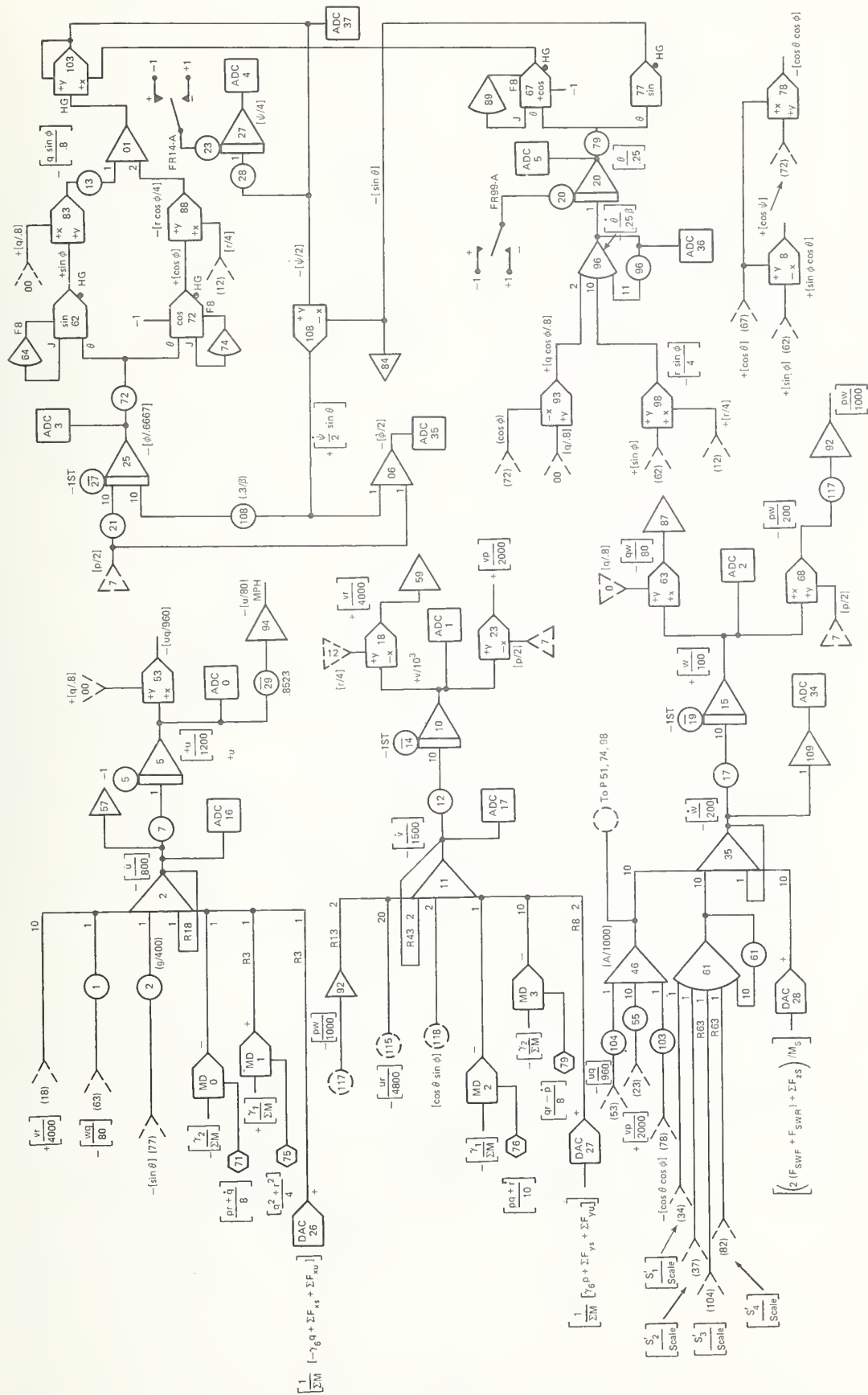


Fig. H-2 Analog Computer Diagram — Linear Accelerations and Velocities, Euler Angles

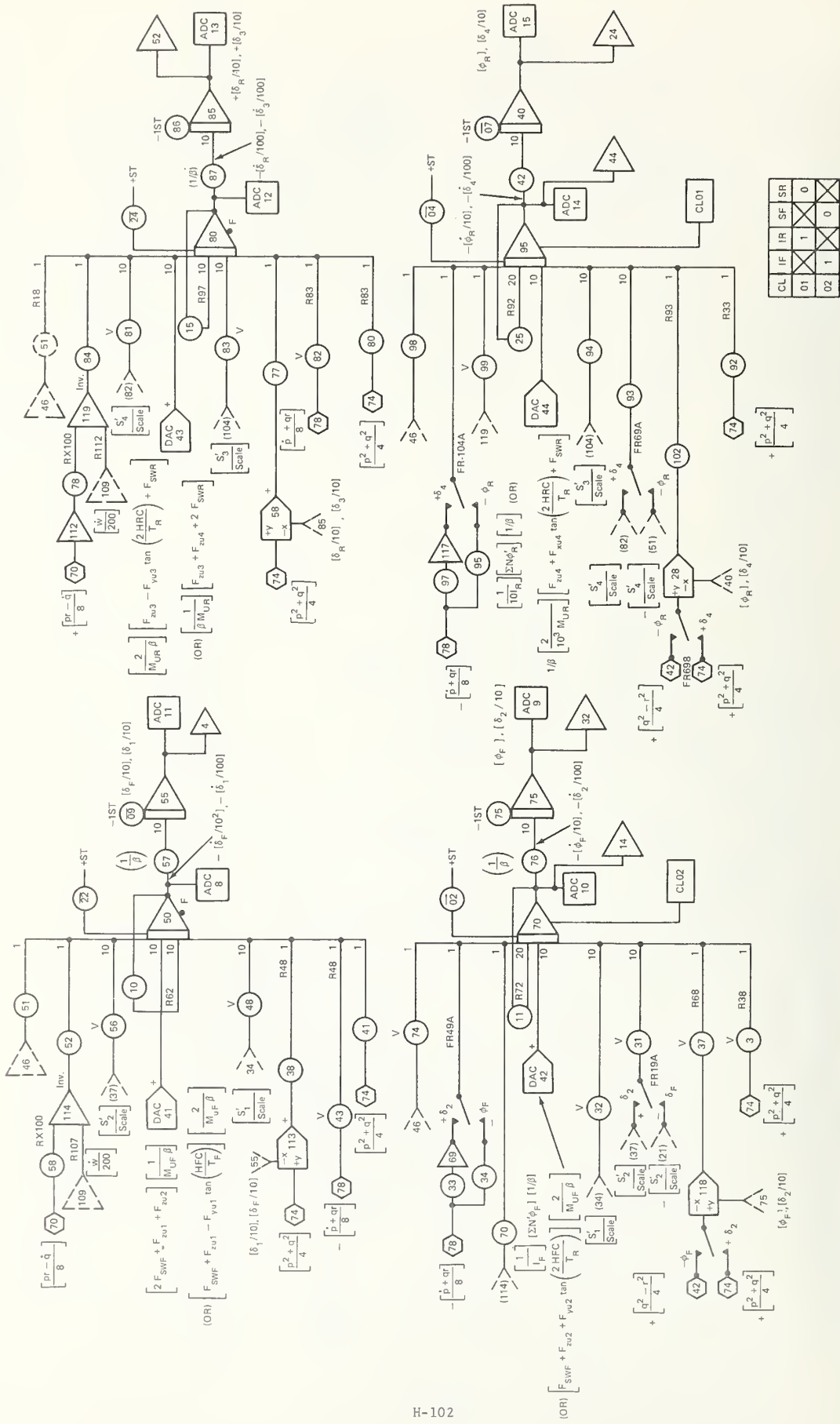


Fig. H-3 Analog Computer Diagram — Deflection Equations



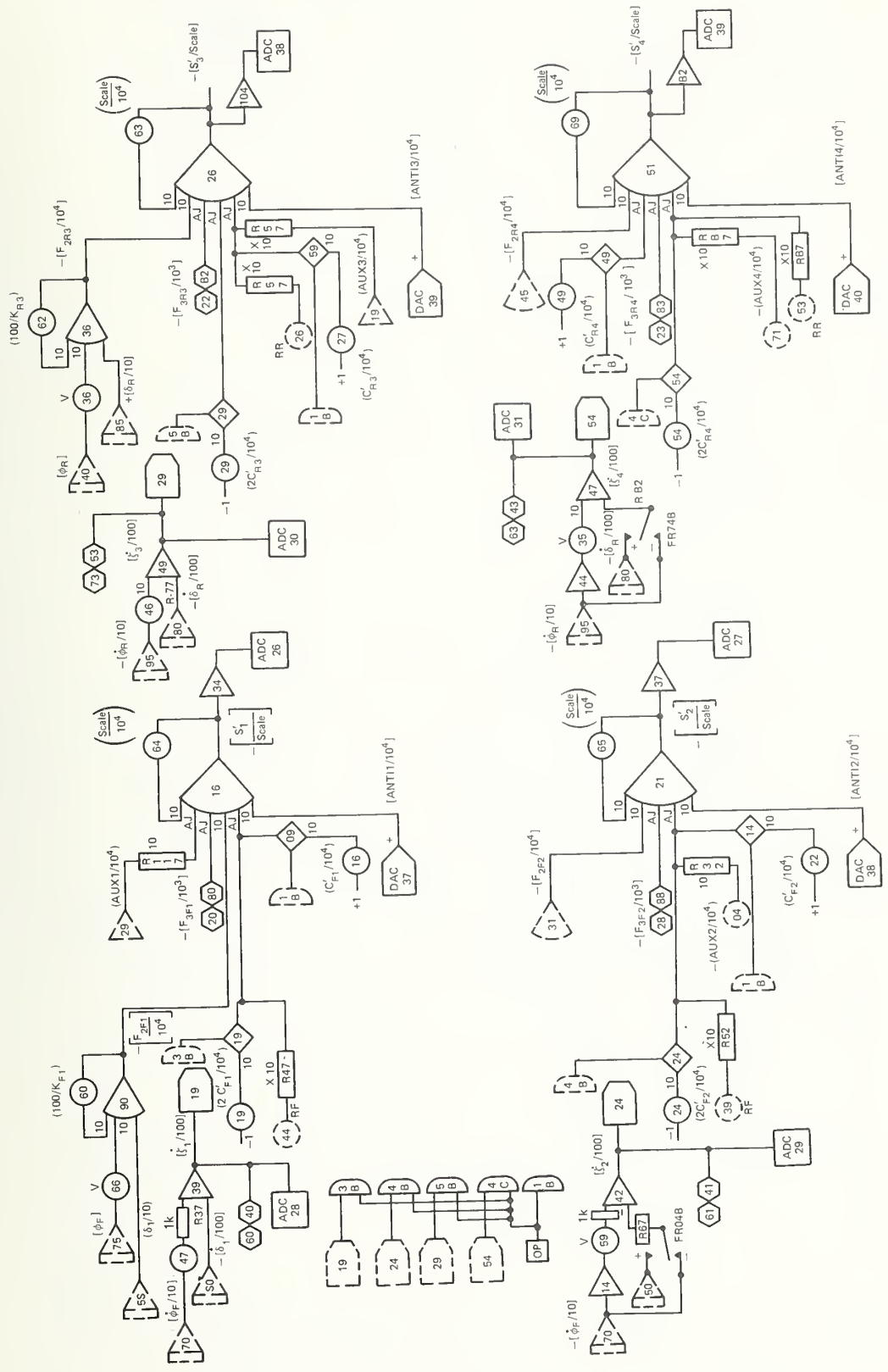


Fig. H-4 Analog Computer Diagram - Suspension Forces



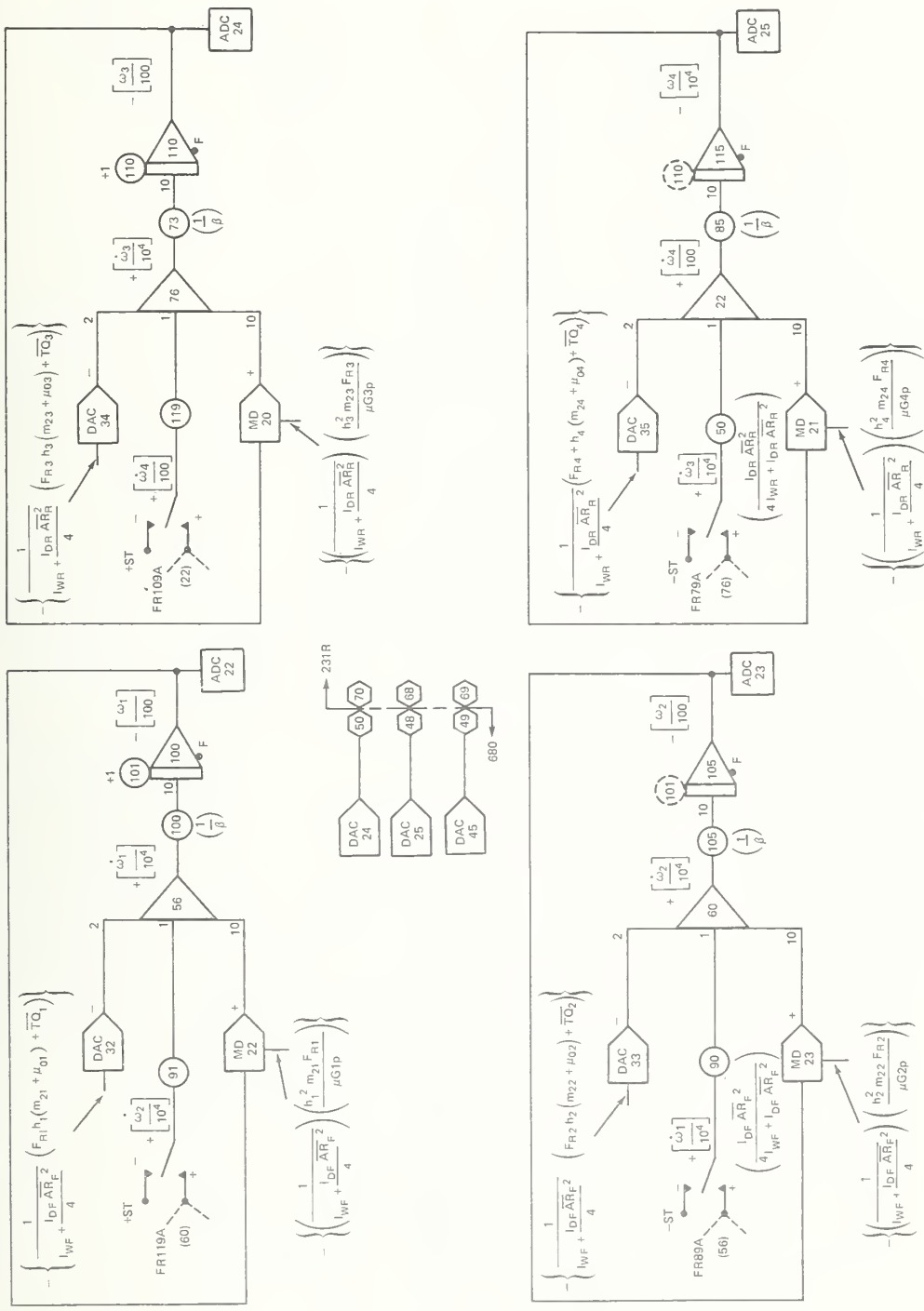


Fig. H-6 Analog Computer Diagram — Rotational Wheel Dynamics

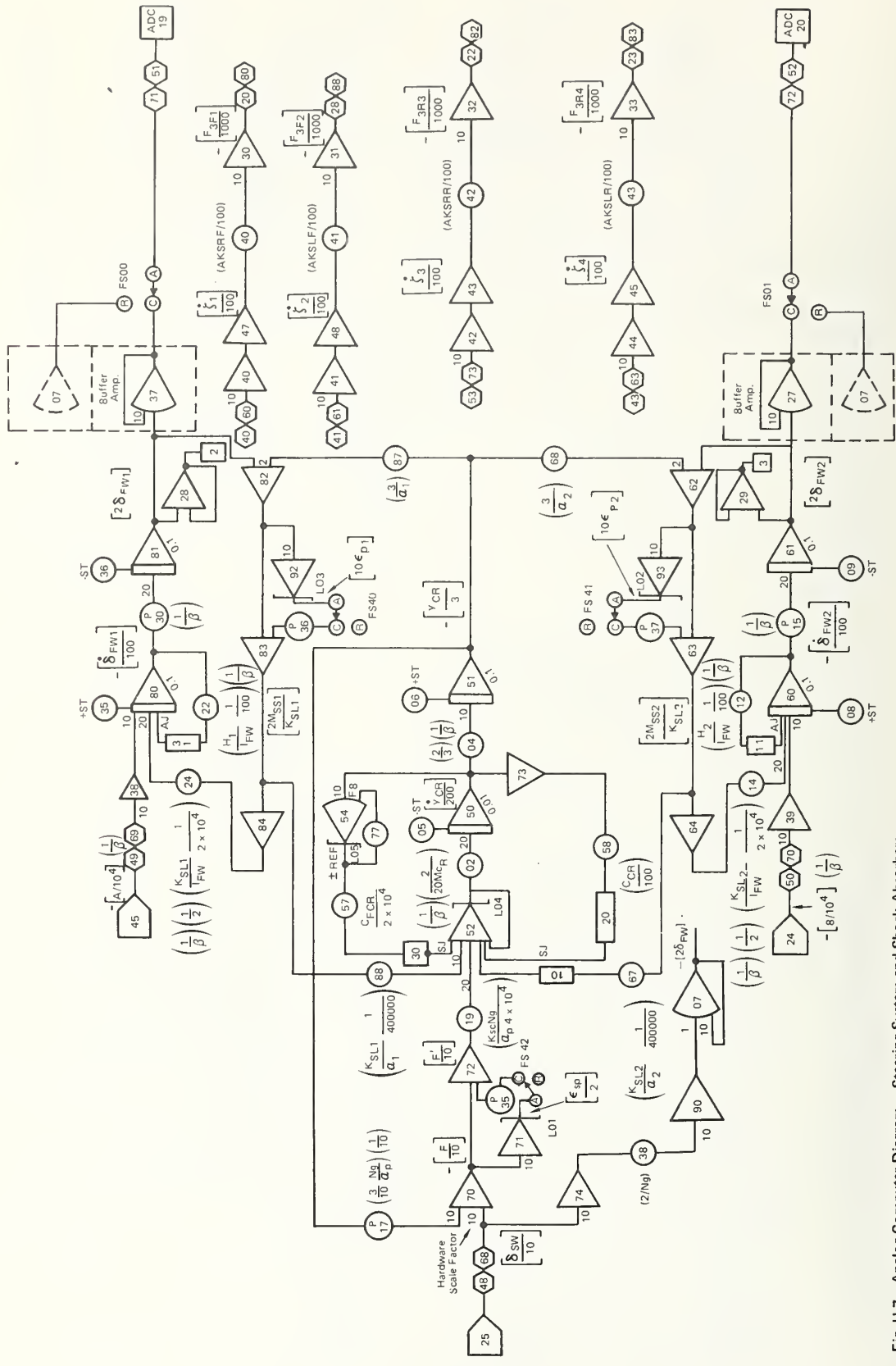


Fig. H-7 Analog Computer Diagram — Steering System and Shock Absorbers



#### H-4. Program Parameter Symbols and Definitions

The symbols and definitions of the program parameters are presented in this section. The order of the parameters corresponds to the input data cards.

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

IN ORDER BY DATA INPUT CARDS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
001	MS	$M_S$	Total sprung mass (lb-s <sup>2</sup> /in.)
002	MUF	$M_{UF}$	Total front unsprung mass (lb-s <sup>2</sup> /in.)
003	MUR	$M_{UR}$	Total rear unsprung mass (lb-s <sup>2</sup> /in.)
004	ZF	$z_F$	Static distance between center of gravity (c.g.) of sprung mass and spin axis of front wheels in z direction (in.)
005	ZR	$z_R$	Static distance between c.g. of sprung mass and spin axis of rear wheels in z direction (in.)
006	A	a	Distance between c.g. of sprung mass and spin axis of front wheels in x direction (in.)
007	B	b	Distance between c.g. of sprung mass and spin axis of rear wheels in x direction (in.)
008	TF	$T_F$	Front tread width (in.)
009	TR	$T_R$	Rear tread width (in.)
010	TSR	$T_{SR}$	Distance between solid rear axle spring centers in y direction (in.)
011	IX	$I_X$	Roll moment of inertia of sprung mass (lb-in.-s <sup>2</sup> )
012	IY	$I_Y$	Pitch moment of inertia of sprung mass (lb-in.-s <sup>2</sup> )
013	IZ	$I_Z$	Yaw moment of inertia of sprung mass (lb-in.-s <sup>2</sup> )

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
014	IXZ	$I_{XZ}$	Product of inertia of sprung mass (lb-in.-s <sup>2</sup> )
015	IR	$I_R$	Moment of inertia of solid rear axle about a line through its c.g. and parallel to the x axis (exclude 0 for computational purposes) (lb-in.-s <sup>2</sup> )
016	ROOR		Vehicle rollover angle (deg)
017	RF	$R_F$	Auxiliary roll stiffness in front suspension (lb-in./rad)
018	STOP		Terminal velocity for simulation shutoff (mph)
019	AKF1	$K_{F1}$	Right front suspension spring rate (lb/in.)
020	AKF2	$K_{F2}$	Left front suspension spring rate (lb/in.)
021	AKR3	$K_{R3}$	Right rear suspension spring rate (lb/in.)
022	AKR4	$K_{R4}$	Left rear suspension spring rate (lb/in.)
023	ALS		Brake antilock option: 023 = 0, no; 023 = 1, yes
024	RR	$R_R$	Auxiliary roll stiffness in rear suspension (lb-in./rad)
025	CF1P	$C'_{F1}$	Coulomb damping at right front wheel (lb)
026	CF2P	$C'_{F2}$	Coulomb damping at left front wheel (lb)
027	CR3P	$C'_{R3}$	Coulomb damping at right rear wheel (lb)



SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
 IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
028	CR4P	$C'_{R4}$	Coulomb damping at left rear wheel (lb)
029	ZBAS	$Z_{BIAS}$	Bias constant to vertically shift the vehicle c.g. position (in.)
030	KRS	$K_{RS}$	Roll steer coefficient of solid rear axle (rad/rad)
031	RW	$R_w$	Undelected tire radius (in.)
032	SCAL		Suspension force scale factor
033	FOT	$A_{\Omega TF}$	Proportionality factor defining limits of small-angle cornering and camber stiffness approximation, front wheels
034	A0	$A_{0F}$	Constant term in small-angle cornering stiffness function, front wheels (lb/rad)
035	A1	$A_{1F}$	Linear term coefficient in small-angle cornering stiffness function, front wheels (l/rad)
036	A2	$A_{2F}$	Quadratic term coefficient in small-angle cornering stiffness function, front wheels (lb)
037	A3	$A_{3F}$	Linear term coefficient in small-angle camber stiffness function, front wheels (l/rad)
038	A4	$A_{4F}$	Quadratic term coefficient in small-angle camber stiffness function, front wheels (lb)
039	TIR	$T_{IR}$	Distance in the y direction between the centers of inside tires for solid rear axle with dual tires (in.)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
040	TOR	$T_{OR}$	Distance in the y direction between the centers of outside tires for solid rear axle with dual tires (in.)
041	KSC	$K_{SC}$	Steering column-gear flexibility (lb-in./rad)
042	NG	$N_G$	Gear ratio of steering gear box
043	TSD		Combined sinusoidal-trapezoidal steer maneuver; start time of trapezoidal steer angle decrease (s)
044	DSL <sub>M</sub>		Combined sinusoidal-trapezoidal steer maneuver; time to achieve 0 trapezoidal steer angle (exclude 0 for computational purposes) (s)
045	TFT		Combined sinusoidal-trapezoidal steer maneuver; end time of trapezoidal steer maneuver (s)
046	DSW2		Sinusoidal steer amplitude (second half of period) (deg)
047	IFW	$I_{FW}$	Moment of inertia of front wheel about the kingpin axis (lb-in.-s <sup>2</sup> )
048	IF	$I_F$	Moment of inertia of solid front axle about a line through its c.g. and parallel to the x axis (lb-in.-s <sup>2</sup> )
049	IWF	$I_{WF}$	Moment of inertia of front wheel about its spin axis (lb-in.-s <sup>2</sup> )
050	IWR	$I_{WR}$	Moment of inertia of rear wheel about its spin axis (lb-in.-s <sup>2</sup> )
051	IDR	$I_{DR}$	Moment of inertia of rear drive line about its spin axis (lb-in.-s <sup>2</sup> )
052	ARR	$\overline{AR}_R$	Rear wheel drive axle ratio

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
053	TSF	$T_{SF}$	Distance between solid front axle spring centers in y direction (in.)
054	KFS	$K_{FS}$	Roll steer coefficient of solid front axle (rad/rad)
055	PT	$\overline{PT}$	Front wheel caster trail (in.)
056	YSAL	$Y_{SA1}$	Distance between kingpin axis and wheel centerline, measured along wheel spin axis, right front (in.)
057	YSA2	$Y_{SA2}$	Distance between kingpin axis and wheel centerline, measured along wheel spin axis, left front (in.)
058	PHS1	$\phi_{SA01}$	Right wheel kingpin inclination angle at equilibrium suspension position (rad)
059	PHS2	$\phi_{SA02}$	Left wheel kingpin inclination angle at equilibrium suspension position (rad)
060	CTSW		Caster trail switch: 060 = 0, function; 1, constant
061	IDF	$I_{DF}$	Moment of inertia of front drive line about its spin axis (lb-in.-s <sup>2</sup> )
062	ARF	$\overline{AR}_F$	Front wheel drive axle ratio
063-074			Initial conditions: p, q, r, u, v, w, x, y, z, $\theta$ , $\phi$ , $\psi$ . Note $z_0$ and $\theta_0$ are computed values at t = 0 and need not be specified.
075	DT		Integration step size (s)
076	TN		Maximum run time (s)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
077-078	KTI	$K_{Ti}$	Tire spring rate, front wheels (lb/in.)
079-080	KTI	$K_{Ti}$	Tire spring rate, rear wheels (lb/in.)
081-084	RPSI	$\omega_i$	Initial wheel rotation rates computed at $t = 0$ (rad/s)
085	B1	$B_{1F}$	Load term coefficient of lateral friction coefficient, front tire (1/lb)
086	B2	$B_{2F}$	Velocity term coefficient of lateral friction coefficient, front tire (1/mph)
087	B3	$B_{3F}$	Constant term of lateral friction coefficient, front tire (dimensionless)
088	B4	$B_{4F}$	Quadratic load term coefficient of lateral friction coefficient, front tire (1/lb <sup>2</sup> )
089-091		$\delta_i$	Initial conditions: $\delta_i$
092	DELF	$\delta_{FIN}$	Static displacement change in front suspension due to vehicle load configuration (in.)
093	DELR	$\delta_{RIN}$	Static displacement change in rear suspension due to vehicle load configuration (in.)
094-106		$\delta_i, \phi_R, \phi_R, \delta_{FWI}, \mu_{Xi}, S'_i$	Initial conditions: $\delta_i, \phi_R, \phi_R, \delta_{FWI}, \mu_{Xi}, S'_i$
107	PPRT		Parameter table, print control: 107 = 0, no print; = 1, print

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
108	FREQ		Sinusoidal steer frequency (Hz)
109			Unassigned
110	TQMX	$TQ_{D_{MAX}}$	Maximum available drive torque (lb-in)
111	KTQ	$K_{TQ}$	Drive torque gain factor (lb-s)
112	VC	$V_C$	Commanded velocity (mph)
113	MTSW		Front wheel kingpin moment switch: 113 = 0, out; = 1, in
114	DSWM	$\delta_{SW}$	Maximum steering wheel angle, except sinusoidal steer (deg)
115	TST		Initial time of steer, except sinusoidal steer (s)
116	DSLPL		Time to achieve maximum steer angle, equivalent to steer rate, except sinusoidal steer (exclude 0 for computational purposes) (s)
117	CGAM		Initial time of brake application, except drastic brake and steer (s)
118	CS		Initial time of brake application, except drastic brake and steer (s)
119	TQR	$\overline{TQ_{Bi}}$	Rear wheel brake torque (lb-in.)
120	TQF	$\overline{TQ_{Bi}}$	Front wheel brake torque (lb-in.)
121	PFL		Applied brake pressure (psi)
122	TTD		Drive torque control (s)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
123	DSWL		Sinusoidal steer amplitude (first half of period) (deg)
124			Unassigned
125	ISW5		VHTP drastic steer-brake switch: 125 = 0, no braking; = 1, braking
126	SW15		VHTP sinusoidal steer switch: 126 = 0, disable; = 1, enable
127			Unassigned
128	VTPS		VHTP switch
129	VHTP		VHTP index
130	AMCR	$M_{CR}$	Mass of steering system connecting rod ( $lb-s^2/in.$ )
131	ESP	$\epsilon_{SP}$	Free play in steering gear box (rad)
132	KSL1	$K_{SL1}$	Steering linkage flexibility, right front wheel ( $lb-in./rad$ )
133	KSL2	$K_{SL2}$	Steering linkage flexibility, left front wheel ( $lb-in./rad$ )
134-135	AAI	$a_{Li}$	Length of steering linkage arms (in.)
136	CCR	$C_{CR}$	Viscous damping coefficient of steering system connecting rod ( $lb-s/in.$ )
137	CFCR	$C_{FCR}$	Coulomb damping of steering system connecting rod (lb)
138	AP	$a_p$	Length of Pitman arm (in.)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
139-140	EPI	$\epsilon_{Pi}$	Free play in steer of front wheel (rad)
141	AERO		Aerodynamic option: 141 = 0, no; = 1, yes
142	VYW	$v_{yw}$	Velocity of cross wind in space-fixed axes, measured at sprung mass c.g. (in./s)
143	OMXW	$\omega_{xw}$	Angular wind velocity about X axis in space-fixed system (rad/s)
144	OMZW	$\omega_{zw}$	Angular wind velocity about Z axis in space-fixed system (rad/s)
145	RHOA	$\rho_a$	Mass density of air (lb-s <sup>2</sup> /in. <sup>4</sup> )
146	CYP	$C_{y p}$	Aerodynamic stability derivative of lateral force coefficient with respect to roll velocity
147	CYR	$C_{y r}$	Aerodynamic stability derivative of lateral force coefficient with respect to yaw velocity
148	CZAL	$C_{z \alpha}$	Aerodynamic stability derivative of normal force coefficient with respect to aerodynamic angle of attack
149	CZQ	$C_{z q}$	Aerodynamic stability derivative of normal force coefficient with respect to pitch velocity
150	CLP	$C_{\lambda p}$	Aerodynamic stability derivative of rolling moment coefficient with respect to roll velocity
151	CLR	$C_{\lambda r}$	Aerodynamic stability derivative of rolling moment coefficient with respect to yaw velocity

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
152	CMAL	$C_{m\alpha}$	Aerodynamic stability derivative of pitching moment coefficient with respect to aerodynamic angle of attack
153	CMQ	$C_{m\dot{q}}$	Aerodynamic stability derivative of pitching moment coefficient with respect to pitch velocity
154	CNP	$C_{n\dot{p}}$	Aerodynamic stability derivative of yawing moment coefficient with respect to roll velocity
155	CNR	$C_{n\dot{r}}$	Aerodynamic stability derivative of yawing moment coefficient with respect to yaw velocity
156	SF	$S_f$	Projected frontal area of vehicle, including tires and underbody parts; characteristic area upon which aerodynamic force and moment coefficients are based (in. <sup>2</sup> )
157	VLEN	$l_v$	Vehicle length; characteristic length upon which aerodynamic moment coefficients are based (in.)
158	REWV	$R_{wv}$	Resultant wind velocity (in./s)
159-168			Unassigned
169	SNT	(SN) <sub>T</sub>	Tire data surface skid number
170	SNSO	(SN) <sub>SO</sub>	Simulated vehicle surface skid number
171	SNSI	(SN) <sub>SI</sub>	Simulated vehicle surface skid number



SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
 IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
172	SNSW		Skid patch switch: 172 = 0, side approach; = 1, front approach; = 2, disable
173	DIST		Initial distance between car and skid patch (in.)
174	PL		Skid patch length (in.)
175	TSCP		Computer time scale factor
176	SCSW		Suspension compensation switch: 176 = 0, disable; = 1, enable
177-181			Unassigned
182-185	SII	$SI_i$	Wheel slip ratio at which peak braking coefficient of friction occurs
186	SARF	$K_{S1}$	Right front shock absorber rate (lb-s/in.)
187	SALF	$K_{S2}$	Left front shock absorber rate (lb-s/in.)
188	SARR	$K_{S3}$	Right rear shock absorber rate (lb-s/in.)
189	SALR	$K_{S4}$	Left rear shock absorber rate (lb-s/in.)
190-191			Unassigned
192	MTQB		Brake force rate (exclude 0 for computational purposes) (psi/s)
193	DCSW		Driver control switch: 193 = 0, disable; = 1, enable
194	LDF		Lateral displacement feedback gain (deg/in.)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
195	LDRF		Lateral displacement rate feedback gain (deg/in./s)
196-197	EKI	$\Delta\psi_i$	Static front wheel toe bias angle (deg)
198	BMPL		Length of single road bump (in.)
199	BMPS		Distance between leading edges of consecutive rectangular road bumps (in.)
200	BMPH		Road bump height (in.)
201	XB		Initial distance from car to first bump (in.)
202	APF1	$P_{BF1}$	Front tire peak braking coefficient of friction, constant term (dimensionless)
203	APF2	$P_{BF2}$	Front tire peak braking coefficient of friction, linear term coefficient (1/lb)
204	APR1	$P_{BR1}$	Rear tire peak braking coefficient of friction, constant term (dimensionless)
205	APR2	$P_{BR2}$	Rear tire peak braking coefficient of friction, linear term coefficient (1/lb)
206	MUSF	$\mu_{SF}$	Front tire sliding coefficient of friction
207	MUSR	$\mu_{SR}$	Rear tire sliding coefficient of friction
208	BCON		$\mu'$ beta constant

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
209	FCSW		Tire sideforce friction coefficient switch: 209 = 0, polynomial function; = 1, tabular function
210	SIF	$S_{IF}$	Front tire linear coefficient of sliding friction (1/lb)
211	SIR	$S_{IR}$	Rear tire linear coefficient of sliding friction (1/lb)
212	KLR	$K_{LR}$	Rear lateral force compliance steer (rad/lb)
213	KOTF	$K_{OTF}$	Front overturning moment compliance camber (rad/lb-in.)
214	KOTR	$K_{OTR}$	Rear overturning moment compliance camber (rad/lb-in.)
215-218			Unassigned
219-220	FEEI	$\Delta\phi_i$	Front wheel camber bias angle (deg)
221-222	THEI	$\Delta\phi_i$	Front wheel caster bias angle (deg)
223	ALMC		Antilock module configuration; 223 = 1, two modules; = 2, one module; = 3, three modules; = 4, four modules
224-230			Unassigned
231-232	HI	$H_i$	Viscous damping derivative in front wheel (lb-in.-s/rad)
233	LAMD	$\lambda_D$	Drive torque distribution factor
234-235			Unassigned

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
236	PS01	$\phi_{S01}$	Constant angle between the right wheel steering axis and the wheel plane (rad)
237	PS02	$\phi_{S02}$	Constant angle between the left wheel steering axis and the wheel plane (rad)
238-241	BRI	$\lambda_{Bi}$	Brake torque multiplier for wheel i
242	KCF	$K_{CF}$	Front lateral force compliance camber coefficient (rad/lb)
243	KCR	$K_{CR}$	Rear lateral force compliance camber coefficient (rad/lb)
244	KSR	$K_{SR}$	Rear aligning torque compliance steer coefficient (rad/(lb-in.))
245	RB1	$B_{1R}$	Load term coefficient of lateral friction coefficient, rear tire (1/lb)
246	RB2	$B_{2R}$	Velocity term coefficient of lateral friction coefficient, rear tire (1/mpH)
247	RB3	$B_{3R}$	Constant term of lateral friction coefficient, rear tire (dimensionless)
248	RB4	$B_{4R}$	Quadratic load term coefficient of lateral friction coefficient, rear tire (1/lb <sup>2</sup> )
249	AFK1	$A_{F1}$	Aligning torque coefficient, front tire (in./lb)
250	AFK2	$A_{F2}$	Aligning torque coefficient, front tire (in./lb)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
251	AFK3	A <sub>F3</sub>	Aligning torque coefficient, front tire (in./rad <sup>1/2</sup> )
252	ARK1	A <sub>R1</sub>	Aligning torque coefficient, rear tire (in./lb)
253	ARK2	A <sub>R2</sub>	Aligning torque coefficient, rear tire (in./lb)
254	ARK3	A <sub>R3</sub>	Aligning torque coefficient, rear tire (in./rad <sup>1/2</sup> )
255	OFC0	O <sub>F0</sub>	Overturning moment coefficient, front tire (lb-in.)
256	OFC1	O <sub>F1</sub>	Overturning moment coefficient, front tire (in./lb)
257	OFC2	O <sub>F2</sub>	Overturning moment coefficient, front tire (in./(lb-rad))
258	OFC3	O <sub>F3</sub>	Overturning moment coefficient, front tire (in./rad)
259	ORC0	O <sub>R0</sub>	Overturning moment coefficient, rear tire (lb-in.)
260	ORC1	O <sub>R1</sub>	Overturning moment coefficient, rear tire (in./lb)
261	ORC2	O <sub>R2</sub>	Overturning moment coefficient, rear tire (in./(lb-rad))
262	ORC3	O <sub>R3</sub>	Overturning moment coefficient, rear tire (in./rad)
263	CPOF	P <sub>F0</sub>	Antipitch coefficient, front suspension (dimensionless)
264	CPIF	P <sub>F1</sub>	Antipitch coefficient, front suspension (1/in.)
265	CP2F	P <sub>F2</sub>	Antipitch coefficient, front suspension (1/in. <sup>2</sup> )

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
266	CPOR	$P_{R0}$	Antipitch coefficient, rear suspension (dimensionless)
267	CP1R	$P_{R1}$	Antipitch coefficient, rear suspension (1/in.)
268	CP2R	$P_{R2}$	Antipitch coefficient, rear suspension (1/in. <sup>2</sup> )
269	CROF	$R_{F0}$	Antiroll coefficient, front suspension (dimensionless)
270	CR1F	$R_{F1}$	Antiroll coefficient, front suspension (1/in.)
271	CR2F	$R_{F2}$	Antiroll coefficient, front suspension (1/in. <sup>2</sup> )
272	CROR	$R_{R0}$	Antiroll coefficient, rear suspension (dimensionless)
273	CR1R	$R_{R1}$	Antiroll coefficient, rear suspension (1/in.)
274	CR2R	$R_{R2}$	Antiroll coefficient, rear suspension (1/in. <sup>2</sup> )
275	STSW		Steer input switch: 275 = 0, VHTP sinusoidal or trapezoidal steer; = 1, tabular function
276	MMSW		Model modification switch: 276 = 0, nominal; ≠ 0, nonnominal
277	BMPN		Number of bumps in bump grid
278	TQBO		Time of brake application in combined drastic brake and steer VHTP (s)
279	TQB1		Time of brake release in combined drastic brake and steer VHTP (s)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
280-283			Unassigned
284	HFC	$h_{FC}$	Distance between ground and static roll center of front independent suspension (set to 0 for solid front axle configuration) (in.)
285	HRC	$h_{RC}$	Distance between ground and static roll center of rear independent suspension (set to 0 for solid rear axle configuration) (in.)
286	DRSW		Drive wheel switch: 286 = 0, rear-wheel drive; = 1, four-wheel drive
287	AXLE		Suspension configuration: 287 = 0, solid front/rear; = 1, independent front/rear
288	DUAL		Rear dual tire option: 288 = 0, no duals; = 1, duals
289	TIRE		Number of vehicle tires: 289 = 4, single rear tires; = 6, dual rear tires; = 10, double dual rear tires
290	ROT	$A_{Q_{TR}}$	Proportionality factor defining limits of small-angle cornering and camber stiffness approximation, rear wheels
291	RA0	$A_{OR}$	Constant term in small-angle cornering stiffness function, rear wheels (lb/rad)
292	RA1	$A_{1R}$	Linear term coefficient in small-angle cornering stiffness function, rear wheels (1/rad)
293	RA2	$A_{2R}$	Quadratic term coefficient in small-angle cornering stiffness function, rear wheels (lb)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
IN ORDER BY DATA INPUT CARDS (cont'd)

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
294	RA3	A <sub>3R</sub>	Linear term coefficient in small-angle camber stiffness function, rear wheels (1/rad)
295	RA4	A <sub>4R</sub>	Quadratic term coefficient in small-angle camber stiffness function, rear wheels (lb)



H-5. Vehicle Descriptor or Tire Model Coefficient Symbols and Definitions

The symbols and definitions of the program parameters that are vehicle descriptors or tire model coefficients are presented in this subsection.

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
001	MS	$M_S$	Total sprung mass (lb-s <sup>2</sup> /in.)
002	MUF	$M_{UF}$	Total front unsprung mass (lb-s <sup>2</sup> /in.)
003	MUR	$M_{UR}$	Total rear unsprung mass (lb-s <sup>2</sup> /in.)
004	ZF	$z_F$	Static distance between center of gravity (c.g.) of sprung mass and spin axis of front wheels in z direction (in.)
005	ZR	$z_R$	Static distance between c.g. of sprung mass and spin axis of rear wheels in z direction (in.)
006	A	a	Distance between c.g. of sprung mass and spin axis of front wheels in x direction (in.)
007	B	b	Distance between c.g. of sprung mass and spin axis of rear wheels in x direction (in.)
008	TF	$T_F$	Front tread width (in.)
009	TR	$T_R$	Rear tread width (in.)
010	TSR	$T_{SR}$	Distance between solid rear axle spring centers in y direction (in.)
011	IX	$I_X$	Roll moment of inertia of sprung mass (lb-in.-s <sup>2</sup> )
012	IY	$I_Y$	Pitch moment of inertia of sprung mass (lb-in.-s <sup>2</sup> )
013	IZ	$I_Z$	Yaw moment of inertia of sprung mass (lb-in.-s <sup>2</sup> )

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
014	IXZ	$I_{XZ}$	Product of inertia of sprung mass (lb-in.-s <sup>2</sup> )
015	IR	$I_R$	Moment of inertia of solid rear axle about a line through its c.g. and parallel to the x axis (exclude 0 for computational purposes) (lb-in.-s <sup>2</sup> )
017	RF	$R_F$	Auxiliary roll stiffness in front suspension (lb-in./rad)
019	AKF1	$K_{F1}$	Right front suspension spring rate (lb/in.)
020	AKF2	$K_{F2}$	Left front suspension spring rate (lb/in.)
021	AKR3	$K_{R3}$	Right rear suspension spring rate (lb/in.)
022	AKR4	$K_{R4}$	Left rear suspension spring rate (lb/in.)
024	RR	$R_R$	Auxiliary roll stiffness in rear suspension (lb-in./rad)
025	CF1P	$C'_{F1}$	Coulomb damping at right front wheel (lb)
026	CF2P	$C'_{F2}$	Coulomb damping at left front wheel (lb)
027	CR3P	$C'_{R3}$	Coulomb damping at right rear wheel (lb)
028	CR4P	$C'_{R4}$	Coulomb damping at left rear wheel (lb)
030	KRS	$K_{RS}$	Roll steer coefficient of solid rear axle (rad/rad)
031	RW	$R_w$	Undelected tire radius (in.)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
033	FOT	$A_{3C,TF}$	Proportionality factor defining limits of small-angle cornering and camber stiffness approximation, front wheels
034	A0	$A_{0F}$	Constant term in small-angle cornering stiffness function, front wheels (lb/rad)
035	A1	$A_{1F}$	Linear term coefficient in small-angle cornering stiffness function, front wheels (1/rad)
036	A2	$A_{2F}$	Quadratic term coefficient in small-angle cornering stiffness function, front wheels (lb)
037	A3	$A_{3F}$	Linear term coefficient in small-angle camber stiffness function, front wheels (1/rad)
038	A4	$A_{4F}$	Quadratic term coefficient in small-angle camber stiffness function, front wheels (lb)
039	TIR	$T_{IR}$	Distance in the y direction between the centers of inside tires for solid rear axle with dual tires (in.)
040	TOR	$T_{OR}$	Distance in the y direction between the centers of outside tires for solid rear axle with dual tires (in.)
041	KSC	$K_{SC}$	Steering column-gear flexibility (lb-in./rad)
042	NG	$N_G$	Gear ratio of steering gear box
047	IFW	$I_{FW}$	Moment of inertia of front wheel about the kingpin axis (lb-in.-s <sup>2</sup> )

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
048	IF	$I_F$	Moment of inertia of solid front axle about a line through its c.g. and parallel to the x axis (lb-in.-s <sup>2</sup> )
049	IWF	$I_{WF}$	Moment of inertia of front wheel about its spin axis (lb-in.-s <sup>2</sup> )
050	IWR	$I_{WR}$	Moment of inertia of rear wheel about its spin axis (lb-in.-s <sup>2</sup> )
051	IDR	$I_{DR}$	Moment of inertia of rear drive line about its spin axis (lb-in.-s <sup>2</sup> )
052	ARR	$\overline{AR}_R$	Rear wheel drive axle ratio
053	TSF	$T_{SF}$	Distance between solid front axle spring centers in y direction (in.)
054	KFS	$K_{FS}$	Roll steer coefficient of solid front axle (rad/rad)
055	PT	$\overline{PT}$	Front wheel caster trail (in.)
056	YSA1	$Y_{SA1}$	Distance between kingpin axis and wheel centerline, measured along wheel spin axis, right front (in.)
057	YSA2	$Y_{SA2}$	Distance between kingpin axis and wheel centerline, measured along wheel spin axis, left front (in.)
058	PHS1	$\phi_{SA01}$	Right wheel kingpin inclination angle at equilibrium suspension position (rad)
059	PHS2	$\phi_{SA02}$	Left wheel kingpin inclination angle at equilibrium suspension position (rad)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
061	IDF	$I_{DFZ}$	Moment of inertia of front drive line about its spin axis (lb-in.-s <sup>2</sup> )
062	ARF	$\overline{AR}_F$	Front wheel drive axle ratio
077-078	KTI	$K_{T1}$	Tire spring rate, front wheels (lb/in.)
079-080	KTI	$K_{T1}$	Tire spring rate, rear wheels (lb/in.)
085	B1	$B_{1F}$	Load term coefficient of lateral friction coefficient, front tire (1/lb)
086	B2	$B_{2F}$	Velocity term coefficient of lateral friction coefficient, front tire (1/mpH)
087	B3	$B_{3F}$	Constant term of lateral friction coefficient, front tire (dimensionless)
088	B4	$B_{4F}$	Quadratic load term coefficient of lateral friction coefficient, front tire (1/lb <sup>2</sup> )
092	DEL F	$\delta_{FIN}$	Static displacement change in front suspension due to vehicle load configuration (in.)
093	DEL R	$\delta_{RIN}$	Static displacement change in rear suspension due to vehicle load configuration (in.)
130	AMCR	$M_{CR}$	Mass of steering system connecting rod (lb-s <sup>2</sup> /in.)
131	ESP	$\epsilon_{SP}$	Free play in steering gear box (rad)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
132	KSL1	$K_{SL1}$	Steering linkage flexibility, right front wheel (lb-in./rad)
133	KSL2	$K_{SL2}$	Steering linkage flexibility, left front wheel (lb-in./rad)
134-135	AAI	$a_{Li}$	Length of steering linkage arms (in.)
136	CCR	CCR	Viscous damping coefficient of steering system connecting rod (lb-s/in.)
137	CFCR	$C_{FCR}$	Coulomb damping of steering system connecting rod (lb)
138	AP	$a_p$	Length of Pitman arm (in.)
139-140	EPI	$\epsilon_{Pi}$	Free play in steer of front wheel (rad)
142	VYW	$v_{yw}$	Velocity of cross wind in space-fixed axes, measured at sprung mass c.g. (in./s)
143	OMXW	$\omega_{xw}$	Angular wind velocity about X axis in space-fixed system (rad/s)
144	OMZW	$\omega_{zw}$	Angular wind velocity about Z axis in space-fixed system (rad/s)
145	RHOA	$\rho_a$	Mass density of air (lb-s <sup>2</sup> /in. <sup>4</sup> )
146	CYP	$C_{yp}$	Aerodynamic stability derivative of lateral force coefficient with respect to roll velocity
147	CYR	$C_{yr}$	Aerodynamic stability derivative of lateral force coefficient with respect to yaw velocity

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
148	CZAL	$C_{z\alpha}$	Aerodynamic stability derivative of normal force coefficient with respect to aerodynamic angle of attack
149	CZQ	$C_{zq}$	Aerodynamic stability derivative of normal force coefficient with respect to pitch velocity
150	CLP	$C_{\ell p}$	Aerodynamic stability derivative of rolling moment coefficient with respect to roll velocity
151	CLR	$C_{\ell r}$	Aerodynamic stability derivative of rolling moment coefficient with respect to yaw velocity
152	CMAL	$C_{m\alpha}$	Aerodynamic stability derivative of pitching moment coefficient with respect to aerodynamic angle of attack
153	CMQ	$C_{mq}$	Aerodynamic stability derivative of pitching moment coefficient with respect to pitch velocity
154	CNP	$C_{np}$	Aerodynamic stability derivative of yawing moment coefficient with respect to roll velocity
155	CNR	$C_{nr}$	Aerodynamic stability derivative of yawing moment coefficient with respect to yaw velocity
156	SF	$S_f$	Projected frontal area of vehicle, including tires and underbody parts; characteristic area upon which aerodynamic force and moment coefficients are based (in. <sup>2</sup> )
157	VLEN	$\ell_v$	Vehicle length; characteristic length upon which aerodynamic moment coefficients are based (in.)



SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
158	REWV	$R_{wV}$	Resultant wind velocity (in./s)
169	SNT	$(SN)_T$	Tire data surface skid number
170	SNSO	$(SN)_{SO}$	Simulated vehicle surface skid number
171	SNSI	$(SN)_{SI}$	Simulated vehicle surface skid number
182-185	SII	$SI_i$	Wheel slip ratio at which peak braking coefficient of friction occurs
186	SARF	$K_{S1}$	Right front shock absorber rate (lb-s/in.)
187	SALF	$K_{S2}$	Left front shock absorber rate (lb-s/in.)
188	SARR	$K_{S3}$	Right rear shock absorber rate (lb-s/in.)
189	SALR	$K_{S4}$	Left rear shock absorber rate (lb-s/in.)
196-197	EKI	$\Delta\psi_i$	Static front wheel toe bias angle (deg)
202	APF1	$P_{BF1}$	Front tire peak braking coefficient of friction, constant term (dimensionless)
203	APF2	$P_{BF2}$	Front tire peak braking coefficient of friction, linear term coefficient (1/lb)
204	APR1	$P_{BR1}$	Rear tire peak braking coefficient of friction, constant term (dimensionless)
205	APR2	$P_{BR2}$	Rear tire peak braking coefficient of friction, linear term coefficient (1/lb)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
206	MUSF	$\mu_{SF}$	Front tire sliding coefficient of friction
207	MUSR	$\mu_{SR}$	Rear tire sliding coefficient of friction
210	S1F	$S_{1F}$	Front tire linear coefficient of sliding friction (1/lb)
211	S1R	$S_{1R}$	Rear tire linear coefficient of sliding friction (1/lb)
212	KLR	$K_{LR}$	Rear lateral force compliance steer (rad/lb)
213	KOTF	$K_{OTF}$	Front overturning moment compliance camber (rad/lb-in.)
214	KOTR	$K_{OTR}$	Rear overturning moment compliance camber (rad/lb-in.)
219-220	FEI	$\Delta\phi_i$	Front wheel camber bias angle (deg)
221-222	THEI	$\Delta\theta_i$	Front wheel caster bias angle (deg)
231-232	HI	$H_i$	Viscous damping derivative in front wheel (lb-in.-s/rad)
236	PS01	$\phi_{S01}$	Constant angle between the right wheel steering axis and the wheel plane (rad)
237	PS02	$\phi_{S02}$	Constant angle between the left wheel steering axis and the wheel plane (rad)
242	KCF	$K_{CF}$	Front lateral force compliance camber coefficient (rad/lb)
243	KCR	$K_{CR}$	Rear lateral force compliance camber coefficient (rad/lb)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
244	KSR	$K_{SR}$	Rear aligning torque compliance steer coefficient (rad/(lb-in.))
245	RB1	$B_{1R}$	Load term coefficient of lateral friction coefficient, rear tire (1/lb)
246	RB2	$B_{2R}$	Velocity term coefficient of lateral friction coefficient, rear tire (1/mph)
247	RB3	$B_{3R}$	Constant term of lateral friction coefficient, rear tire (dimensionless)
248	RB4	$B_{4R}$	Quadratic load term coefficient of lateral friction coefficient, rear tire (1/lb <sup>2</sup> )
249	AFK1	$A_{F1}$	Aligning torque coefficient, front tire (in./lb)
250	AFK2	$A_{F2}$	Aligning torque coefficient, front tire (in./lb)
251	AFK3	$A_{F3}$	Aligning torque coefficient, front tire (in./rad <sup>1/2</sup> )
252	ARK1	$A_{R1}$	Aligning torque coefficient, rear tire (in./lb)
253	ARK2	$A_{R2}$	Aligning torque coefficient, rear tire (in./lb)
254	ARK3	$A_{R3}$	Aligning torque coefficient, rear tire (in./rad <sup>1/2</sup> )
255	OFC0	$O_{F0}$	Overturning moment coefficient, front tire (lb-in.)
256	OFC1	$O_{F1}$	Overturning moment coefficient, front tire (in./lb)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
257	OFC2	$O_{F2}$	Overturning moment coefficient, front tire (in./lb-rad))
258	OFC3	$O_{F3}$	Overturning moment coefficient, front tire (in./rad)
259	ORCO	$O_{R0}$	Overturning moment coefficient, rear tire (lb-in.)
260	ORC1	$O_{R1}$	Overturning moment coefficient, rear tire (in./lb)
261	ORC2	$O_{R2}$	Overturning moment coefficient, rear tire (in./lb-rad))
262	ORC3	$O_{R3}$	Overturning moment coefficient, rear tire (in./rad)
263	CPOF	$P_{F0}$	Antipitch coefficient, front suspension (dimensionless)
264	CP1F	$P_{F1}$	Antipitch coefficient, front suspension (1/in.)
265	CP2F	$P_{F2}$	Antipitch coefficient, front suspension (1/in. <sup>2</sup> )
266	CPOR	$P_{R0}$	Antipitch coefficient, rear suspension (dimensionless)
267	CP1R	$P_{R1}$	Antipitch coefficient, rear suspension (1/in.)
268	CP2R	$P_{R2}$	Antipitch coefficient, rear suspension (1/in. <sup>2</sup> )
269	CR0F	$R_{F0}$	Antiroll coefficient, front suspension (dimensionless)
270	CR1F	$R_{F1}$	Antiroll coefficient, front suspension (1/in.)
271	CR2F	$R_{F2}$	Antiroll coefficient, front suspension (1/in. <sup>2</sup> )

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
272	CR0R	$R_{R0}$	Antiroll coefficient, rear suspension (dimensionless)
273	CR1R	$R_{R1}$	Antiroll coefficient, rear suspension (1/in.)
274	CR2R	$R_{R2}$	Antiroll coefficient, rear suspension (1/in. <sup>2</sup> )
284	HFC	$h_{FC}$	Distance between ground and static roll center of front independent suspension (set to 0 for solid front axle configuration) (in.)
285	HRC	$h_{RC}$	Distance between ground and static roll center of rear independent suspension (set to 0 for solid rear axle configuration) (in.)
286	DRSW		Drive wheel switch: 286 = 0, rear-wheel drive; = 1, four-wheel drive
287	AXLE		Suspension configuration: 287 = 0, solid front/rear; = 1, independent front/rear
288	DUAL		Rear dual tire option: 288 = 0, no duals; = 1, duals
289	TIRE		Number of vehicle tires: 289 = 4, single rear tires; = 6, dual rear tires; = 10, double dual rear tires
290	ROT	$A_{\Omega,TR}$	Proportionality factor defining limits of small-angle cornering and camber stiffness approximation, rear wheels
291	RA0	$A_{0R}$	Constant term in small-angle cornering stiffness function, rear wheels (lb/rad)
292	RA1	$A_{1R}$	Linear term coefficient in small-angle cornering stiffness function, rear wheels (1/rad)

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS  
VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS

Parameter Number	Symbol		Definition or Function (units)
	Table	Equation	
293	RA2	$A_{2R}$	Quadratic term coefficient in small-angle cornering stiffness function, rear wheels (1b) <sup>-</sup>
294	RA3	$A_{3R}$	Linear term coefficient in small-angle camber stiffness function, rear wheels (1/rad)
295	RA4	$A_{4R}$	Quadratic term coefficient in small-angle camber stiffness function, rear wheels (1b)

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