DOT HS-801 290



# HYBRID COMPUTER VEHICLE HANDLING PROGRAM

Contract No. DOT-HS-213-3-695

November 1974

Final Report

PREPARED FOR:

U.S. DEPARTMENT OF TRANSPORTATION

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

WASHINGTON, D.C. 20590

Document is available to the public through
the National Technical Information Service,
Springfield, Virginia 22151

Technical Report Documentation Page

| | | |
|---|---|---|
| 1. Report No. DOT HS-801 290 | 2. Government Accession No. | 3. Recipient's Catalog No. |
| 4. Title and Subtitle HYBRID COMPUTER VEHICLE HANDLING PROGRAM | | 5. Report Date November 1974 |
| | | 6. Performing Organization Code |
| 7. Author(s) P. F. Bohn, R. J. Keenan | | 8. Performing Organization Report No. CP-037/TSA-003 |
| 9. Performing Organization Name and Address The Johns Hopkins University Applied Physics Laboratory 8621 Georgia Avenue Silver Spring, Maryland 20910 | | 10. Work Unit No. (TRAIS) |
| | | 11. Contract or Grant No. DOT-HS-213-3-695 |
| 12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Admin. Washington, D.C. 20590 | | 13. Type of Report and Period Covered Final 6/73 - 7/74 |
| | | 14. Sponsoring Agency Code NHTSA |
| 15. Supplementary Notes | | |

16. Abstract

A hybrid computer simulation for vehicle handling studies has been implemented, checked out, and validated. The simulation has been programmed to study both solid rear axle and independent rear suspension vehicles.

Model validation was accomplished using parametric data representative of four 1971 vehicles: Volkswagen Super Beetle, Chevrolet Brookwood, Dodge Coronet and Pontiac Trans AM. Braking, steering, and combinations of braking and steering were the inputs to the simulated mathematical model for the validation tests.

This hybrid vehicle handling program can be used for general studies of vehicle dynamics. Performance of the standard passenger car vehicle handling test procedures and calculation of the associated comparison variables are simulation options. A special interactive user's interface has been added to allow program use by vehicle engineers as well as computer specialists.

| | |
|---|---|
| 17. Key Words Hybrid Computer, Simulation, Vehicle Mechanics, Limit Performance Test Procedures, Vehicle Handling, Comparison Variables | 18. Distribution Statement Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151 |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unlimited | Unlimited | 355 | |

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

Table of Contents (cont'd) Page

Table of Contents (Cont'd) Page

Table of Contents (Cont'd)

# LIST OF ILLUSTRATIONS



*Analog Computer Diagram

LIST OF ILLUSTRATIONS (cont'd)

# SECTION 1
# INTRODUCTION AND SUMMARY

This document presents the latest version of the NHTSA Hybrid Computer Vehicle Handling Program (HVHP), which is operational at The Johns Hopkins University Applied Physics Laboratory. Many refinements have been incorporated into the simulation since the publication of Reference 2. In particular, the tire/road interface model (Reference 3) has been improved. Additional important features are:

1) Preprogrammed simulation initialization for performing any one of the six Vehicle Handling Test Procedures (VHTP).

2) Automatic data collection of system variables for immediate calculation of the Vehicle Comparison Variables (CV) associated with the selected VHTP (References 4 and 5).

3) The incorporation of a flexible set of input/output routines specifically designed as an engineer's interface for hybrid computer control and operation.

4) Reorganization of simulation model to minimize execution time.

The tire model improvements were made in conjunction with the Calspan Corp. under DOT contract HS-053-3-727. The VHTP initialization and comparison variable calculation were implemented in a general manner to allow redefinition of the

VHTP's and CV's for all classes of vehicles (passenger, recreational, commercial, etc.), instead of just automobiles. The extensive engineer interfacing features and input/output options were made practical by the expected continued use of the HVHP to perform vehicle handling research.

For program verification, a set of six VHTP maneuvers was run for four 1971 vehicles: VW Superbeetle, Chevrolet Brookwood, Dodge Coronet, and Pontiac Trans AM. The simulation comparison variable output was compared with that obtained from full-scale tests of these vehicles under contract DOT HS-031-1-159 (Reference 6). Good correlation between simulated and test comparison variables was achieved. The vehicle descriptors used in the simulation were not those obtained for the vehicles tested in the above contract but were instead obtained from like models of these vehicles used in conjunction with the Calspan Corp. contract. When published (Reference 3), these data can be compared with the latest Calspan full-scale tests. The simulation of the independent rear suspension VW or a solid rear axle vehicle, such as the Dodge, is performed with the same simulation.

User experience with the HVHP has shown that while performing parametric runs, 500 seconds of vehicle motion can be simulated in one hour of computer use. This translates to a cost of less than $0.50 per vehicle simulation second and represents a 50% utilization of the available computing time. Since this simulation, running at one-fourth of real time, is capable of 900 vehicle simulated seconds per hour, approximately 50% of the time is utilized for observing data and changing parameters. The $0.50 per simulated second 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 is being produced. Therefore, the cost per vehicle simulated second 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, HVHP cost usually ranges between one and two dollars per vehicle simulated second, with a decreasing trend to the $0.50 per second figure.

# SECTION 2
# FOUR-WHEELED VEHICLE HYBRID SIMULATION

## 2.1 INTRODUCTION

Contained in this section is a description of the four-wheeled vehicle hybrid computer simulation. The basic mathematical model is described in terms of seventeen degrees of freedom. The perturbing forces and moments which act on the vehicle are also considered. The simulation implementation and validation are discussed.

## 2.2 SIMULATION

### 2.2.1 Mathematical Model

The seventeen-degrees-of-freedom vehicle model consists of:

1) A basic ten-degree-of-freedom model of the vehicle body, front wheels, and rear axle.

2) A three-degree-of-freedom steering system model.

3) A four-degree-of-freedom wheel rotational dynamics model.

The basic ten-degree-of-freedom model regards the vehicle as an assembly of four rigid masses: the vehicle body, two front wheel masses, and the rear wheel axle combination (solid rear axle). The ten degrees of freedom consist of the six standard translational and rotational degrees of freedom for the body, two for the vertical motion of each front wheel, and two for the rotation and vertical motion of the rear axle. When the vehicle model includes the independent rear suspension, each rear wheel is considered as an independent mass; and the vertical motion of each rear wheel is a degree of freedom.

The steering system model with three degrees of freedom represents the compliance in each of the front wheels and in the connecting rod. The tire moments about each king-pin axis are functions of the circumferential and side tire forces, tire aligning torque, the inclination and caster of the king pins, and the caster trail effects of the tires. Steering wheel displacement is the steering system input.

Four additional degrees of freedom (for a total of seventeen) are contained in the rotational equations of motion about the spin axis of each wheel. These equations, which include the differential effects of the rear wheels, yield the wheel rotation rates from which slip and, in turn, the circumferential and lateral friction coefficients are computed. The input to the equations can be either drive torque or brake torque.

The equations of motion of the vehicle body, wheels, and rear axle are perturbed by suspension, gravity, and tire forces and moments. The suspension equations include the effects of the springs, shock absorbers, and front and rear auxiliary roll stiffness. The suspension deflections are calculated relative to the suspension equilibrium position which varies with vehicle weight. Vehicle functions, such as camber, caster, and toe angles, anti-pitch and anti-roll forces, and bump stop forces are input relative to the unloaded vehicle suspension positions. These functions are then corrected to the equilibrium position for varying vehicle weight when used for calculations within the vehicle model.

The tire forces (radial, circumferential, and lateral) are computed for each wheel. The radial load is proportional to the distance between the wheel center and the road. The circumferential force is the product of the tire radial load and circumferential coefficient of friction which is a function of wheel slip, radial load, and normalized slip angle. The lateral tire force is the product of the tire radial load, lateral friction coefficient, and two shaping functions representing the effects of normalized steer angle and longitudinal slip. Additionally, the lateral friction coefficient is a function of radial load and wheel velocity. Wheel aligning torques and overturning moments are included as functions of wheel radial load, side force, and camber angle.

### 2.2.2 Allocation of Analog and Digital Computer Tasks

The hybrid simulation block diagram of the automobile is shown in Figure A-1. Calculated in the digital portion are the sprung mass equations of motion, wheel orientation angles, and tire force equations. Wheel brake and drive torques, velocities of the tire contact point, and resultant forces and moments are also computed in the digital portion.

The analog computations include the suspension forces, shock absorber and wheel spring functions, longitudinal wheel slip, and circumferential coefficient of friction. In addition, the equations of motion of the unsprung masses and steering system equations are solved on the analog computer.

The hybrid simulation is time scaled to run at one-fourth real time, i.e., 20 seconds of clock-on-the-wall time is required for 5 seconds of vehicle simulation.

### 2.2.3 Implementation of the Mathematical Model

#### 2.2.3.1 Analog Portion

The APL/JHU hybrid computer facility (Appendix C) contains analog machines manufactured by Electronic Associates, Inc. (EAI). The portion of 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, circumferential friction coefficient calculation, tire deflection, and suspension dynamics contained on an EAI 680. Data communication with the digital computer is provided by 24 multiplying digital-to-analog converters (MDAC's), 24 non-multiplying DAC's and 24 channels of analog-to-digital conversion (ADC's). The system contains a control interface which 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 both the solid and independent rear is used. This was accomplished by programming the mathematical model equations solved on the analog as a digital simulation language program (Reference 7). The digital program output provided an independent check of the simulation. The static check results verify that the programmed analog portion of the simulation represents the respective vehicle mathematical model equations.

#### 2.2.3.2 Digital Portion

The APL/JHU hybrid facility (Appendix C) utilizes an IBM 360, Model 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 (Reference 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.

- 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 (digital-to-analog converters) and ADC's (analog-to-digital converters).

- Rescaling the digital variables output on the DAC's or input on the ADC's.

- Commenting the computer output with observations pertinent to the computer runs.

- Printing the value of all digital variables on command.

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

- The output unit for all digital computer responses is selectable (line printer, CRT, or both).

- Extensive subroutine error recovery which allows operation by untrained personnel.

- Free format input which obviates the need to always insert decimal points, spaces, etc. which would be required by Fortran syntax.

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

## 2.4 VHTP MANEUVERS AND COMPARISON VARIABLES

### 2.4.1 VHTP Maneuvers

The simulation has the capability of self-initializing to perform any of the six automobile VHTP maneuvers and calculating the comparison variables appropriate for the selected VHTP. Utilizing 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 multi-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, 5), the STR variable contains the steering wheel rotation required to input 2.0 degrees of normalized steer. This value is required for run series in which the steering is incremented.

### 2.4.2 VHTP Comparison Variables

Comparison variables 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 CV's are output. However, only those pertinent to the selected VHTP will be non-zero. 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 CV's. An example is presented in Figure 2-1, in which the following occurs:

1) VHTP 4 is selected.

2) The STR4 variable is interrogated to determine the steering wheel rotation for 2 degrees of normalized steer.

3) The steering wheel input is set equal to 300 degrees.

4) A single run is executed.

5) A run series of four runs is set up with STR4 initialized to two degrees normalize steer (NS) and incremented by two degrees NS in each run.

6) A multiple run is executed.

A representative parametric run series for each VHTP is presented in Figures 2-2a to 2-2f.

## 2.5 VALIDATION

### 2.5.1 Tire Effects Program

The HVHP was used extensively for vehicle simulation while APL worked cooperatively with the Calspan Corp. on DOT contract HS-053-3-727. For this contract,

```
**********    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
****  VHTFNO 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 DIDMAX=   0.210 RTMAX=   0.126 DFLRT    0.126
AYMAX=   0.945 PHIMAX=   4.101 RMAX=   0.708 LANE CHNG DEL=   0.0   DELPSI=   0.0   MAX STEER= 300.000
LTRQMAX=   0.0   RTRQMAX=   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) BETDMX(   1) CURVATI(   1) AYMAX.(   1) RMAX..(   1)
  1      2        27.9       0.315E-02    0.200E-01    0.920E-01    0.134       0.694E-01
  2      3        55.8       0.105E-01    0.341E-01    0.260        0.342       0.106
  3      4        83.7       0.219E-01    0.646E-01    0.428        0.539       0.304
  4      5        111.       0.375E-01    0.909E-01    0.573        0.691       0.409
OPTION
```

Fig. 2-1   HVHP USER'S INTERACTIVE CONTROL

```
TERMINAL ACTIVE
        VEHICLE HANDLING SIMULATION
ENGAGE PATCH PANEL FOR TEST
TYPE CR WHEN READY
****
JUNE      14  1974
TIME  16 14 46.99
OPTION
****  F
ENTER
****  VHTPNO 1
****
OPTION
****  IC
OPTION
****  MULTI
NUM OF LOOPS VARS
****  4 1
VAR
****  PFL
LOOP/VAL/INC
****  1 300 100
****
OPTION
****  XM
JUNE      14  1974
TIME  16 15 1.46
RUN   1 HAS STARTED
OUTPUT LIST
```

| MULTI | TOTAL | PFL | 1) [illegible] | 1) [illegible] | 1) [illegible] | 1) [illegible] | 1) [illegible] | 1) [illegible] | 1) [illegible] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | [illegible] | 0.419 | 2.75 | [illegible] 01 | [illegible] 01 | [illegible] 01 | [illegible] | [illegible] 01 |
| 2 | 2 | [illegible] | 0.561 | 2.04 | [illegible] 01 | [illegible] | [illegible] | [illegible] | [illegible] |
| 3 | 3 | [illegible] | 0.637 | [illegible] | [illegible] 01 | [illegible] | [illegible] | 1.00 | [illegible] |
| 4 | 4 | [illegible] | [illegible] | 1.62 | [illegible] 01 | 1.00 | 1.00 | 1.00 | [illegible] |

Fig. 2-2a HVHP INTERACTION FOR VHTP NO. 1

```
OPTION
****  IC
OPTION
****  F
ENTER
****  VHTPNO 2
****
OPTION
****  IC
OPTION
****  MULTI
NUM OF LOOPS/VARS
****  4 1
VAR
****  PFL
LOOP/VAL/INC
****  1 [illegible] 100
****
OPTION
****  XM
[illegible]  14  1974
[illegible]  16 16 [illegible]
[illegible]
[illegible]
```

| MULTI | TOTAL | PFL | 1) [illegible] | 1) [illegible] | 1) [illegible] | 1) CUST [illegible] | 1) SLIPT [illegible] | 1) SLIPI [illegible] | 2) SLIPT [illegible] | 3) SLIPI [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | [illegible] | 0.425 | 0.300 | [illegible] 01 | 1.10 | [illegible] 01 | 0.776E 01 | [illegible] 01 | [illegible] 01 |
| 2 | 6 | [illegible] | 0.539 | 0.297 | [illegible] 01 | 1.18 | 0.115 | 0.101 | 1.00 | 0.114 |
| 3 | 7 | [illegible] | [illegible] | 0.295 | [illegible] 01 | [illegible] | 1.00 | 0.125 | 1.00 | [illegible] |
| 4 | 8 | [illegible] | [illegible] | 0.297 | [illegible] 01 | 0.312 | 1.00 | 0.156 | 1.00 | 0.997 |

Fig. 2-2b HVHP INTERACTION FOR VHTP NO. 2

```
OPTION
**** IC
OPTION
**** F
ENTER
**** VHTPNO 3
****
OPTION
**** IC
OPTION
**** MULTI
NUM OF LOOPS/VARS
**** 3 2
VAR
**** DMEN
LOOP/VAL/INC
**** 1 8 0
**** 2 10
**** 2 10 0
**** 3 13 0
****
VAR
**** DMPS
LOOP/VAL/INC
**** 1 57.6
**** 2 [illegible]3.0
**** 3 37.7
****
OPTION
**** XM
JUNE     14  1974
TIME  15 23 12.14
RUN    9 WAS STARTED
OUTPUT [illegible]
```

| MULTI | LOOSE | DMEN...I | I DMPS...I | I [illegible] | I [illegible] | I [illegible] | I [illegible] | I |
|---|---|---|---|---|---|---|---|---|
| 1 | 9 | 8.00 | 57.6 | 0.511 | 0.315 | 0.9[illegible] | 0.110 | |
| 2 | 10 | 10.0 | [illegible].0 | 0.531 | 0.350 | 1.01 | 0.207 | |
| 3 | 11 | 13.0 | 37.7 | 0.415 | 0.331 | 0.973 | 0.177 | |

Fig. 2-2c HVHP INTERACTION FOR VHTP NO. 3

```
TERMINAL ACTIVE
        VEHICLE HANDLING SIMULATION
CHANGE PATCH PANEL FOR TEST
TYPE CR WHEN READY
****
JUNE     14  1974
TIME  15 58 [illegible].84
OPTION
**** F
ENTER
**** VHTPNO 1
****
OPTION
**** IC
OPTION
**** F
ENTER
**** VHTPNO 4
****
OPTION
**** IC
OPTION
**** FU
ENTER
**** F
ENTER
**** STR4
  [illegible].93
****
OPTION
**** MULTI
NUM OF LOOPS/VARS
**** 4 1
VAR
**** STR4
LOOP/VAL/INC
**** 1 55.[illegible] 55.[illegible]6
****
OPTION
**** XM
JUNE     14  1974
TIME  16  1  [illegible].91
RUN   1 WAS STARTED
OUTPUT [illegible]
```

| MULTI | LOOP | [illegible]...I | I [illegible] | I BETDAV | I [illegible] | I [illegible] | I MAX...I | I |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 55.7 | [illegible] | 0.5[illegible] 01 | 0.[illegible] | 0.[illegible]12 | 0.1[illegible] | |
| 2 | 2 | 112. | [illegible] | 0.[illegible] 01 | 0.343 | 0.[illegible]2 | 0.255 | |
| 3 | 3 | 168. | [illegible] | 0.11[illegible] | 0.[illegible] | [illegible]3 | 0.3[illegible]1 | |
| 4 | 1 | [illegible]3. | [illegible].110 | 0.1[illegible]7 | [illegible] | [illegible] | 0.[illegible]3 | |

Fig. 2-2d HVHP INTERACTION FOR VHTP NO. 4

```
OPTION
****  F
ENTER
****  VHTPNO 5
****
OPTION
****  IC
OPTION
****  F
ENTER
****  STR5
   27.93
****
OPTION
****  MULTI
NUM OF LOOPS/VARS
****  4 1
VAR
****  STR5
LOOP/VAL/INC
****  1 55.86 55.86
****
OPTION
****  XM
JUNE      14  1974
TIME  16: 7 46.00
RUN   5 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR5..(    1) AYMAX.(    1) DFL...(    1) BETAMX(    1) DELPSI(    1) UIN...(    1)
  1     5        55.9        0.177         9.90        0.137E-01    0.117E-02      45.0
  2     6        112.        0.372         6.48        0.399E 01   -0.[illegible]E 02      45.0
  3     7        168.        0.562         4.69        0.7[illegible]E-01   -0.117E 01      45.0
  4     8        223.        0.710         6.41        0.129       -0.[illegible]E 01      45.0
```

Fig. 2-2e HVHP INTERACTION FOR VHTP NO. 5

```
OPTION
****  F
ENTER
****  VHTPNO 6
****
OPTION
****  IC
OPTION
****  F
ENTER
****  IRLON
   0.5200
****
OPTION
****  MULTI
NUM OF LOOPS/VARS
****  3 1
VAR
****  DRLOFF
LOOP/VAL/INC
****  1 0.9 0.05
****
OPTION
****  XM
JUNE      14  1974
TIME  16:11: 2.72
RUN   9 HAS STARTED
OUTPUT BELOW
MULTI TOTAL PHIMAX(    1) PHIEMX(    1) RMAX..(    1) ZIMX..(    1) ZIMX..(    2) ZIMX..(    3) ZIMX..(    1) UIN...(    1) ICNCFF(    1)
  1     9      8.17        0.730        0.425       -0.892        0.615        0.424E-01    0.507E-01     50.0        0.900
  2    10      8.22        0.725        0.428       -1.01         0.636        0.330E 01    0.496E-01     50.0        0.950
  3    11      8.14        0.693        0.425       -0.915        0.658        0.831E 02    0.318E-01     50.0        1.00
```

Fig. 2-2f HVHP INTERACTION FOR VHTP NO. 6

"Research on the Influence of Tire Properties on Vehicle Handling," Calspan was responsible for refining the tire/road interface model which APL incorporated into the HVHP. Calspan monitored the simulation modification and examined the output for authenticity. Therefore, in addition to APL validation, the HVHP performance has been examined by engineers with extensive backgrounds in vehicle handling.

In the performance of DOT contract HS-053-3-727, over 2000 simulated VHTP's were run. Four vehicles were simulated: Chevrolet Brookwood station wagon, Dodge Coronet, Pontiac Trans Am, and Volkswagen Super Beetle. For each vehicle, a complete set of VHTP's was performed using simulated OE tires. Parametric studies were then run varying tire parameters to determine their affect on vehicle handling performance. The comparison variable graphs for the original equipment tire configuration runs are presented in Appendix F of this report.

### 2.5.2 Vehicle Handling Test Procedures

Time Histories for a typical set of VHTP maneuvers is presented in figures 2-3 to 2-8. The vehicle simulated for these runs is the 1971 Dodge Coronet.

#### 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 and all four wheels were locked at 650 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 gee turn. For this vehicle, the inside rear wheel was locked at 400 psi and both rear wheels and the inside front wheel were locked at 525 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 gee turn. Three grid frequences 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 degrees of normalized steer angle were used. For this vehicle, 28 degrees of steering wheel angle is required for 2 degrees of normalized steer. The CV output for the VHTP is presented in Appendix F.

### 2.5.2.5 Sinusoidal Steer

In this run series, sinusoidal steers with a maximum amplitude of 4, 8, 12 and 16 degrees of normalized steer angle were used. For this vehicle, 28 degrees of steering wheel angle is required for 2 degrees of normalized steer. The CV output for this VHTP is presented in Appendix F.

#### 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 0.15 radians and a peak roll rate of 0.72 radians per second was achieved.

## 2.6 TIRE DATA

As previously stated, the current HVHP tire/road interface model was defined by Calspan as part of DOT contract HS-053-3-727. For this contract, Calspan tested many tires at their TIRF (Tire Research Facility) testing complex. As a convenience for working with APL and using the HVHP, the TIRF associated computer was programmed to process tire data into a format directly compatible with the HVHP tire model. Therefore, very little effort is required to prepare tire data for input to the HVHP for tires which have been tested on the TIRF machine. For tires tested on other tire test machines or flat bed testers, APL has the TIRF computer data processing program. When the tire test data has been properly formatted, the program output will be compatible with the HVHP. However, data preparation for the latter approach can be very time consuming.

## 2.7 HVHP INPUT DATA

### 2.7.1 Data Deck Description

A general input data deck is used with the HVHP. Defined in the data deck are the following:

1) Vehicle simulated.

2) Front and rear camber, caster, and toe functions via coefficients for a fifth order polynomial approximation.

3) Front and rear brake torques as pairs of brake pressure in, brake torque out data points.

4) Lateral friction coefficient degradation with circumferential slip as pairs of percent slip in, percent of lateral friction coefficient out data points.

5) Interactive OPTIONS.

6) Default output variable list for the Track Option.

7) Default output variable list for the Table Option for VHTP's performed in the multi-run mode.

8) Initial values of input members of the PARAM vehicle descriptor data array input as pairs of array element number and initial value.

9) Digital-to-analog converter variable and scale factor assignments input as pairs of digital variable and corresponding scale factor.

10) Analog-to-digital converter variable and scale

factor assignments input as pairs of digital variables and corresponding scale factor.

11) PARAM data array members which 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 1 to 6.

The input data decks for the four passenger vehicles recently simulated are presented in Appendix E. Also presented in Appendix E is a sample of the PARAM Table for each vehicle which is output to the system line printer prior to each simulation run. This provides PARAM value documentation.

#### 2.7.1.1 Vehicle Identification

The first data card is used to document the vehicle being simulated. Any message confined to 80 characters is allowed.

#### 2.7.1.2 Camber, Caster, and Toe Functions

The next six data cards define the front wheel camber, caster, and toe and the rear wheel camber, caster, and toe functions for wheel displacement from the unloaded vehicle suspension equilibrium position. One function is defined per data card which contain 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 original data for these functions is presented in Appendix E.

2.7.1.3 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 per card, a value of brake line pressure and the corresponding value of the brake torque. A group of cards (2 to 20) 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 238-241.

2.7.1.4 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 per card as percent of slip and the corresponding percent of possible side force which is attained. The function data (2 to 20 cards) is terminated by a card containing the number 99999. Linear interpolation is used between data points to obtain intermediate function values.

2.7.1.5 Interactive Options

The next group of data cards defines the names usable in response to the OPTION cue for simulation interactive control. The input of any of these names at the hybrid control console in response to the OPTION cue will enable a specific interactive routine. The interactive routines are specified in Appendix D.

#### 2.7.1.6 Track Output Variables

The next group of cards defines the initial set of interactive variables to be output if the track OPTION is enabled. Fifty variables may be selected on as many cards as is required. This group of cards is terminated by a blank card. This list may be altered interactively using the Track OPTION.

#### 2.7.1.7 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 card 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.

#### 2.7.1.8 Vehicle Descriptor and Tire Data

The next group of cards is used to input the initial values of variables which are elements of the PARAM data array. This 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 is presented in Section 4 of Appendix B. The subset of PARAM elements which represent vehicle descriptors or tire model coefficients is presented in Section 5 of Appendix B. Data is input one PARAM element per card by indicating the PARAM element address followed by the assigned value.

#### 2.7.1.9 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 the digital-to-analog conversion (DAC). Any variable name which has been specified as an interactive variable may be output. If the variable output 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 variable output is used strictly for strip chart recorder display purposes, the scale factor can take on any rational value. The maximum expected value of the variable is an appropriate starting value. Either the variable, 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 the DAC's 0-47. Each card contains a variable name followed by its normalizing scale factor.

#### 2.7.1.10 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 the analog-to-digital conversion (ADC). Any variable name which has been specified as an interactive variable and exists on the analog computer may be input. The scale factor must be consistent with the use of the variable on the analog computer. Either the variable, 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. Twenty-eight cards must be included, one for each analog-to-digital input in the order of assignment to ADC's 0-27. Each card contains a variable name followed by its analog scale factor.

#### 2.7.1.11 VHTP Initialization Data

The last group of cards allows the input of data that is used for initialization of the simulation for performing a specific VHTP maneuver. Since this data is 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.

### 2.7.2 Springs, Shock Absorbers and Load Dependent Data

In addition to the data deck, the spring and shock absorber functions are simulation inputs. The shock absorber functions are input using analog function generators.

The spring forces are generated using a combination of analog and digital techniques. In order to achieve correct placement of the compression and rebound bump stops, relative to the suspension equilibrium position, suspension deflection parameters must be specified for loaded vehicle conditions.

### 2.7.2.1 Spring Functions

The front and rear spring functions are input as three line segment approximations to the actual curve for restoring force versus suspension deflection from the equilibrium position. The three segments are a linear region for plus and minus deflections about the equilibrium position and a segment for each of the compression and rebound bump stops. The bump stop segments are specified by a multiplier factor which is the ratio of the curve slope at the bump stop segment relative to the linear segment. A different multiplier can be input to represent the rebound and compression bump stops individually.

The linear segment is generated on the analog computer. Bump stop impact is tested in the digital computer and an auxiliary force, representing the bump stop contribution in excess of the linear portion, is calculated and output digitally. Bump stop locations should be specified relative to the unloaded vehicle equilibrium suspension position.

### 2.7.2.2 Shock Absorber Functions

The front and rear shock absorber functions are generated using analog function generators. Since the function generator is a versatile analog device, the shock absorber characteristic can be represented as a general function of suspension deflection rate. However, in practice, representation by three or four line segments has proven sufficient. The function may be specified for input purposes either graphically or as a list of slopes for various suspension deflection rates.

2.7.2.3 Load Dependent Data

Since the HVHP 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 1-3 and for automatic controller used in VHTP's 4-6. The vehicle parameters which are load dependent and their corresponding PARAM element addresses are as follows:

| Variable | PARAM Address |
|---|---|
| MS | 1 |
| ZF | 4 |
| ZR | 5 |
| a | 6 |
| b | 7 |
| IX | 11 |
| IY | 12 |
| IZ | 13 |
| DELF | 92 |
| DELR | 93 |

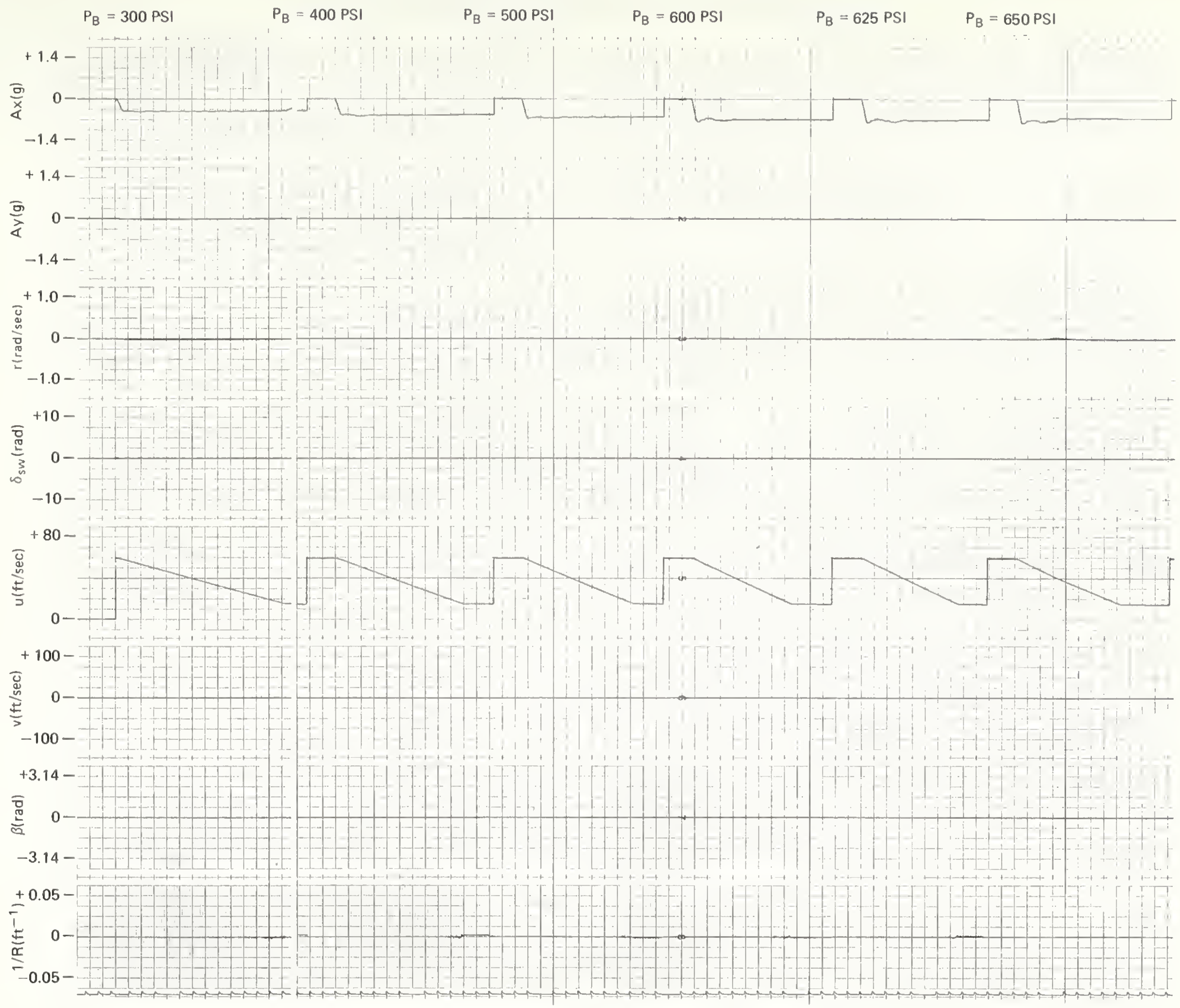



Fig. 2-3a TIME HISTORIES - STRAIGHT LINE BRAKING

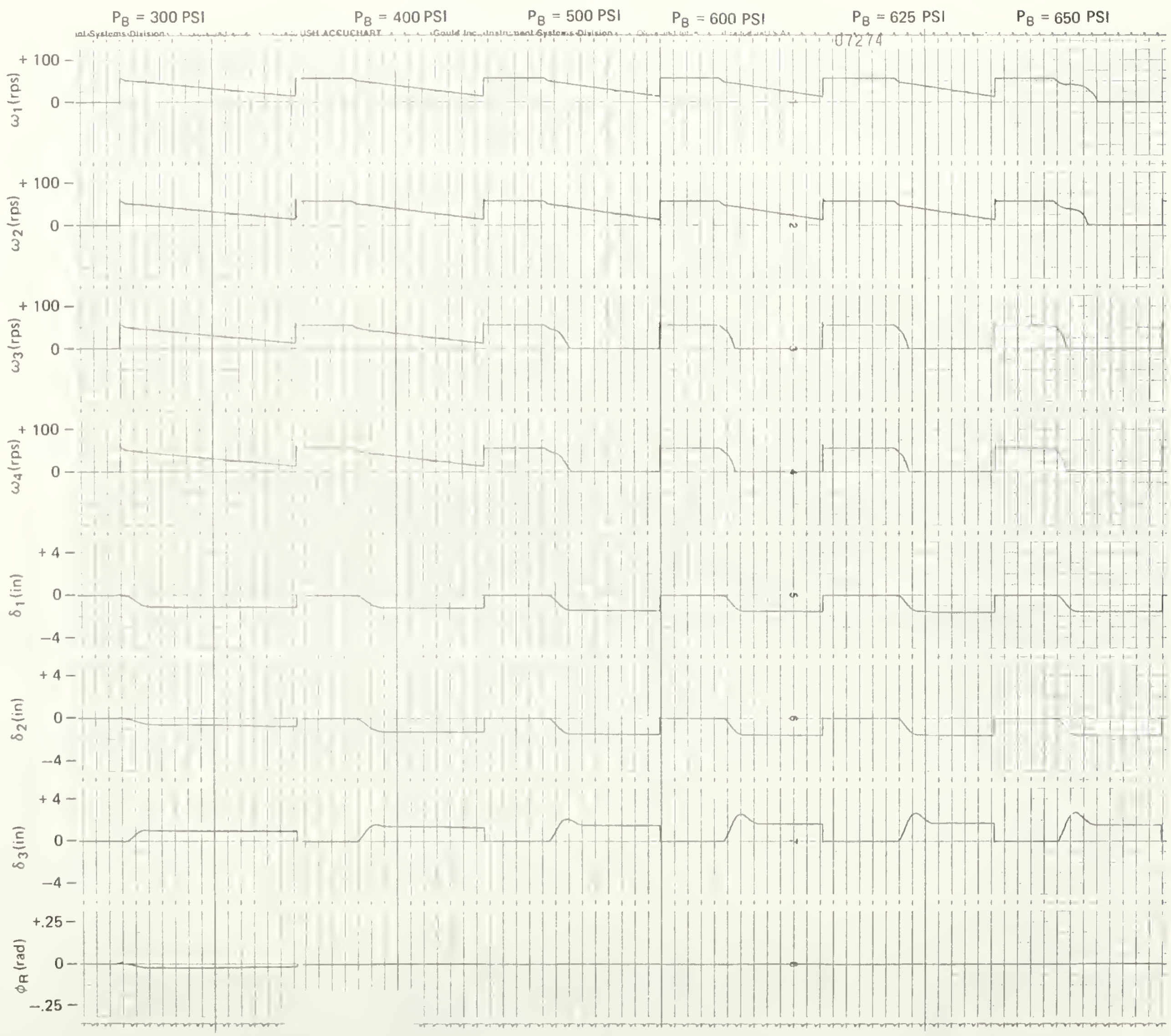



Fig. 2-3b TIME HISTORIES - STRAIGHT LINE BRAKING

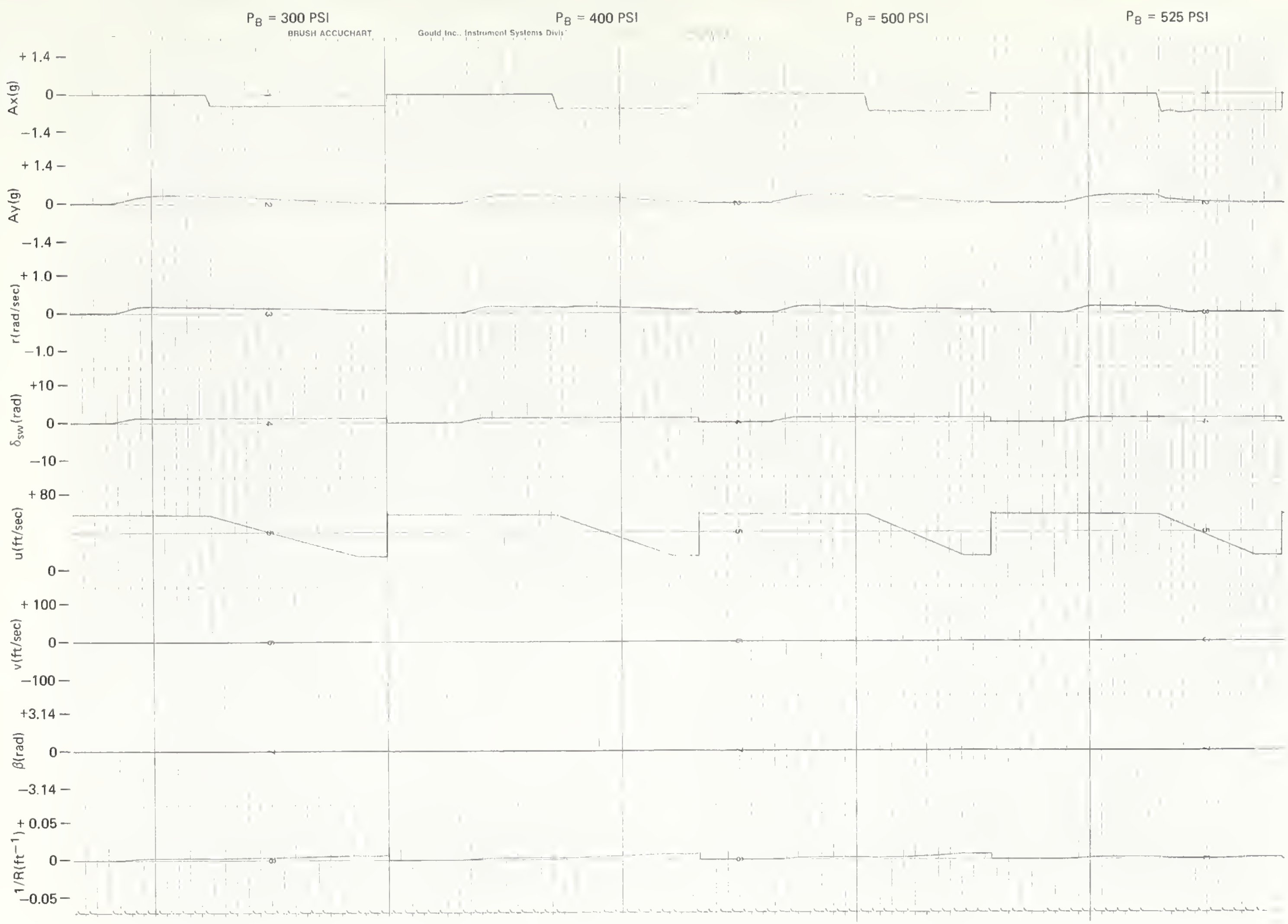



Fig. 2-4a TIME HISTORIES - BRAKING IN A TURN

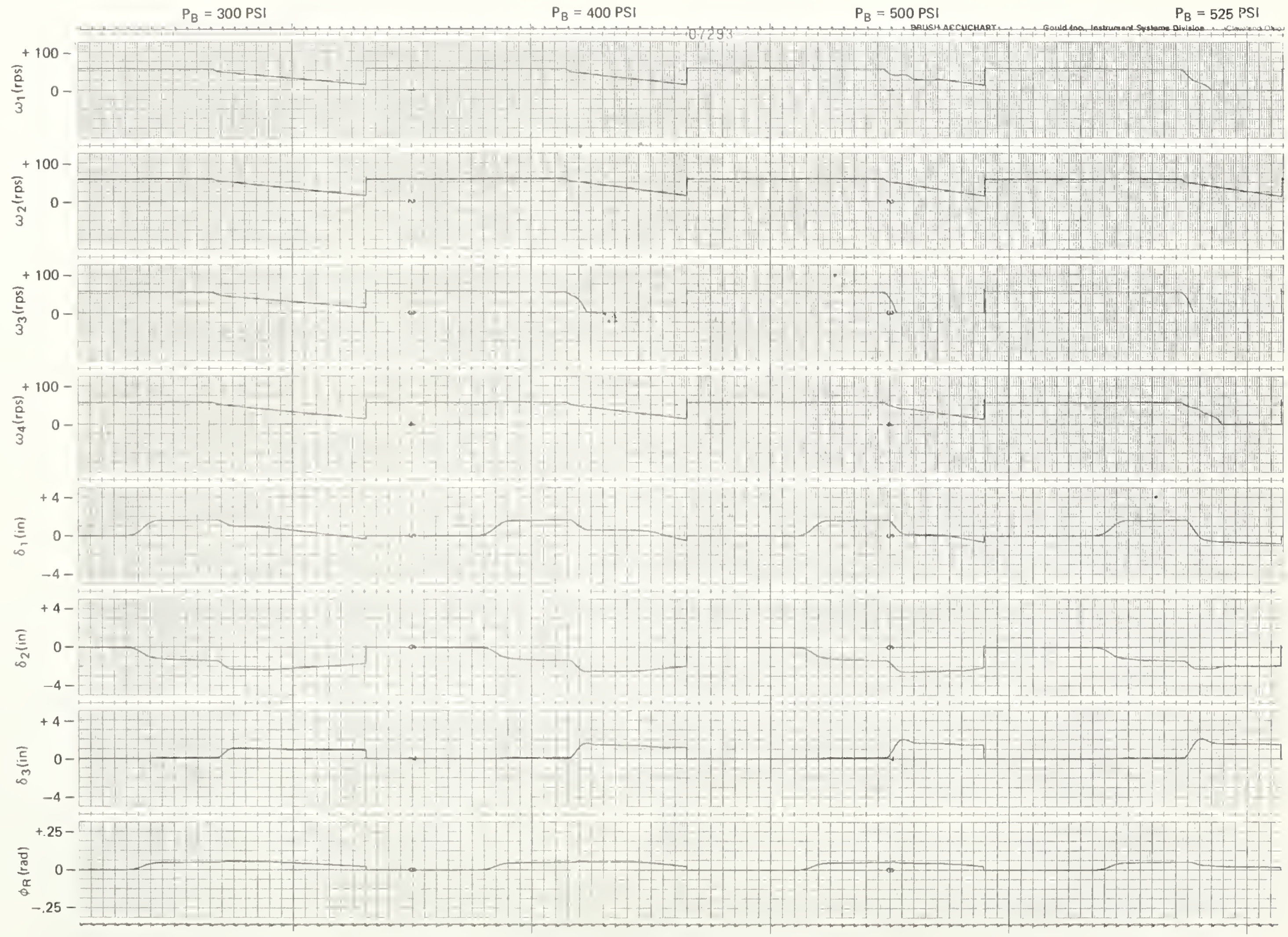



Fig. 2-4b TIME HISTORIES - BRAKING IN A TURN

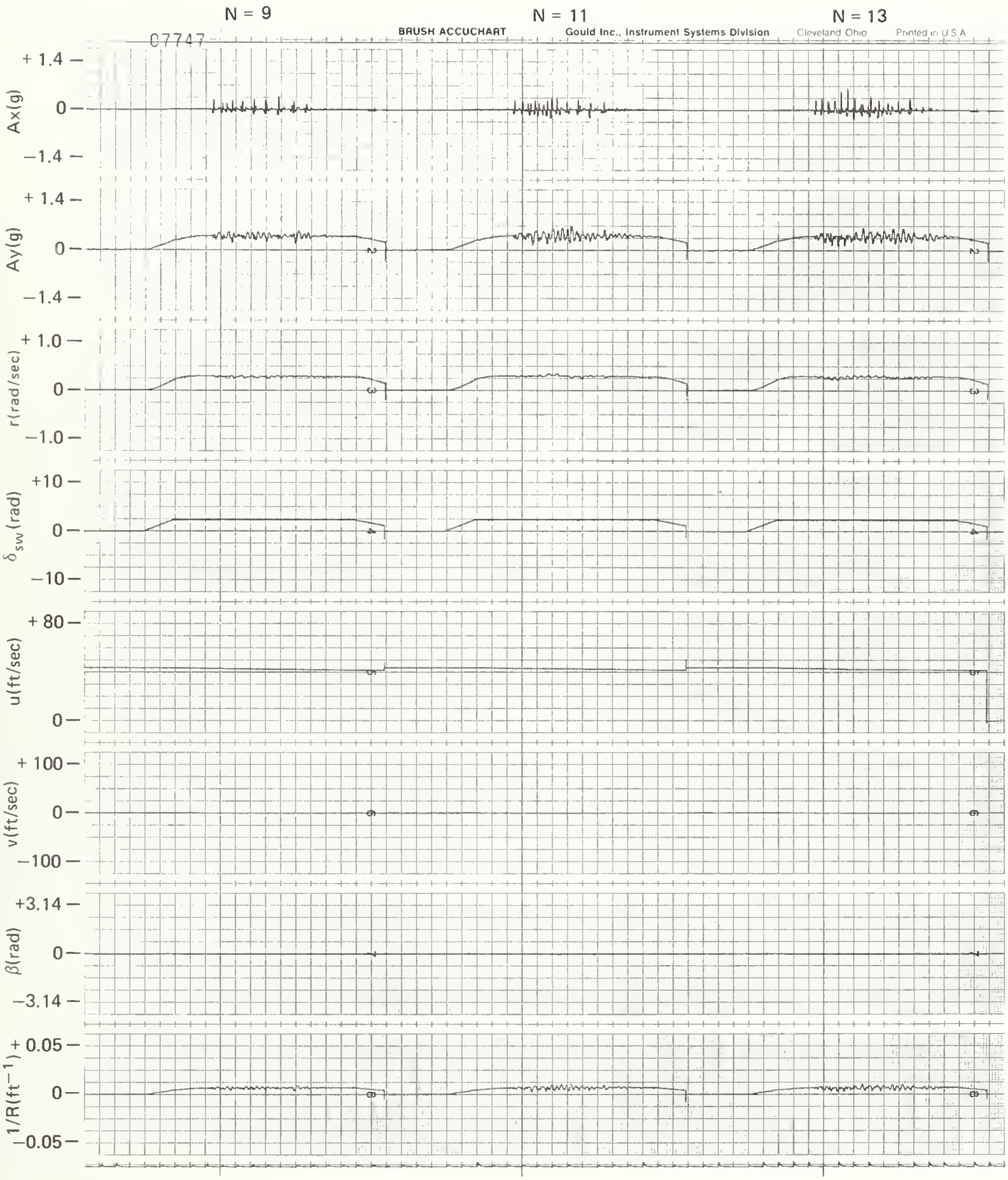



Fig. 2-5a  TIME HISTORIES - TURNING ON A ROUGH ROAD

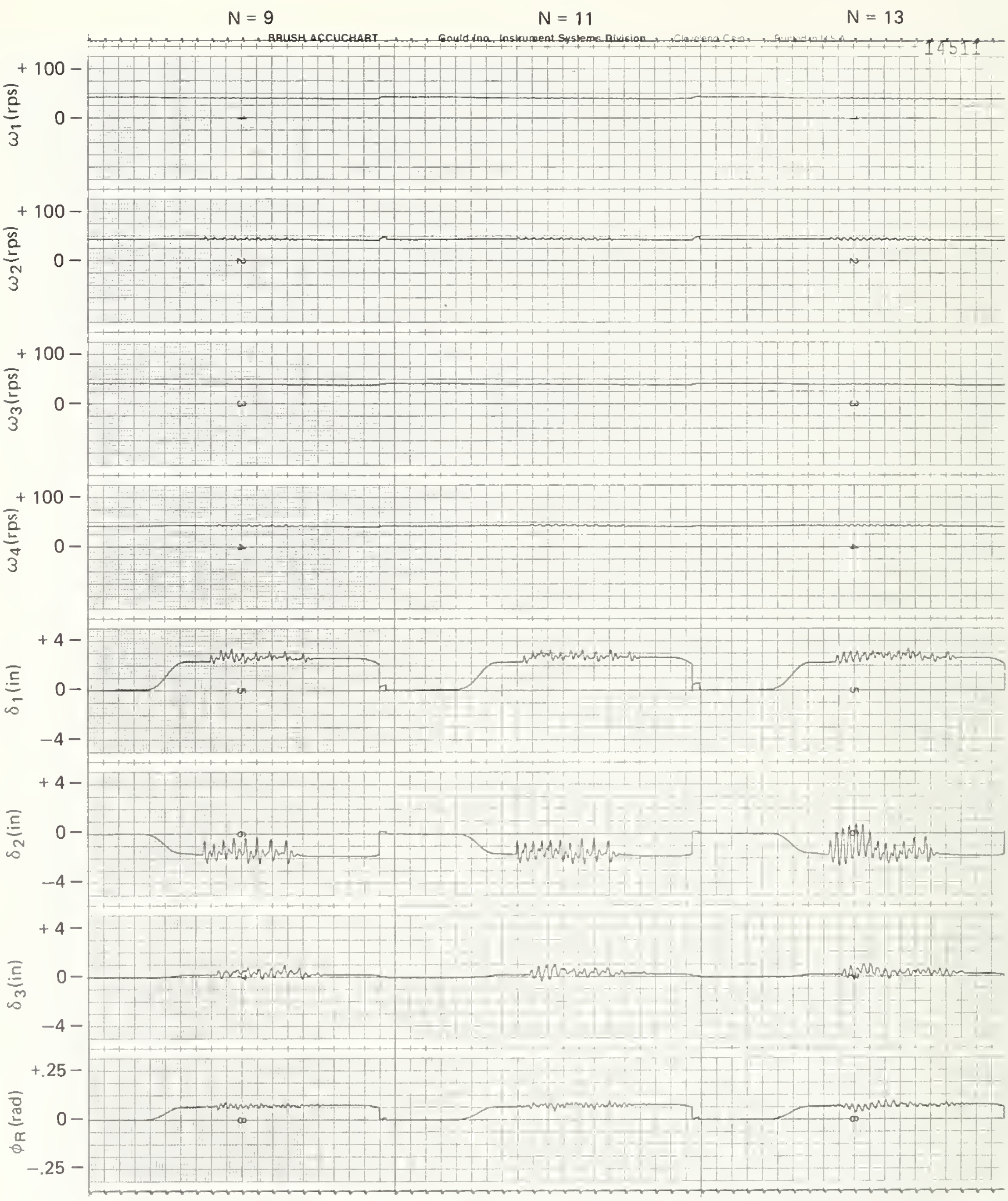



Fig. 2-5b TIME HISTORIES - TURNING ON A ROUGH ROAD

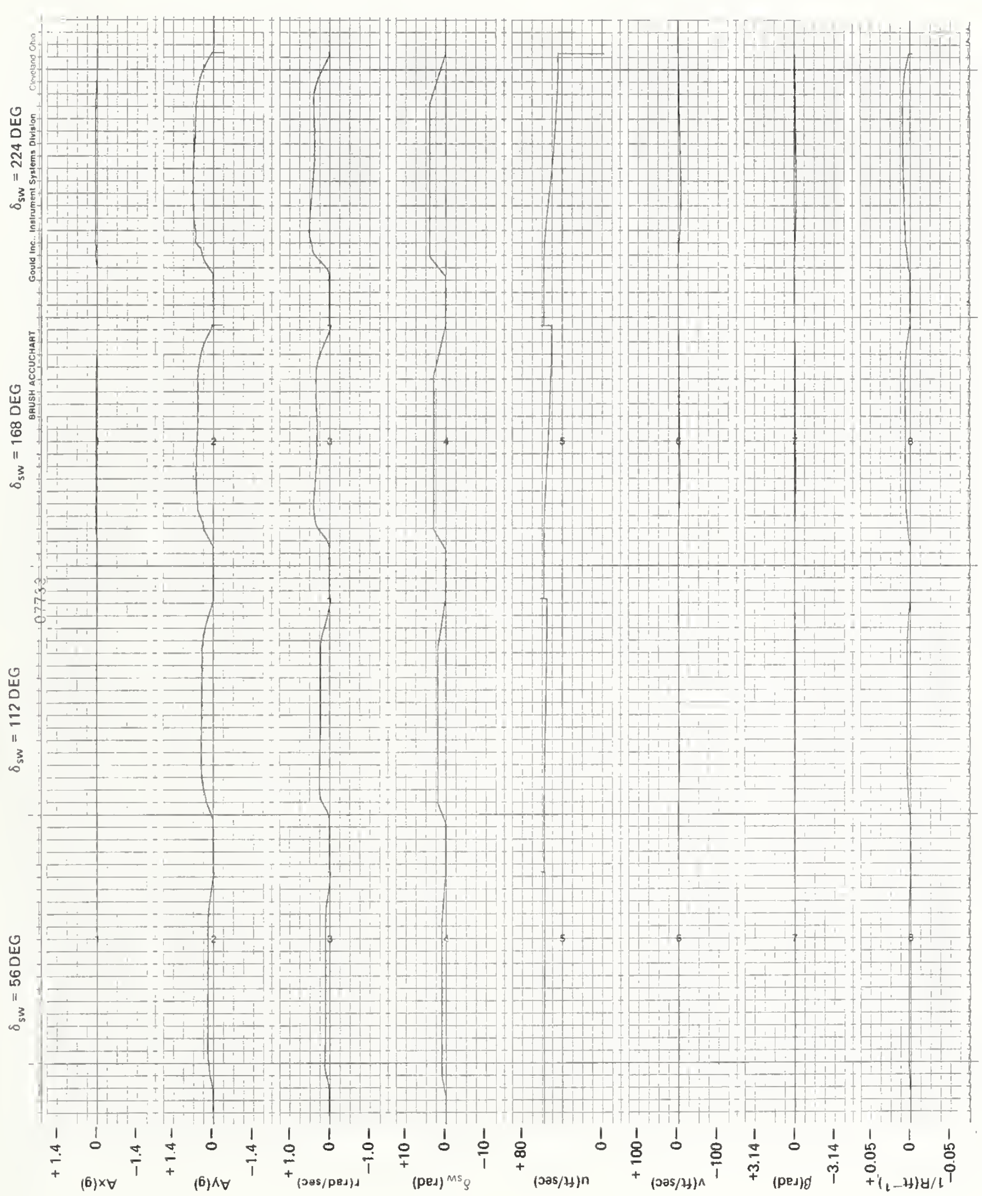



Fig. 2-6a TIME HISTORIES - TRAPEZOIDAL STEER

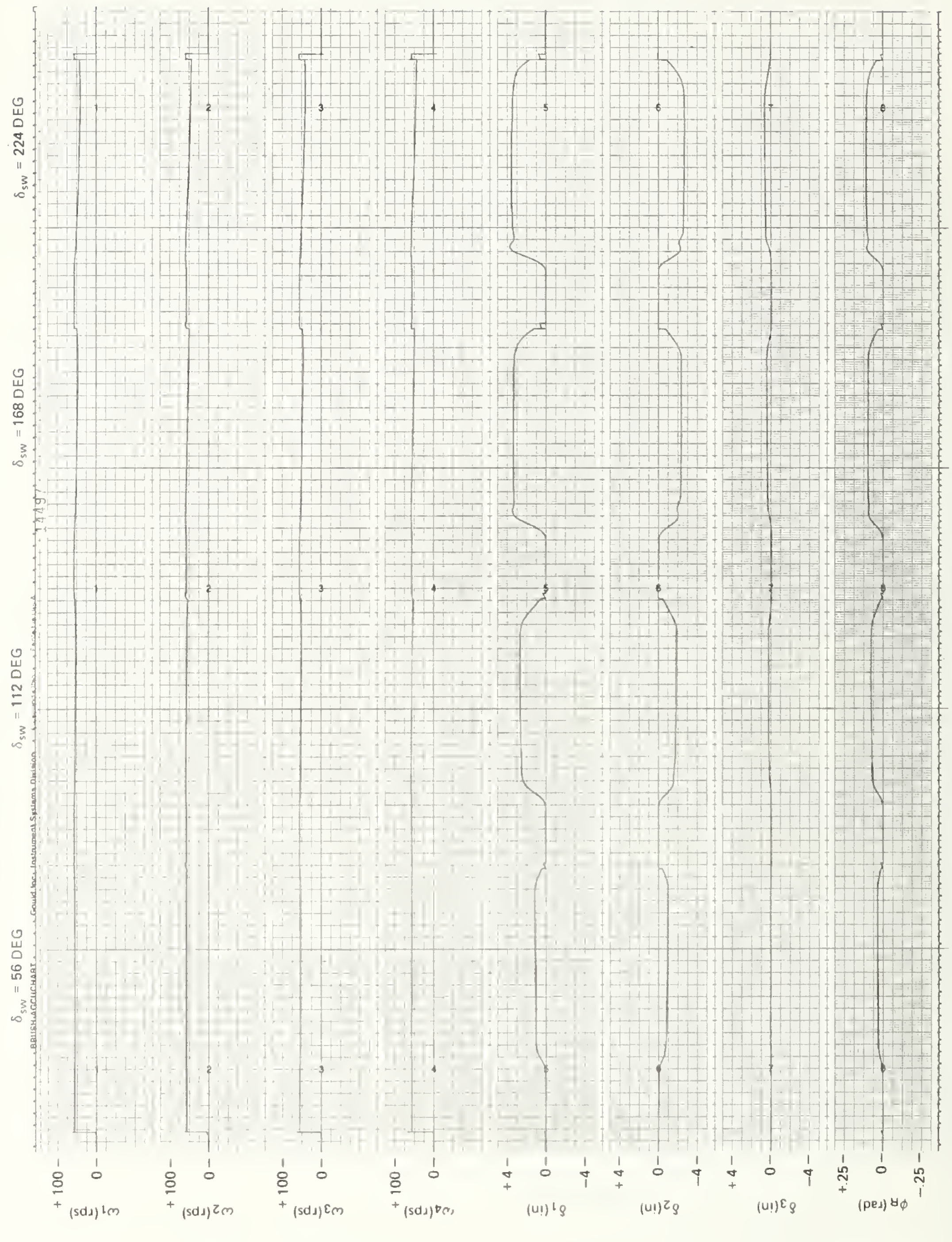



Fig. 2-6b TIME HISTORIES - TRAPEZOIDAL STEER


Fig. 2-7a TIME HISTORIES - SINUSOIDAL STEER

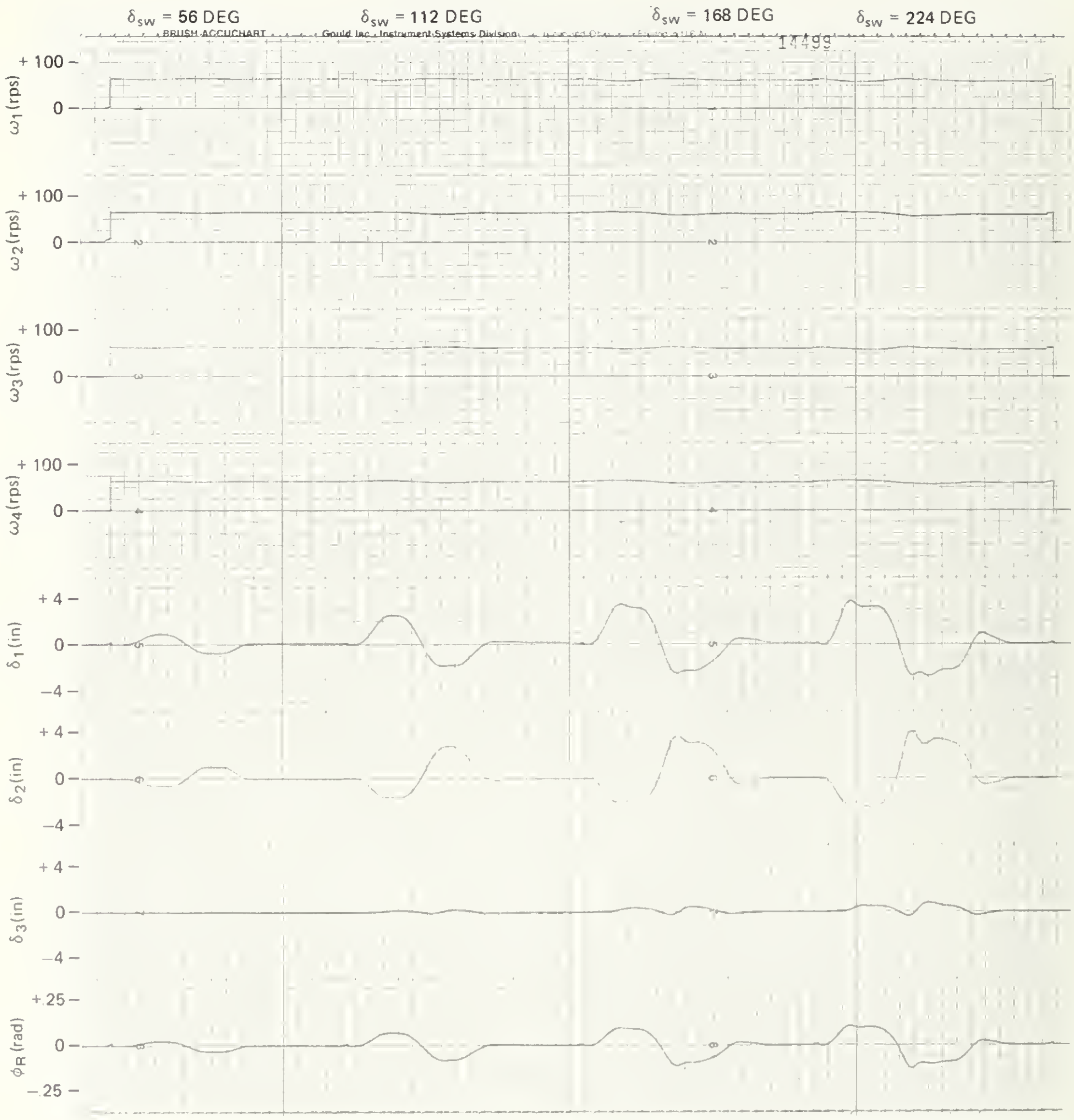



Fig. 2-7b TIME HISTORIES - SINUSOIDAL STEER

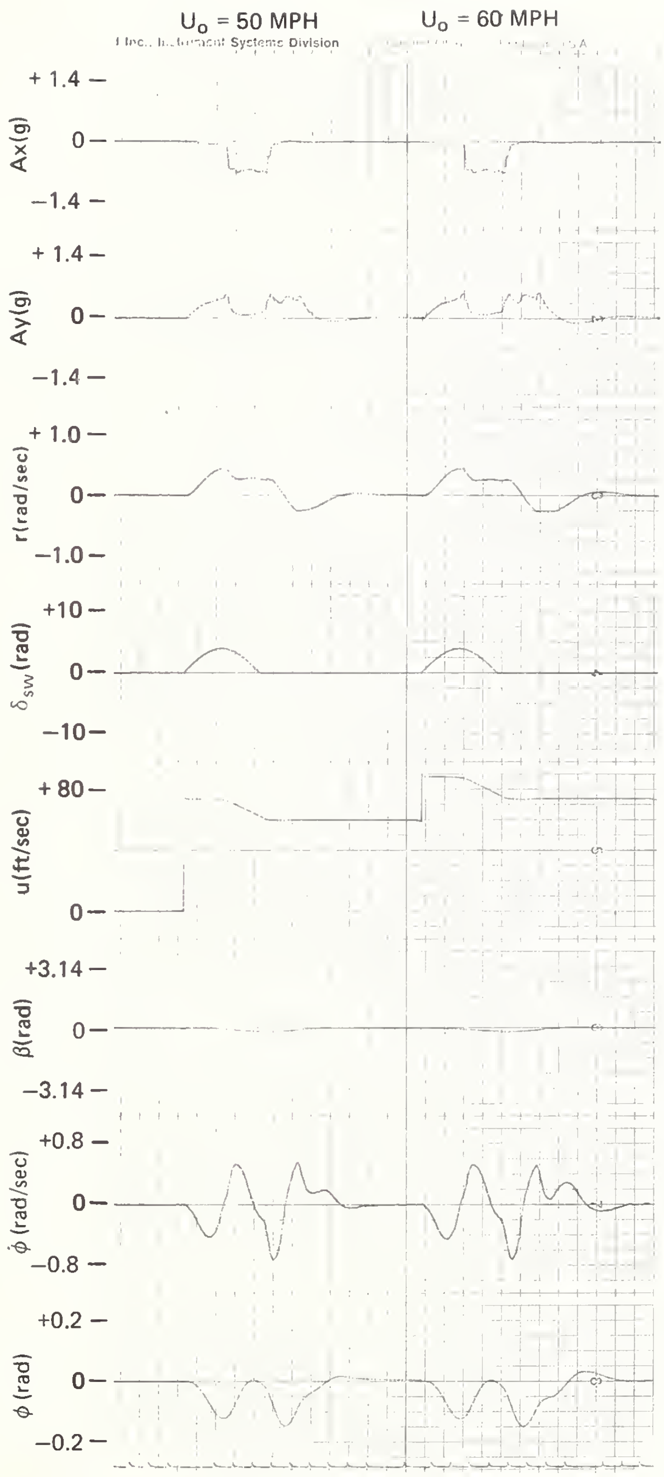



Fig. 2-8a TIME HISTORIES - DRASTIC STEER AND BRAKE

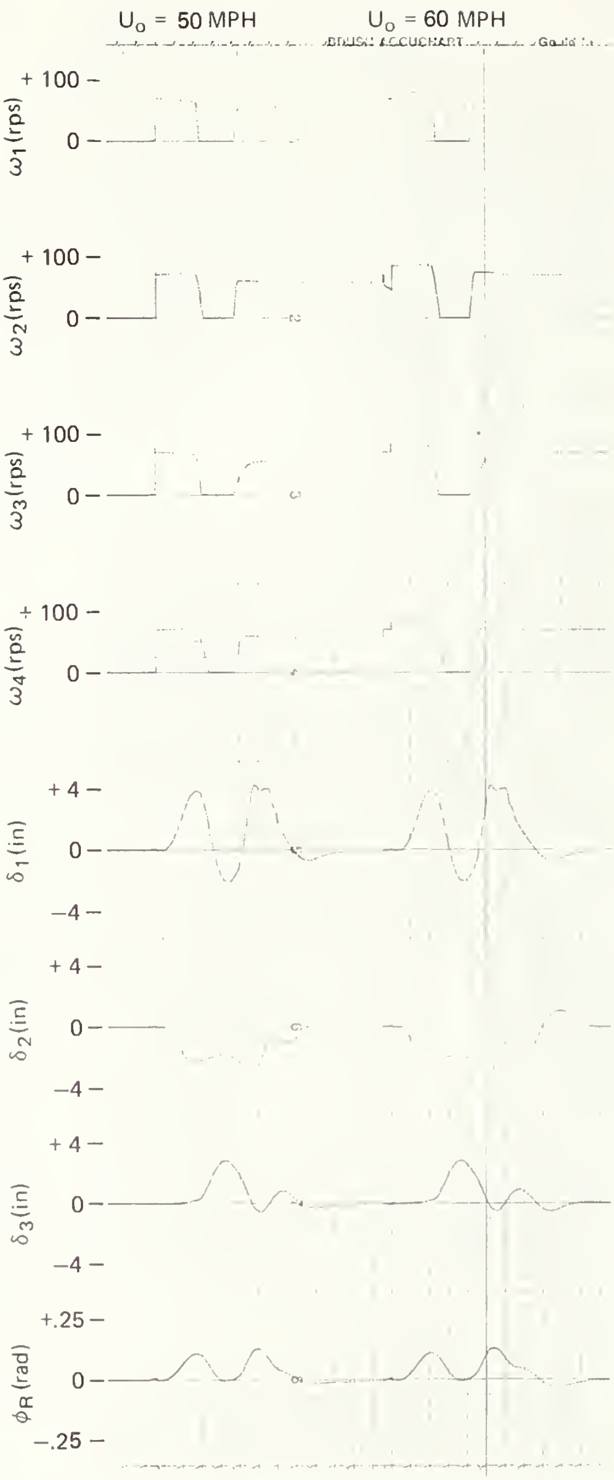



Fig. 2-8b TIME HISTORIES - DRASTIC STEER AND BRAKE

# SECTION 3
# CONCLUSIONS AND RECOMMENDATIONS

The Hybrid Computer Vehicle Handling Program (HVHP) has demonstrated realistic dynamic simulations of passenger vehicles with an independent front suspension and either an independent or solid axle rear suspension. The performance of simulation runs, especially those involving the six vehicle handling test procedures (VHTP), are inexpensively and easily performed. In addition, the performance measuring vehicle Comparison Variables (CV) for each VHTP are also provided.

Although good correlation between the HVHP and full-scale test data has been achieved, it is recommended that changes in all areas of the model, including the tire/road interface, the vehicle description, etc., be given serious consideration where an improvement in correlation could result. Also, since the HVHP has been proven adequate for the simulation of passenger vehicles, it is recommended that current plans to modify the HVHP mathematical model to allow the simulation of recreational and commercial vehicles be carried through to completion.

# APPENDIX A

# FOUR-WHEELED VEHICLE MATHEMATICAL MODEL

# APPENDIX A
# FOUR-WHEELED VEHICLE MATHEMATICAL MODEL

## 1. INTRODUCTION

This Appendix contains the vehicle mathematical model which was implemented on the APL/JHU hybrid computer. A hybrid simulation block diagram is shown in Figure A-1.

## 2. SYSTEM EQUATIONS

### 2.1 Table of Contents

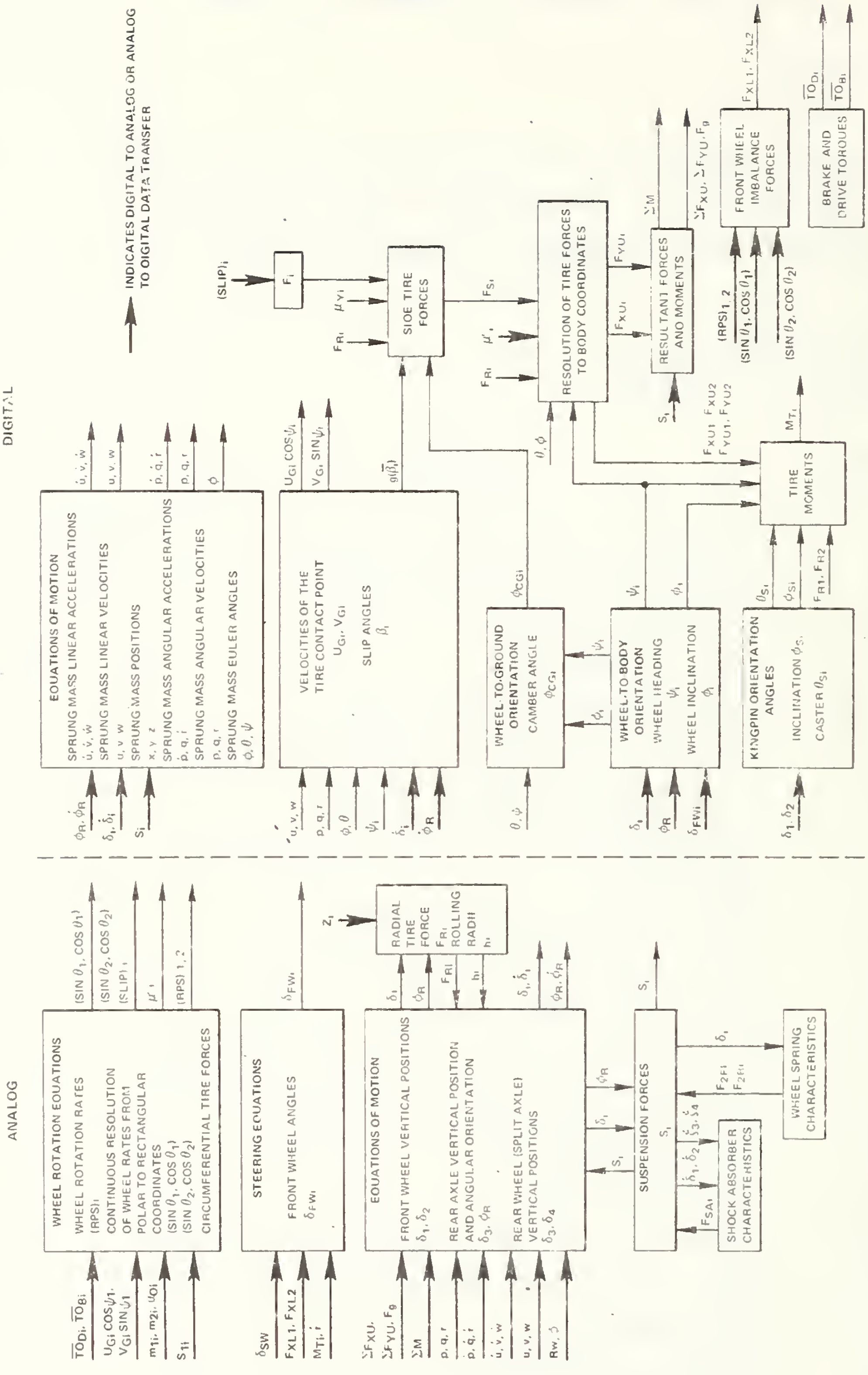



Fig. A-1 HYBRID SIMULATION BLOCK DIAGRAM OF THE AUTOMOBILE

## 2.2 Equations of Motion (Ten Degrees of Freedom)

The equations of motion of the sprung mass, front wheel unsprung masses, and rear axle are presented below:

$$(\Sigma\ M)\ \dot{u} + \gamma_2\ \dot{q} = (\Sigma\ M)\ (vr - wq - g\ \theta) + \Sigma\ F_{xu} \qquad (1)$$

$$(\Sigma\ M)\ \dot{v} - \gamma_2\ \dot{p} + \gamma_1\ \dot{r} = (\Sigma\ M)\ (wp - ur + g\ \phi) + \Sigma\ F_{yu} \qquad (2)$$

$$M_s\ \dot{w} = M_s\ (uq - vp + g) - \sum_{i=1}^{4} S_i \qquad (3)$$

$$-\gamma_3\ \dot{v} + (I_x + I_x')\ \dot{p} - (I_{xz}' + I_{xz})\ \dot{r} = \gamma_3\ (ur - wp - g\ \phi) + \Sigma\ N_{\phi u} \qquad (4)$$

$$\gamma_2\ \dot{u} + (I_y + I_y')\ \dot{q} = \gamma_2\ (vr - wq - g\ \theta) + \Sigma\ N_{\theta u} \qquad (5)$$

$$\gamma_1\ \dot{v} - (I_{xz} + I_{xz}')\ \dot{p} + (I_z + I_R + I_z')\ \dot{r} = \gamma_1\ (wp - ur + g\ \phi) + \Sigma\ N_{\psi u} \qquad (6)^*$$

$$\gamma_1\ \dot{v} - (I_{xz} + I_{xz}')\ \dot{p} + (I_z + I_z')\ \dot{r} = \gamma_1\ (wp - ur + g\ \phi) + \Sigma\ N_{\psi u} \qquad (7)^{**}$$

$$\frac{M_{uF}}{2}\ \dot{w} + \frac{M_{uF}\ T_F}{4}\ \dot{p} - \frac{M_{uF}\ a}{2}\ \dot{q} + \frac{M_{uF}}{2}\ \ddot{\delta}_1 = \frac{M_{uF}}{2}\ (uq - vp + g) + F_{zu1} + S_1 - F_{yu1}\ \mathrm{TAN}\left(\frac{2H_{FC}}{T_F}\right) \qquad (8)$$

*Solid Rear Axle
**Split Rear Axle

$$\frac{M_{uF}}{2}\dot{w} - \frac{M_{uF}\,T_F}{4}\dot{p} - \frac{M_{uF}\,a}{2}\dot{q} + \frac{M_{uF}}{2}\ddot{\delta}_2$$

$$= \frac{M_{uF}}{2}(uq - vp + g) + F_{zu2} + S_2$$

$$+ F_{yu2}\,\mathrm{TAN}\left(\frac{2H_{FC}}{T_F}\right) \qquad (9)$$

$$M_{uR}\dot{w} + b\,M_{uR}\dot{q} + \ddot{\delta}_3 M_{uR} = M_{uR}(uq - vp + g)$$

$$+ F_{zu3} + F_{zu4} + S_3 + S_4 \qquad (10)*$$

$$I_R\dot{p} + I_R\ddot{\phi}_R = \Sigma N_{\phi R} - (F_{yu3} + F_{yu4})\,H_{RC} \qquad (11)*$$

$$\frac{M_{uR}}{2}\dot{w} + \frac{M_{uR}\,b\dot{q}}{2} + \frac{M_{uR}\,T_R\,\dot{p}}{4} + \ddot{\delta}_3\frac{M_{uR}}{2}$$

$$= \frac{M_{uR}}{2}(uq - vp + g) + F_{zu3} + S_3$$

$$- F_{yu3}\,\mathrm{TAN}\left(\frac{2H_{RC}}{T_R}\right) \qquad (12)**$$

$$\frac{M_{uR}}{2}\dot{w} + \frac{M_{uR}}{2}b\dot{q} - \frac{M_{uR}\,T_R\,\dot{p}}{4} + \ddot{\delta}_4\frac{M_{uR}}{2}$$

$$= \frac{M_{uR}}{2}(uq - vp + g) + F_{zu4} + S_4$$

$$+ F_{yu4}\,\mathrm{TAN}\left(\frac{2H_{RC}}{T_R}\right) \qquad (13)**$$

where

$$\Sigma M = M_s + M_{uF} + M_{uR} \qquad (14)$$

$$I_x' = M_{uF}\,z_F^2 + M_{uR}\,z_R^2 \qquad (15)$$

*Solid Rear Axle
**Split Rear Axle

$$I'_y = I'_x \tag{16}$$

$$I'_z = M_{uF}\left(a^2 + \frac{T_F 2}{4}\right) + M_{uR}\, b^2 \qquad (17)^*$$

$$I'_z = M_{uF}\left(a^2 + \frac{T_F 2}{4}\right) + M_{uR}\left(b^2 + \frac{T_R 2}{4}\right) \qquad (18)^{**}$$

$$I'_{xz} = M_{uF}\, a\, z_F - M_{uR}\, b\, z_R \tag{19}$$

$$\gamma_1 = M_{uF}\, a - M_{uR}\, b \tag{20}$$

$$\gamma_2 = M_{uF}\, z_F + M_{uR}\, z_R \tag{21}$$

$$\gamma_3 = \gamma_2 \tag{22}$$

## 2.3 Vehicle Attitude and Position

The Euler angles and x, y, z coordinates in fixed space of the sprung mass are computed by the following equations:

$$\phi = \int_o^t (p + r\theta)\, dt + \phi(o) \tag{23}$$

$$\theta = \int_o^t (q - r\phi)\, dt + \theta(o) \tag{24}$$

$$\Psi = \int_o^t (r + q\phi)\, dt + \Psi(o) \tag{25}$$

$$x = \int_o^t (u \text{ COS } \Psi - v \text{ SIN } \Psi)\, dt + x(o) \tag{26}$$

$$y = \int_o^t (u \text{ SIN } \Psi + v \text{ COS } \Psi)\, dt + y(o) \tag{27}$$

$$z = \int_o^t (-u\theta + v\phi + w)\, dt + z(o) \tag{28}$$

*Solid Rear Axle
**Split Rear Axle

## 2.4 Suspension Forces

Suspension forces, including effects of viscous and coulomb damping, suspension stops, auxiliary roll stiffness, anti-pitch and anti-roll for front and rear are presented below:

For i = 1, 2 (Front)

$$S_i = \frac{b}{2(a+b)} M_s g - F_{1Fi} - F_{2Fi} - F_{3Fi} - (-1)^i \frac{R_F (\delta_2 - \delta_1)}{T_F^{\,2}} + A_{pi}(\delta_i) + A_{Ri}(\delta_i) \quad (29)$$

where

$$F_{1Fi} = C_F' \operatorname{sgn} \dot{\delta}_i \quad (30)$$

$$F_{2Fi} = K_{Fi}\, \delta_i + F_{BSi} \quad (31)$$

$$F_{BSi} = K_{Fi}(\lambda_{Fc} - 1)(\delta_{Si} - \Omega_{Fc}), \delta_{Si} < \Omega_{Fc} \quad (32)$$

$$= K_{Fi}\, \delta_i + K_{Fi}(\lambda_{FT} - 1)(\delta_{Si} - \Omega_{FT}), \delta_{Si} > \Omega_{FT} \quad (33)$$

$$= 0 \qquad \text{otherwise}$$

where

$$\delta_{Si} = \delta_i + \delta_{FIN} \quad (34)$$

$$\begin{aligned} F_{3Fi} &= C_1 \dot{\delta}_i + \left| C_2 - C_1 \right| \dot{\delta}_{(A)}, & \dot{\delta}_i &< \dot{\delta}_{(A)} \quad (35) \\ &= C_2 \dot{\delta}_i, & \dot{\delta}_{(A)} &\le \dot{\delta}_i < 0 \\ &= C_3 \dot{\delta}_i, & 0 &\le \dot{\delta}_i \le \dot{\delta}_{(B)} \\ &= C_4 \dot{\delta}_i - \left| C_4 - C_3 \right| \dot{\delta}_{(B)}, & \dot{\delta}_i &> \dot{\delta}_{(B)} \end{aligned}$$

$$A_{pi}(\delta_i) = (P_{Fo} + P_{F1}\ \delta_i + P_{F2}\ \delta_i^2)\ F_{xui} \tag{36}$$

$$A_{Ri}(\delta_i) = (R_{Fo} + R_{F1}\ \delta_i + R_{F2}\ \delta_i^2)\ F_{yui} \tag{37}$$

$$S_i = \frac{a}{2(a+b)} M_s\ g - F_{1Ri} - F_{2Ri} - F_{3Ri} + (-1)^i \left[\frac{R_R\ \phi_R}{T_s}\right] + A_{pi}(\delta_i) + A_{Ri}(\delta_i) \tag{38*}$$

$$S_i = \frac{a}{2(a+b)} M_s\ g - F_{1Ri} - F_{2Ri} - F_{3Ri} + (-1)^{i-1} \left[\frac{R_R^{\ 2}}{T_R}\right] (\delta_4 - \delta_3) + A_{pi}(\delta_i) + A_{Ri}(\delta_i) \tag{39**}$$

$$F_{1Ri} = C_R'\ \mathrm{sgn}\ \dot{\zeta}_i \tag{40}$$

For $i = 3, 4$ (Rear)

$$F_{2Ri} = K_{Ri}\ \zeta_i + F_{BSi} \tag{41}$$

$$F_{BSi} = K_{Ri}\ (\lambda_{RC} - 1)\ (\zeta_{si} - \Omega_{RC})\ , \quad \zeta_{si} < \Omega_{RC} \tag{42}$$

$$= K_{Ri}\ (\lambda_{RT} - 1)\ (\zeta_{si} - \Omega_{RT})\ , \quad \zeta_{si} > \Omega_{FT} \tag{43}$$

$$= 0 \qquad \text{otherwise}$$

where

$$\zeta_{si} = \zeta_i + \delta_{RIN} \tag{44}$$

$$F_{3Ri} = D_1\ \dot{\zeta}_i + |D_2 - D_1|\ \dot{\zeta}_{(A)}\ , \quad \dot{\zeta}_i < \dot{\zeta}_{(A)} \tag{45}$$

$$= D_2\ \dot{\zeta}_i\ , \qquad \dot{\zeta}_{(A)} \leq \dot{\zeta}_i < 0$$

$$= D_3\ \dot{\zeta}_i, \qquad 0 \leq \dot{\zeta}_i < \dot{\zeta}_{(B)}$$

*Solid Rear Axle
**Split Rear Axle

$$= D_4 \dot{\zeta}_i - |D_4 - D_3| \dot{\zeta}_{(B)} , \quad \dot{\zeta}_i > \dot{\zeta}_{(B)}$$

where

$\dot{\delta}_{(A)}, \dot{\delta}_{(B)}, \dot{\zeta}_{(A)}, \dot{\zeta}_{(B)}$ = non-zero break points on the restoring force characteristic.

$C_1, C_2, C_3, C_4, D_1, D_2, D_3, D_4$ = slope of four-line segments representing the restoring force characteristic.

and

$$\zeta_3 = \frac{T_s}{2} \phi_R + \delta_3 \quad (46)^*$$

$$\dot{\zeta}_3 = \frac{T_s}{2} \dot{\phi}_R + \dot{\delta}_3 \quad (47)^*$$

$$\zeta_4 = - \frac{T_s}{2} \phi_R + \delta_3 \quad (48)^*$$

$$\dot{\zeta}_4 = - \frac{T_s}{2} \dot{\phi}_R + \dot{\delta}_3 \quad (49)^*$$

$$\zeta_3 = \delta_3 \quad (50)^{**}$$

$$\dot{\zeta}_3 = \dot{\delta}_3 \quad (51)^{**}$$

$$\zeta_4 = \delta_4 \quad (52)^{**}$$

$$\dot{\zeta}_4 = \dot{\delta}_4 \quad (53)^{**}$$

$$A_{pi}(\delta_i) = (P_{Ro} + P_{R1} \delta_i + P_{R2} \delta_i^2) F_{xui} \quad (54)$$

*Solid Rear Axle
**Split Rear Axle

$$A_{Ri}(\delta_i) = (R_{R0} + R_{R1}\ \delta i + R_{R2}\ \delta_i^2)\ F_{yui} \tag{55}$$

## 2.5 Wheel Orientation

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

$$\phi_1 = \sum_{i=o}^{6} C_{iF}\ \delta_{S1}^{i} + \Delta\phi_1 \ \text{sgn}\ F_{S1} \tag{56}$$

$$\phi_2 = -\sum_{i=o}^{6} C_{iF}\ \delta_{S2}^{i} + \Delta\phi_2 \ \text{sgn}\ F_{S2} \tag{57}$$

$$\phi_3 = \sum_{i=o}^{6} C_{iR}\ \zeta_{S3}^{i} \tag{58**}$$

$$\phi_4 = -\sum_{i=o}^{6} C_{iR}\ \zeta_{S4}^{i} \tag{59**}$$

$$\phi_3 = \phi_4 = \phi_R \tag{60*}$$

$$\Psi_1 = \delta_{FW1} + \sum_{i=o}^{6} D_{iF}\ \delta_{S1}^{i} + \varepsilon_{K1} \tag{61}$$

$$\Psi_2 = \delta_{FW2} - \sum_{i=o}^{6} D_{iF}\ \delta_{S2}^{i} + \varepsilon_{K2} \tag{62}$$

$$\Psi_3 = K_{RS}\ \phi_R + K_{SR}\ M_{ZR} \tag{63*}$$

$$\Psi_4 = \Psi_3 \tag{64*}$$

$$\Psi_3 = \sum_{i=o}^{6} D_{iR}\ \zeta_{S3}^{i} + K_{SR}\ M_{ZR} \tag{65**}$$

$$\Psi_4 = -\sum_{i=o}^{6} D_{iR}\ \zeta_{S4}^{i} + K_{SR}\ M_{ZR} \tag{66**}$$

$$\theta_{S1} = \sum_{i=o}^{6} E_{iF}\ \delta_{S1}^{i} + \Delta\theta_1 \tag{67}$$

*Solid Rear Axle
**Split Rear Axle

$$\theta_{S2} = \sum_{i=o}^{6} E_{iF}\ \delta_{S2}^{i} + \Delta\theta_2 \tag{68}$$

## 2.6 Resultant Forces and Moments

The resultant tire and suspension forces and moments, including the anti-pitch and wheel imbalance, as required for the equations of motion are given below.

Forces:

$$\Sigma F_{xu} = \sum_{i=1}^{4} F_{xui} \tag{69}$$

$$F_{xui} = F_{Ri}\ \theta + F_{Ci}\ \mathrm{COS}\ \Psi_i - F_{Si}\ \mathrm{SIN}\ \Psi_i \tag{70}$$

$$\Sigma F_{yu} = \sum_{i=1}^{4} F_{yui} \tag{71}$$

$$F_{yui} = -F_{Ri}\ \phi + F_{Ci}\ \mathrm{SIN}\ \Psi_i + F_{Si}\ \mathrm{COS}\ \Psi_i \tag{72}$$

$$\Sigma F_{zu} = \sum_{i=1}^{4} F_{zui} \tag{73}$$

$$F_{zui} = -F_{Ri} \tag{74}$$

$$F_{XL1} = M_{L1}\ R_{RIM}\ \mathrm{RPS1}\ \mathrm{RPS1}\ \mathrm{COS}\ \theta_{L1} \tag{75}$$

$$F_{XL2} = M_{L2}\ R_{RIM}\ \mathrm{RPS2}\ \mathrm{RPS2}\ \mathrm{COS}\ \theta_{L2} \tag{76}$$

$$F_{ZL1} = M_{L1}\ R_{RIM}\ \mathrm{RPS1}\ \mathrm{RPS1}\ \mathrm{SIN}\ \theta_{L1} \tag{77}$$

$$F_{ZL2} = M_{L2}\ R_{RIM}\ \mathrm{RPS2}\ \mathrm{RPS2}\ \mathrm{SIN}\ \theta_{L2} \tag{78}$$

Moments:

$$\Sigma N_{\psi u} = (F_{yu1} + F_{yu2})\, a - (F_{yu3} + F_{yu4})\, b \tag{79}$$
$$+ (F_{xu2} - F_{xu1}) \frac{T_F}{2} + (F_{xu4} - F_{xu3}) \frac{T_R}{2}$$
$$+ \sum_{i=1}^{2} M_{ZFi} + \sum_{i=3}^{4} M_{ZRi}$$

$$\Sigma N_{\phi u} = \frac{T_F}{2} (S_2 - S_1) + \frac{T_S}{2} (S_4 - S_3) \quad (80)^*$$
$$- F_{yu1} (Z_F + \delta_1 + h_1 - H_{FC})$$
$$- F_{yu2} (Z_F + \delta_2 + h_2 - H_{FC})$$
$$- (F_{yu3} + F_{yu4}) (\delta_3 + H_{RC} + Z_R) + \sum_{i=1}^{2} M_{XFi}$$

$$\Sigma N_{\theta u} = (S_1 + S_2)\, a - (S_3 + S_4)\, b \quad (81)^*$$
$$+ F_{xu1} (z_F + \delta_1 + h_1) + F_{xu2} (z_F + \delta_2 + h_2)$$
$$+ F_{xu3} \left(z_R + \delta_3 + \frac{T_R}{2} \phi_R + h_3\right)$$
$$+ F_{xu4} \left(z_R + \delta_3 - \frac{T_R}{2} \phi_R + h_4\right)$$

$$\Sigma N_{\phi u} = \frac{T_F}{2} (S_2 - S_1) + \frac{T_R}{2} (S_4 - S_3) \quad (82)^{**}$$
$$- F_{yu1} (Z_F + \delta_1 + h_1 - H_{FC})$$
$$- F_{yu2} (Z_F + \delta_2 + h_2 - H_{FC})$$
$$- F_{yu3} (Z_R + \delta_3 + h_3 - H_{RC})$$
$$- F_{yu4} (Z_R + \delta_4 + h_4 - H_{RC})$$
$$+ \sum_{i=1}^{2} M_{XFi} + \sum_{i=3}^{4} M_{XRi}$$

*Solid Rear Axle
**Split Rear Axle

$$\Sigma N_{\theta u} = (S_1 + S_2)\ a - (S_3 + S_4)\ b + F_{xu1}\ (Z_F + \delta_1 + h_1) + F_{xu2}\ (Z_F + \delta_2 + h_2) + F_{xu3}\ (Z_R + \delta_3 + h_3) + F_{xu4}\ (Z_R + \delta_4 + h_4) \qquad (83)^{**}$$

$$\Sigma N_{\phi R} = F_{zu3}\left(\frac{T_R}{2} - h_3\phi_R\right) - F_{zu4}\left(\frac{T_R}{2} + h_4\phi_R\right) - F_{yu3}\left(\frac{T_R}{2}\ \phi_R + h_3\right) - F_{yu4}\left(-\ \frac{T_R}{2}\ \phi_R + h_4\right) + (S_3 - S_4)\ \frac{T_S}{2} + \sum_{i=3}^{4} M_{XRi} \qquad (84)^{*}$$

where $M_{ZFi}$, $M_{ZRi}$, $M_{XFi}$ and $M_{XRi}$ are the front and rear wheel aligning torques and overturning moments.

## 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:

$$F_{Ri} = K_{Ti}\ (R_W - h_i), \qquad (R_W - hi) > o \qquad (85)$$
$$= 0, \qquad (R_W - hi) \leq o$$

where

$$h_i = -\ Z_i\ ;\ i = 1,2,3,4$$

$$Z_1 = Z - a\ \theta + \frac{T_F}{2}\ \phi + Z_F + \delta_1 \qquad (86)$$

$$Z_2 = Z - a\ \theta - \frac{T_F}{2}\ \phi + Z_F + \delta_2 \qquad (87)$$

$$Z_3 = Z + b\ \theta + \frac{T_R}{2}\ \phi + Z_R + \frac{T_R}{2}\ \phi_R + \delta_3 \qquad (88)^{*}$$

$$Z_4 = Z + b\ \theta - \frac{T_R}{2}\ \phi + Z_R - \frac{T_R}{2}\ \phi_R + \delta_3 \qquad (89)^{*}$$

*Solid Rear Axle
**Split Rear Axle

$$Z_3 = Z + b\,\theta + \frac{T_R}{2}\,\phi + Z_R \div \delta_3 \qquad (90)^{**}$$

$$Z_4 = Z + b\,\theta - \frac{T_R}{2}\,\phi + Z_R + \delta_4 \qquad (91)^{**}$$

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

$$\theta_{(0)} = \frac{\left[h_{1(0)} - h_{3(0)}\right] \div \left[Z_F - Z_R\right]}{a+b}$$

$$h_{1(0)} = h_{2(0)} = R_w - \frac{g}{2K_{T1}}\left[M_{UF} + \left(\frac{b}{a+b}\right) M_S\right]$$

$$h_{3(0)} = h_{4(0)} = R_w - \frac{g}{2K_{T3}}\left[M_{UR} + \left(\frac{a}{a+b}\right) M_S\right]$$

$$Z_{(0)} = \frac{b\left[h_{1(0)} + Z_F\right] + a\left[h_{3(0)} + Z_R\right]}{a+b}$$

Wheel lift-off indication is provided by

$$Z_{MXi} = R_w - h_i \qquad i = 1,2,3,4 \qquad (92)$$

where

$Z_{MXi} > o$ wheel i in contact with tire-terrain patch

$Z_{MXi} \leq o$ wheel i not in contact with tire-terrain patch

## 2.8 Tire Circumferential Force

The circumferential tire forces for both driving and braking are defined below:

$$F_{Ci} = -\mu_i' F_{Ri} \qquad (93)$$

**Split Rear Axle

## 2.9 Circumferential Friction Coefficient

The circumferential friction coefficient equations are shown below:

$$\mu_i' = m_{2i}\ (SLIP)_i + \mu_{0i} \quad \text{for } (SLIP)_i > SI_i \tag{94}$$

$$= m_{1i}\ (SLIP)_i \quad \text{for } (SLIP)_i \leq SI_i$$

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

$$m_{1i} = \left(\frac{\mu_{PF}}{SI_i}\right) (1.0 - 0.03|\beta_i + \beta_i'|\ 57.3)\ SN_i \tag{95}$$

$$= \mu_{SF}\ SN_i \qquad m_{1i} < \mu_{SF}$$

$$m_{2i} = \frac{(\mu_{SF} - \mu_{PF})}{(1.0 - SI_i)} (1.0 - 0.06|\beta_i + \beta_i'|\ 57.3)\ SN_i \tag{96}$$

$$= \mu_{SF}\ SN_i \qquad m_{2i} \geq \mu_{SF}$$

$$\mu_{PF} = P_{BF1} + P_{BF2}\ F_{Ri} \tag{97}$$

$$\mu_{1i} = \mu_{SF}\ SNi \tag{98}$$

$$\mu_{0i} = \mu_{1i} - m_{2i} \tag{99}$$

$$i = 1,2$$

$$m_{1i} = \left(\frac{\mu_{PR}}{SI_i}\right) (1.0 - 0.03\ |\beta_i + \beta_i'|\ 57.3)\ SN_i \tag{100}$$

$$= \mu_{SR}\ SN_i \qquad m_{1i} < \mu_{SR}$$

$$m_{2i} = \frac{(\mu_{SR} - \mu_{PR})}{(1.0 - SI_i)} (1.0 - 0.06\ |\beta_i + \beta_i'|\ 57.3)\ SN_i \tag{101}$$

$$\mu_{SR}\ SN_i \qquad m_{2i} \geq \mu_{SR}$$

$$\mu_{PR} = P_{BR1} + P_{BR2}\ F_{Ri} \tag{102}$$

$$\mu_{1i} = \mu_{SR}\, SN_i \tag{103}$$

$$\mu_{0i} = \mu_{1i} - m_{2i} \qquad\qquad i = 3,4 \tag{104}$$

$$SN_i = S_{NSO}/S_{NT} \tag{105}$$

2.10 Wheel Slip

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

$$\begin{aligned}(SLIP)_i &= 1 \quad \text{for } \xi_i > 1 \\ &= \xi_i \text{ for } -1 \leq \xi_i \leq 1 \\ &= -1 \text{ for } \xi_i < -1\end{aligned} \tag{106}$$

where

$$\xi_i = 1 - \frac{(RPS)_i\ h_i}{u_{Gi}\ \cos \Psi_i + v_{Gi}\ \sin \Psi_i}, \qquad \overline{TQ}_{\beta i} \geq 0 \tag{107}$$

2.11 Wheel Rotational Equations

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

$$I_{WF} \left[\frac{d}{dt}\ (RPS)_1\right] = -F_{C1}\ h_1 + \overline{TQ}_1\ \lambda_{B1} \tag{108}$$

$$I_{WF} \left[\frac{d}{dt}\ (RPS)_2\right] = -F_{C2}\ h_2 + \overline{TQ}_2\ \lambda_{B2} \tag{109}$$

$$\left[I_{WR} + \frac{I_D\ (\overline{AR})^2}{4}\right]\left[\frac{d}{dt}\ (RPS)_3\right] + \left[\frac{I_D\ (\overline{AR})^2}{4}\right]\left[\frac{d}{dt}\ (RPS)_4\right] = -F_{C3}\ h_3 + \overline{TQ}_3\ \lambda_{B3} \tag{110}$$

$$\left[\frac{I_D\,(\overline{AR})^2}{4}\right]\left[\frac{d}{dt}\,(RPS)_3\right] + \left[I_{WR} + \frac{I_D\,(\overline{AR})^2}{4}\right]\left[\frac{d}{dt}\,(RPS)_4\right]$$
$$= -F_{C4}\,h_4 + \overline{TQ}_4\,\lambda_{B4} \qquad (111)$$

where

$$(RPS)_i = (RPS)_{io} + \int_o^t \frac{d}{dt}\left[(RPS)_i\right] dt \qquad (112)$$

For $(SLIP)_i = 0$ at $t = 0$

$$(RPS)_{io} = \frac{u_{Gi}(o)\ \cos \Psi_i(o) + v_{Gi}(o)\ \sin \Psi_i(o)}{h_i(o)} \qquad (113)$$

and where

$$\overline{TQ}_1 = \overline{TQ}_{B1} \qquad (114)$$

$$\overline{TQ}_2 = \overline{TQ}_{B2} \qquad (115)$$

$$\overline{TQ}_3 = \frac{\overline{AR}}{2}\,\overline{TQ}_D + \overline{TQ}_{B3} \qquad (116)$$

$$\overline{TQ}_4 = \frac{\overline{AR}}{2}\,\overline{TQ}_D + \overline{TQ}_{B4} \qquad (117)$$

## 2.12 Brake and Drive Torques

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

$$\overline{TQ}_D = K_{TQ}\,(V_C - u),\ \text{for } \overline{TQ}_D \leqq TQ_{D_{MAX}} \qquad (118)$$

$$= TQ_{D_{MAX}}\ ,\quad \text{otherwise} \qquad (119)$$

where $V_C$ is the desired velocity.

Values of 1000 in-lb/in/sec and 6000 in-lb were assigned to $K_{TQ}$ and $TQ_{DMAX}$ respectively. When braking is investigated, the drive torque is zero and the brake torque magnitudes are determined from input data functions.

$$\overline{TQ}_{B1} = \overline{TQ}_{B2} = FF(PFL), \text{ in-lbs} \tag{120}$$

$$\overline{TQ}_{B3} = \overline{TQ}_{B4} = FR(PFL), \text{ in-lbs} \tag{121}$$

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 equation:

$$F_{Si} = \mu_{yi} F_{Ri} \left[g\ (\overline{\beta}_i)\right] \left[F_i\ (SLIP_i)\right] \tag{122}$$

## 2.14 Tire Side Force Friction Coefficient

The side force coefficient of friction is defined below:

$$\mu_{yi} = (B_1 F_{Ri} + B_2 C_{vi} + B_3 + B_4 F_{Ri}^2)\ SN_i \qquad i = 1,2 \tag{123}$$

$$\mu_{yi} = (RB_1 F_{Ri} + RB_2 C_{vi} + RB_3 + RB_4 F_{Ri}^2)\ SN_i \qquad i = 3,4 \tag{124}$$

and

$$C_{vi} = \sqrt{u_{Gi}^2 + v_{Gi}^2} \tag{125}$$

## 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:

$$u_1 = u - \frac{T_F}{2} r + z_F q \tag{126}$$

$$u_2 = u + \frac{T_F}{2} r + z_F q \tag{127}$$

$$u_3 = u - \frac{T_R}{2} r + z_R q \tag{128}$$

$$u_4 = u + \frac{T_R}{2} r + z_R q \tag{129}$$

$$v_1 = v + ar - z_F p - h_1 p \tag{130}$$

$$v_2 = v + ar - z_F p - h_2 p \tag{131}$$

$$v_3 = v - br - z_R p - h_3 (p + \dot{\phi}_R) \qquad (132)*$$

$$v_3 = v - br - z_R p - h_3 p \qquad (133)**$$

$$v_4 = v - br - z_R p - h_4 (p + \dot{\phi}_R) \qquad (134)*$$

$$v_4 = v - br - z_R p - h_4 p \qquad (135)**$$

$$w_1 = w - aq + \frac{T_F}{2} p + \dot{\delta}_1 \tag{136}$$

$$w_2 = w - aq - \frac{T_F}{2} p + \dot{\delta}_2 \tag{137}$$

$$w_3 = w + bq + \dot{\delta}_3 + \frac{T_R}{2} (\dot{\phi}_R + p) \qquad (138)*$$

$$w_3 = w + bq + \dot{\delta}_3 + \frac{T_R}{2} p \qquad (139)**$$

$$w_4 = w + bq + \dot{\delta}_3 - \frac{T_R}{2} (\dot{\phi}_R + p) \qquad (140)*$$

$$w_4 = w + bq + \dot{\delta}_4 - \frac{T_R}{2} p \qquad (141)**$$

*Solid Rear Axle
**Split Rear Axle

The wheel velocities in the ground plane are obtained by:

$$u_{Gi} = u_i + \theta w_i \tag{142}$$

$$v_{Gi} = v_i - \phi w_i \tag{143}$$

## 2.16 Combined Slip Angle and Camber Shaping Function

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

$$g(\overline{\beta}_i) = \overline{\beta}_i - \frac{1}{3}\overline{\beta}_i\,|\overline{\beta}_i| + \frac{1}{27}\overline{\beta}_i^{\,3} \quad \text{if } |\overline{\beta}_i| < 3 \tag{144}$$

$$= \frac{\overline{\beta}_i}{|\overline{\beta}_i|} \quad \text{if } |\overline{\beta}_i| \geqq 3 \qquad i = 1,2,3,4$$

where $\overline{\beta}_i$ is defined by

For $F_{Ri} \leqq A\Omega_T\, A_2$,

$i = 1,2$

$$\overline{\beta}_i = \frac{A_1\, F_{Ri}\, (F_{Ri} - A_2) - A_o\, A_2}{A_2\, \mu_{yi}\, F_{Ri}}\,(\beta_i + \beta_i') \tag{145}$$

$$\beta_i' = \frac{A_2\, A_3\, (A_4 - F_{Ri})\, F_{Ri}\, \phi_{CGi}}{A_4\, |A_1\, F_{Ri}\, (F_{Ri} - A_2) - A_o\, A_2|} \tag{146}$$

If $F_{Ri} > A\Omega_T\, A_2$,

$i = 1,2$

$$\overline{\beta}_i = \frac{A_1\, A_2\, A\Omega_T\, (A\Omega_T - 1) - A_o}{\mu_{yi}\, F_{Ri}}\,(\beta_i + \beta_i') \tag{147}$$

$$\beta_i' = \frac{A_2\, A_3\, A\Omega_T\, (A_4 - A\Omega_T\, A_2)\, \phi_{CGi}}{A_4\, |A_1\, A_2\, A\Omega_T\, (A\Omega_T - 1) - A_o|} \tag{148}$$

For $F_{Ri} \leq R\Omega_T\ RA_2$, $\qquad i = 3,4$

$$\overline{\beta}_i = \frac{RA_1\ F_{Ri}\ (F_{Ri} - RA_2) - RA_o\ RA_2}{RA_2\ \mu_{yi}\ F_{Ri}} (\beta_i + \beta_i') \tag{149}$$

$$\beta_i' = \frac{RA_2\ RA_3\ (RA_4 - F_{Ri})\ F_{Ri}\ \phi_{CGi}}{RA_4\ \left[RA_1\ F_{Ri}\ (F_{Ri} - RA_2) - RA_o\ RA_2\right]} \tag{150}$$

If $F_{Ri} > R\Omega_T\ RA_2$, $\qquad i = 3,4$

$$\overline{\beta}_i = \frac{RA_1\ RA_2\ R\Omega_T\ (R\Omega_T - 1) - RA_o}{\mu_{yi}\ F_{Ri}} (\beta_i + \beta_i') \tag{151}$$

$$\beta_i' = \frac{RA_2\ RA_3\ R\Omega_T\ (RA_4 - R\Omega_T\ RA_2)\ \phi_{CGi}}{RA_4\ \left[RA_1\ RA_2\ R\Omega_T\ (R\Omega_T - 1) - RA_o\right]} \tag{152}$$

## 2.17 Wheel Slip Angle

$$\beta_i = \tan^{-1}\left[\frac{v_{Gi}}{|u_{Gi}|}\right] - \Psi_i\ \mathrm{sgn}\ u_{Gi} \tag{153}$$

## 2.18 Wheel Camber with Respect to the Road

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

$$\phi_{CGi} = \theta\ \mathrm{SIN}\ \Psi_i + \phi\ \mathrm{COS}\ \Psi_i + \phi_i + K_{CF}\ F_{Si} \qquad i = 1,2 \qquad (154)$$

$$\phi_{CGi} = \theta\ \mathrm{SIN}\ \Psi_i + \phi\ \mathrm{COS}\ \Psi_i + \phi_i + K_{CR}\ F_{Si} \qquad i = 3,4 \qquad (155)^{**}$$

$$\phi_{CGi} = 0;\ i = 3,4 \qquad (156)^{*}$$

*Solid Rear Axle
**Split Rear Axle

## 2.19 Wheel Slip Shaping Function

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

$$F_i \ (SLIP_i) = \text{input table} \tag{157}$$

| $F_i$ | $SLIP_i$ (%) |
|---|---|
| 1.00 | 0.0 |
| 0.99 | 5.0 |
| 0.97 | 10.0 |
| 0.93 | 15.0 |
| 0.86 | 20.0 |
| 0.72 | 30.0 |
| 0.56 | 40.0 |
| 0.34 | 60.0 |
| 0.25 | 80.0 |
| 0.18 | 100.0 |

## 2.20 Tire Moments

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

$$\begin{aligned} M_{Ti} = {} & F_{xui} \left[\overline{PT}_i \text{ SIN } \Psi_i - y_{SAi} \text{ COS } \Psi_i \right. \\ & \left. + h_i \ (\phi_i \text{ COS } \Psi_i - \phi_{Si})\right] + F_{yui} \left[-\overline{PT}_i \ KK_i \text{ COS } \Psi_i \right. \\ & \left. - y_{SAi} \text{ SIN } \Psi_i + h_i \ (\phi_i \text{ SIN } \Psi_i - \theta_{Si})\right] \\ & + F_{zui} \left[-\overline{PT}_i \ (\phi_{Si} \text{ COS } \Psi_i + \theta_{Si} \text{ SIN } \Psi_1) \right. \\ & + y_{SAi} \ (\theta_{Si} \text{ COS } \Psi_i - \phi_{Si} \text{ SIN } \Psi_i) \\ & \left. + h_i \ (\phi_{Si} \ \phi_i \text{ SIN } \Psi_i - \theta_{Si} \ \phi_i \text{ COS } \Psi_i)\right] + M_{ZF} \\ & - F_{XLi} \ (Y_{SAi} + \frac{R_{WR}}{2}) \ ; \qquad i = 1,2 \end{aligned} \tag{158}$$

$$\phi_{S1} = \phi_{SA1} + \phi_1 \tag{159}$$

$$\phi_{S2} = \phi_{SA2} + \phi_2 \tag{160}$$

The tire aligning torques are defined as

$$M_{ZFi} = (AF_1\, F_{Ri} + AF_2\, |F_{Si}|)\, F_{Si} + AF_3\, F_{Ri}\, (\phi_{CGi})^{\frac{1}{2}} \quad (161)$$

$$i = 1,2$$

$$M_{ZRi} = (AR_1\, F_{Ri} + AR_2\, |F_{Si}|)\, F_{Si} + AR_3\, F_{Ri}\, (\phi_{CGi})^{\frac{1}{2}} \quad (162)$$

$$i = 3,4$$

The tire overturning moments are defined as

$$M_{XFi} = OF_0 + (OF_1 + OF_2\, \phi_{CGi})\, F_{Si}\, F_{Ri} + OF_3\, \phi_{CGi}\, F_{Ri} \quad (163)$$

$$i = 1,2$$

$$M_{XRi} = OR_0 + (OR_1 + OR_2\, \phi_{CGi})\, F_{Si}\, F_{Ri} + OR_3\, \phi_{CGi}\, F_{Ri} \quad (164)$$

$$i = 3,4$$

## 2.21 Steering Equations

The steering equations are presented below:

$$(\dot{r} + \ddot{\delta}_{FWi})\, I_{FW} = -H_i\, \dot{\delta}_{FWi} + M_{Ti} - M_{SSi} \quad (165)$$

$$i = 1,2$$

$$M_{CR}\, \ddot{y}_{CR} = -C_{FCR} - C_{CR}\, \dot{y}_{CR} + \frac{T_p}{a_p} + \frac{M_{SS1}}{a_{L1}} + \frac{M_{SS2}}{a_{L2}} \quad (166)$$

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

conditions:

$$T_p = N_G \left\{K_{SC} \left(\delta_{SW} - N_G \frac{Y_{CR}}{a_p} - \frac{\varepsilon_{SP}}{2} \operatorname{sgn} \delta_{SW}\right)\right\} \quad (167)$$

if $\left|\delta_{SW} - N_G \dfrac{Y_{CR}}{a_p}\right| > \dfrac{\varepsilon_{SP}}{2}$

otherwise $T_p = 0$

$$M_{SSi} = K_{SLi} \left[ \left( \delta_{FWi} - \frac{y_{CR}}{a_{Li}} \right) - \frac{\varepsilon_{pi}}{2} \operatorname{sgn} \delta_{FWi} \right] \tag{168}$$

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

otherwise $M_{SSi} = 0$

## 2.22 Longitudinal and Lateral Accelerations

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

$$A_x = \dot{u} - vr + wq \tag{169}$$

$$A_y = \dot{v} + ru - wp \tag{170}$$

# 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 $\left(\text{i.e., } \dot{\delta} = \frac{d\delta}{dt},\ \ddot{\delta} = \frac{d^2\delta}{dt^2}.\right)$

Also: 1 degree = 0.0174532925 radians

1 g = 386.4 in/sec$^2$

The following subscript notation is employed:

F = front
R = rear, or rear axle
s = sprung mass
u = unsprung mass
i = wheel number, 1 - right front, 2 - left front, 3 - right rear, 4 - left rear

## 3.2 List of Symbols

$a,b$ = distances along the vehicle fixed $x_B$ axis from the sprung mass center of gravity to the spin axes of the front and rear wheels, respectively, in.

$AF_1$, $AF_2$, $AF_3$ = front wheel aligning torque function coefficients.

$a_{Li}$ = length of steering linkage arm, in. - i = 1,2

$a_p$ = length of pitman arm, in.

$A_{pi}$ = anti-pitch forces in front and rear suspensions, lb.

$\overline{AR}$ = drive axle ratio.

$A_{Ri}$ = anti-roll forces in front and rear suspensions, lb.

$AR_1, AR_2, AR_3$ = rear wheel aligning torque function coefficients.

$A_x$ = longitudinal acceleration of the sprung mass, gees.

$A_y$ = lateral acceleration of the sprung mass, gees.

$A_0, A_1, A_2$ = coefficients in quadratic cornering stiffness function for a pneumatic tire, front.

$A_3, A_4$ = coefficients in quadratic camber stiffness function for a pneumatic tire, front.

$A\Omega_T, R\Omega_T$ = multiple of $A_2$ and $RA_2$ at which the assumed parabolic variations of small-angle cornering and camber stiffness with tire loading are made constant.

$B_1, B_2, B_3, B_4$ = constant coefficients for curves fitted to the lateral friction coefficient properties, front tires.

$C_{CR}$ = viscous damping coefficient of steering system connecting rod, lb-sec/in.

$C_{FCR}$ = coulomb damping coefficient of steering system connecting rod, lb.

$C_F, C_R$ = viscous damping coefficient for a single wheel, effective at the wheel for the front and at the spring for the rear suspension, at the front and rear, respectively, lb-sec/in.

$C_F', C_R'$ = coulomb damping for a single wheel, effective at the wheel for the front and at the spring for the rear suspension, at the front and rear, respectively, lb.

$C_{iF}$, $C_{iR}$ = coefficients for wheel camber angle versus suspension deflection polynominal function, front and rear, respectively, i = 1, ..., 6.

$C_{vi}$ = total contact point velocity of wheel i, in/sec.

$D_{iF}$, $D_{iR}$ = coefficients for wheel toe angle versus suspension deflection polynominal function, front and rear, respectively, i = 1, ..., 6.

$E_{iF}$ = coefficients for front wheel caster angle versus suspension deflection polynominal function, i = 1, ...., 6.

$F_{BSi}$ = suspension forces increment produced by spring deflections at compression and rebound bump stops, lb.

$F_{Ci}$ = circumferential tire force at wheel i, lb.

FF, FR = front and rear brake torque curves which are input as functions of brake line pressure, in - lb.

$F_i$ = side force shaping function for braking slip.

$F_{Ri}$ = radial tire force at wheel i, lb.

$F_{Si}$ = lateral tire force at wheel i, lb.

$F_{XLi}$, $F_{ZLi}$ = unbalanced forces on front wheel due to wheel imbalance, lb.

$F_{xui}$, $F_{yui}$, $F_{zui}$ = components of the tire force on wheel i in the body coordinate system, lb.

$\Sigma F_{xu}$, $\Sigma F_{yu}$, $\Sigma F_{zu}$ = summation of the forces acting on the sprung mass along the vehicle $X_B$, $Y_B$ and $Z_B$ axes, lb.

$F_{1Fi}$, $F_{1Ri}$ = coulomb damping forces in front and rear suspensions, at an individual wheel, effective at wheels in front and at spring locations in rear, lb.

$F_{2Fi}$, $F_{2Ri}$ = suspension forces produced by deflection of springs and elastic travel limits, lb.

$F_{3Fi}$, $F_{3Ri}$ = coulomb damping forces in front and rear suspensions, at an individual wheel, effective at wheels in front and at spring locations in rear, lb.

$F_{2Fi}$, $F_{2Ri}$ = suspension forces produced by deflection of springs and elastic travel limits, lb.

$F_{3Fi}$, $F_{3Ri}$ = viscous suspension damping force due to shock absorbers, effective at wheel i, lb.

$g$ = acceleration of gravity.

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

$H_{FC}$ = distance between ground and roll center of front suspension, in.

$h_i$ = rolling radius of wheel i, in.

$H_i$ = front wheel viscous damping coefficient, in-lb/rad/sec.

$H_{RC}$ = distance between center of rear axle and roll center of rear suspension, in.

$I_D$ = drive line moment of inertia about its spin axis, lb-sec$^2$-in.

$I_{FW}$ = moment of inertia of one front wheel about the kingpin axis, lb-sec$^2$-in.

$I_R$ = rear unsprung mass moment of inertia about a line through its center of gravity and parallel to the $X_B$ axis, lb-sec$^2$-in.

$I_{Wj}$ = rotational inertia of individual wheel about its spin axis, at front and rear (j = F, R), respectively, lb-sec$^2$-in.

$I_x$ = moment of inertia of sprung mass about the $X_B$ axis. lb-sec$^2$-in.

$I_y$ = moment of inertia of sprung mass about the $Y_B$ axis, lb-sec$^2$-in.

$I_z$ = moment of inertia of sprung mass about the $Z_B$ axis, lb-sec$^2$-in.

$I_{xz}$ = product of inertia of sprung mass about the $X_B, Z_B$ axes, lb-sec$^2$-in.

$I'_x$, $I'_y$, $I'_z$, $I'_{xz}$ = moments of inertia of unsprung masses, lb-sec$^2$-in.

$K_{CF}$, $K_{CR}$ = front and rear lateral compliance camber coefficients, respectively.

$K_{Fi}$, $K_{Ri}$ = suspension load-deflection rate for a single wheel in the quasi-linear range about the design position, effective at the wheel for the front and at the spring for the rear suspension, at the front and rear, respectively, lb/in.

$K_{RS}$ = roll steer gain of rear wheels relative to the vehicle coordinate system, rad/rad.

$K_{SC}$ = steering column-gear box flexibility, in-lbs/rad.

$K_{SLi}$ = steering linkage flexibility between the output of the steering unit and the kingpin, in-lb/rad. i = 1,2

$K_{SR}$ = rear aligning torque compliance steer coefficient.

$K_{Ti}$ = radial tire rate in quasi-linear range for a single tire, lb/in.

$K_{TQ}$ = gain in drive torque equation for controlling vehicle velocity, in-lbs/in/sec.

$m_{1i}$, $m_{2i}$ = rise and decay slopes of the circumferential friction coefficient versus wheel slip function.

$\Sigma M$ = total vehicle mass, lb-sec$^2$/in.

$M_{CR}$ = mass of steering system connecting rod, lb-sec$^2$/in.

$M_{Li}$ = unbalanced front wheel mass, lb-sec$^2$/in.

$M_s$ = sprung mass, lb-sec$^2$/in.

$M_{SSi}$ = steering torque applied by steering system connecting rod, in-lb., i = 1,2

$M_{Ti}$ = wheel aligning moment, in-lb., i = 1,2

$M_{uF}$ = total front unsprung mass, lb-sec$^2$/in.

$M_{XFi}$, $M_{XRi}$ = overturning moments acting on the front and rear unsprung masses, respectively, lb-in.

$M_{ZFi}$, $M_{ZRi}$ = front and rear tire aligning torques, respectively, lb-in.

$M_1 = M_2 = \frac{M_{uF}}{2}$ = front unsprung mass at a single wheel, lb-sec$^2$/in.

$M_3 = M_{uR}$ = total rear unsprung mass, lb-sec$^2$/in. (solid axle)

$M_3 = M_4 = \frac{M_{uR}}{2}$ = rear unsprung mass at a single wheel, lb-sec$^2$/in. (split axle)

$N_G$ = gear ratio of steering gear box.

$\Sigma N_{\phi R}$ = summation of roll moments acting on solid rear axle, lb-in.

$\Sigma N_{\phi u}$ = summation of roll moments acting on the unsprung mass, lb-in.

$\Sigma N_{\theta u}$ = summation of pitch moments acting on the unsprung mass, lb-in.

$\Sigma N_{\psi u}$ = summation of yaw moments acting on the unsprung mass, lb-in.

$OF_0$, $OF_1$, $OF_2$, $OF_3$ = front tire overturning moment coefficients.

$OR_0$, $OR_1$, $OR_2$, $OR_3$ = rear tire overturning moment coefficients.

p, q, r = scalar components of angular velocity of the sprung mass, taken along $X_B$, $Y_B$, $Z_B$ axes, respectively, rad/sec.

$P_{BF1}$, $P_{BF2}$, $P_{BR1}$, $P_{BR2}$ = coefficients for peak braking coefficient of friction function, front and rear, respectively.

$P_{F0}$, $P_{F1}$, $P_{F2}$ = anti-pitch coefficients for front suspension.

$P_{FL}$ = brake line pressure, lb/in$^2$.

$P_{R0}$, $P_{R1}$, $P_{R2}$ = anti-pitch coefficients for rear suspension.

$\overline{PT}$ = caster trail of front wheels, in.

$RA_0$, $RA_1$, $RA_2$ = coefficients in a quadratic cornering stiffness function for a pneumatic tire, rear.

$RA_3$, $RA_4$ = coefficients in a quadratic camber stiffness function for a pneumatic tire, rear.

$RB_1$, $RB_2$, $RB_3$, $RB_4$ = constant coefficients for curves fitted to the lateral friction coefficient properties, rear tires.

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

$R_{F0}$, $R_{F1}$, $R_{F2}$ = anti-roll coefficients for front suspension.

$(RPS)_i$ = rotational velocity of wheel i, rad/sec.

$R_{R0}$, $R_{R1}$, $R_{R2}$ = anti-roll coefficients for rear suspension.

$R_w$ = undeflected radius of wheels, in.

$R_{WR}$ = width of wheel rim, in.

$S_i$ = total suspension force produced by the combination of springs, travel stops, viscous damping, friction, and auxiliary roll stiffness, effective at the wheel for the front suspension, at the spring location for the solid rear axle suspension and at the wheel for the independent rear axle suspension, at wheel i, lb.

$SI_i$ = wheel slip ratio at which peak braking coefficient of friction occurs.

$SN_i$ = skid number ratio of simulated vehicle operating surface to tire data measurement surface.

$(SLIP)_i$ = longitudinal braking slip at wheel i.

$T_F$, $T_R$ = wheel tread width at front and rear, respectively, in.

$T_p$ = Pitman arm torque applied to connecting rod, in-lb.

$T_S$ = distance between spring mountings on solid rear axle, in.

$\overline{TQ}_{Bi}$ = brake torque at wheel i, in-lb.

$\overline{TQ}_{Di}$ = drive torque at wheel i, in-lb.

$(\overline{TQ}_D)_{max}$ = maximum drive torque, in-lb.

u, v, w = scalar components of linear velocity of the sprung mass, taken along the $X_B$, $Y_B$, $Z_B$ axes, respectively, in/sec.

$u_{Gi}$ = longitudinal velocity of the tire-road contact point of wheel i, in/sec.

$v_{Gi}$ = lateral velocity of the tire-road contact point of wheel i, in/sec.

$u_i$, $v_i$, $w_i$ = linear velocity components of the wheel centers along the vehicle axes, in/sec.

$v_c$ = desired vehicle velocity, in/sec.

x, y, z = coordinates of vehicle center of gravity in the inertial coordinate axes system, in.

$X_B$, $Y_B$, $Z_B$ = coordinates of vehicle center of gravity in the vehicle fixed coordinate system, in.

$Y_{CR}$ = linear displacement of steer connecting rod, in.

$Y_{SAi}$ = distance along the wheel spin axis from the kingpin axis to the wheel center line, in.

$z_F$ = static distance along the $Z_L$ axis between the center of gravity of the sprung mass and the spin axis of the front wheels, in.

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

$z_R$ = static distance along the $Z_P$ axis between the center of gravity of the sprung mass and the roll center of the rear suspension, in.

$\beta$ = vehicle body angle of sideslip, rad.

$\beta_i$ = sideslip angle at wheel i, rad.

$\overline{\beta}_i$ = non-dimensional slip angle variable for wheel i.

$\beta_i'$ = camber thrust angle at wheel i, rad.

$\delta_{F1N}$, $\delta_{R1N}$ = static displacement change in front and rear suspensions due to vehicle load configuration, in.

$\delta_{FWi}$ = front wheel steer angle produced by steering system, rad.

$\delta_{si}$ = total front suspension deflection from the unloaded vehicle configuration, i = 1,2, in.

$\delta_{SW}$ = steering wheel angle, rad.

$\delta_1$, $\delta_2$, $\delta_3$ = suspension deflection relative to the vehicle from the positions of static equilibrium, at the right front wheel center, left front wheel center, and rear axle roll center, respectively, in. (solid axle)

$\delta_3$, $\delta_4$ = suspension deflection relative to the vehicle from positions of static equilibrium, at the right rear wheel center and left rear wheel center, respectively, in. (split axle).

$\Delta\theta_i$ = static front wheel caster bias, i = 1,2

$\Delta\phi_i$ = static front wheel camber bias, i = 1,2

$\varepsilon_{Ki}$ = static front wheel toe bias, i = 1,2

$\varepsilon_{Pi}$ = free play in steer of front wheels, rad.

$\varepsilon_{SP}$ = free play in steering gear box, rad.

$\zeta_{Si}$ = total rear suspension deflection from the unloaded vehicle configuration, i = 3,4, in.

$\zeta_3$, $\zeta_4$ = suspension deflections relative to the vehicle, from the positions of static equilibrium, measured at the right and left rear spring positions, respectively, in.

$\theta_{Li}$ = front wheel angular displacement, rad.

$\theta_{Si}$ = caster angle as a function of relative vertical deflection between wheel and body, rad.

$\lambda_{Bi}$ = brake torque multipler for wheel i.

$\lambda_{FC}$, $\lambda_{FT}$, $\lambda_{RC}$, $\lambda_{RT}$ = terms by which $K_{Fi}$ and $K_{Ri}$ are multiplied to represent the suspension spring rate when the suspension deflection stops are encountered.

$\mu_{PF}$, $\mu_{PR}$ = peak braking coefficient of friction, front and rear, respectively.

$\mu_{SF}$, $\mu_{SR}$ = sliding coefficient of friction, front and rear, respectively.

$\mu_{yi}$ = lateral friction coefficient.

$\mu_i'$ = circumferential friction coefficient.

$\mu_{0i}$, $\mu_{1i}$ = values of circumferential friction coefficient at braking slip equal to zero and one, respectively.

$\phi$, $\theta$, $\Psi$ = Euler angles - roll, pitch, and yaw angles - defining the attitude of the sprung mass relative to the space-fixed axis system, rad.

$\phi_{CGi}$ = camber angle of wheel i relative to its tire-terrain contact plane, rad.

$\phi_i$ = right front, left front, right rear and left rear wheel camber angles, respectively, relative to the vehicle-fixed coordinate axes, positive when clockwise as viewed from the rear, as a function of relative vertical deflection between wheel and body, rad.

$\phi_R$ = angular displacement of the rear axle relative to the vehicle about a line parallel to the $X_P$ axis through the rear axle roll center (positive when clockwise as viewed from the rear), rad.

$\phi_{SAi}$ = kingpin inclination angle, right and left front, respectively, rad. i = 1,2

$\Psi_i$ = heading angle of right front, left front, right rear and left rear wheels relative to vehicle coordinate axes system, positive for clockwise steer as viewed from above vehicle, rad.

$\Omega_{FC}$, $\Omega_{RC}$ = suspension deflections for initial wheel contact with front and rear compression bump stops from the positions of static equilibrium relative to the vehicle for quasi-linear load-deflection characteristics of the springs, in.

$\Omega_{FT}$, $\Omega_{RT}$ = suspension deflections for initial wheel contact with front and rear rebound bump stops from the positions of static equilibrium relative to the vehicle for quasi-linear load-deflection characteristics of the springs, in.

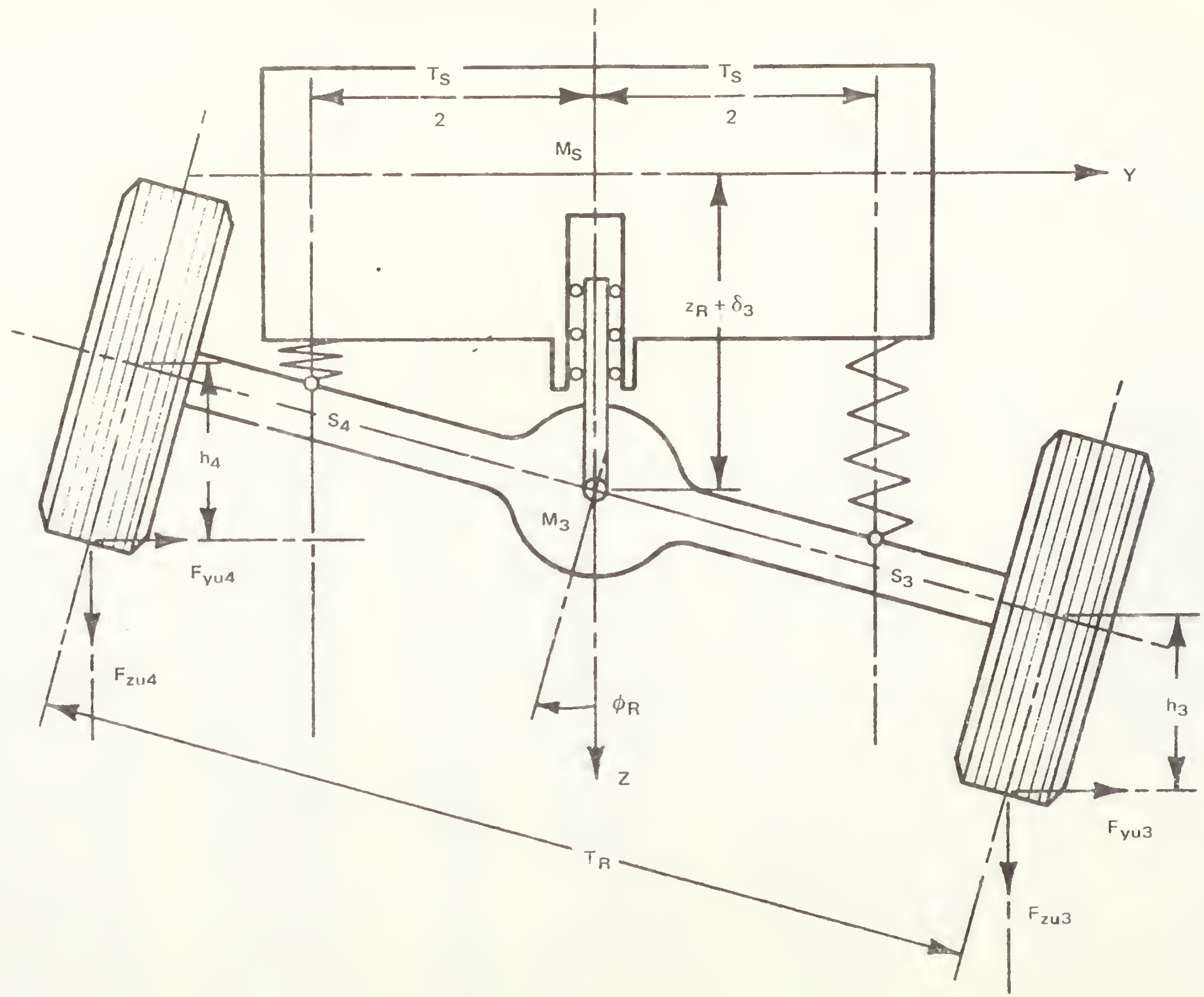



Fig. A-2 REAR AXLE REPRESENTATION

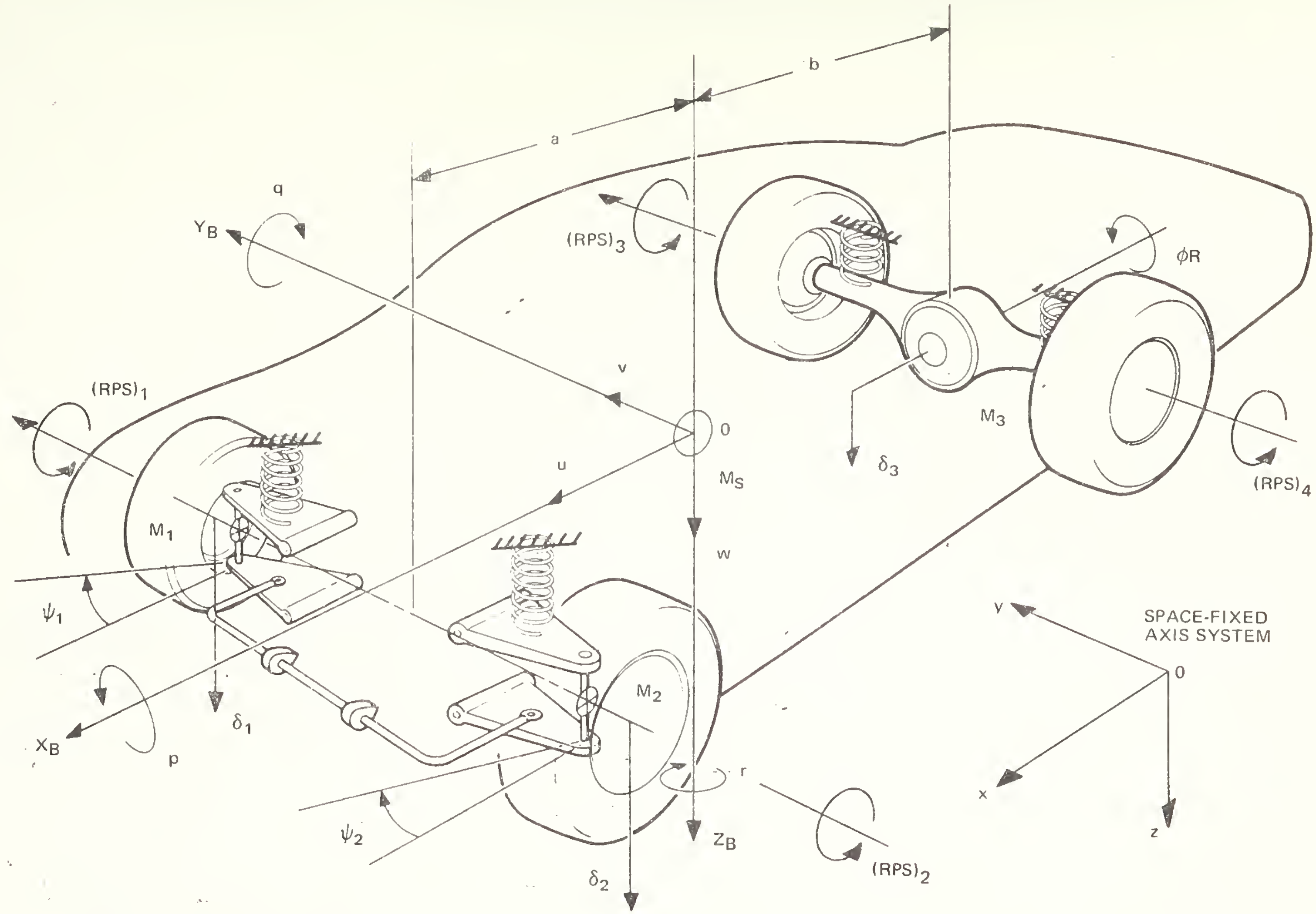



Fig. A-3 ANALYTICAL REPRESENTATION OF THE FOUR-WHEELED VEHICLE

# APPENDIX B

# FOUR-WHEELED VEHICLE HYBRID SIMULATION IMPLEMENTATION DOCUMENTATION

1. PRESENTED HERE IS THE COMPUTER LISTING OF THE DSL/91 DIGITAL STATIC CHECK PROGRAM

```
*          ********** LISTING OF DSL/91 DIGITAL PROGRAM **********
TITLE ### PROB:52 VEHICLE SIMULATION ###
INCON  SHAPE1=-.0065,SHAPE2=-.0037,SHAPE3=.0050 ,SHAPE4=.0029
INCON  DEL1DT=10.    ,DEL1  =.3830 ,DEL2DT=15.    ,DEL2  = 1.866
INCON  THETA1=60.    ,THETA2=37.5  ,ERR1  =1.     ,ERR2  =-0.6
INCON  DFW2DT=37.    ,DFW2  =0.15  ,YCRDT =80.    ,YCR   =2.55
INCON  RPS1  =43.06  ,RPS2  =43.06 ,RPS3  =43.057,XPS3DT=10000.
INCON  RPS4  =43.057,XPS4DT=10000.,DFW1DT=30.    ,DFW1  =0.35
INCON  PSI1  =.2140  ,PSI2  =.2040 ,PSI3  =.01667,PSI4  =-.0150
INCON  ZO    =-23.4  ,THEO  =.00209,PHIO  =.00300,RDTO  =-500.0
INCON  U01   =.120   ,U02   =1.01  ,U03   =.900  ,U04   =2.000
INCON  U11   =-.6133,U12    =1.11  ,U13   =1.621 ,U14   =1.700
INCON  AM11  =5.25   ,AM12  =-7.40 ,AM13  =-7.50 ,AM14  =-8.30
INCON  TQFBR =8000.  ,TQRBR =7100. ,MT1   =-164.3,MT2   =164.3
INCON  PDTO  =-.12   ,QDTO  =.0900 ,UO    =704.  ,VO    =.1300
INCON  WO    =.0050  ,PO    =.0200 ,QO    =-.0370,RO    =.0110
INCON  F1    =.9     ,F2    =.8    ,F3    =-.3   ,F4    =.6
INCON  GB1   =.2     ,GB2   =.4    ,GB3   =.5    ,GB4   =.85
PARAM  AMS   =5.162  ,AMUF  =0.359 ,AMUR  =0.574 ,TS    = 35.86
PARAM  AIR   =800.   ,RF    =81E03 ,TF    =54.3  ,ER    =50E03
PARAM  RW    =12.85  ,AIFW  =5.815 ,AH1   =200.  ,AH2   =200.
PARAM  AKT1  =812.   ,AKT2  =812.  ,AKT3  =1192. ,AKT4  =1192.
PARAM  AMCR  =0.08   ,CFCR  =200.  ,CCR   =11.   ,AP    =6.06
PARAM  AA1   =5.53   ,AA2   =5.53  ,ANG   =17.5  ,AKSC  =610.
PARAM  ESP   =-6.    ,AKSL1 =1.17E5,AKSL2 =1.17E5,EP1   =-.2000
PARAM  EP2   =-.1    ,AIWF  =7.3777,AID   =0.3   ,ARBP  =4.125
PARAM  AIWR  =7.3777,AKF    =133.  ,AKR   =185.  ,ALAMP =5.1
PARAM  ORT   =2.2    ,CFP   =25.   ,CRP   =45.   ,TR    =53.3
PARAM  AKF1  =52.2   ,AKF2  =52.2  ,AKF3  =100.  ,AKF4  =100.
PARAM  AKR3  =100.  ,AKR4  =100.
PARAM  A     =56.3   ,B     =39.0  ,G     =386.4 ,ZF    =10.8
PARAM  ZR    =10.6   ,AMU1  =.1795 ,AMU2  =.1795 ,AMU3  =.2870
PARAM  AMU4  =.2870  ,AMUF  =.3590 ,AMUR  =.5740 ,HFC   =7.20
PARAM  HRC   =4.70   ,CRRC  =0.0110,TANP  =0.0   ,DELSWO=1.425
PARAM  LB1   =1.65   ,LB2   =1.65  ,LB3   =1.0   ,LB4   =1.0
*
* SOLID AXLE IF AXLE = 1
*
PARAM  AXLE  =1
*
* 231'R SCALED FOR BETA TIMES REAL TIME
*
PARAM  BETA  =0.25
*
CONTRL TSTART=0.0,FINTIM=.001,DELT=.001
DYNAMIC
*
* THE FOLLOWING PARAMETERS ARE USED IF THE AXLE IS SPLIT
*
      IF(AXLE.EQ.1) GOTO 1
      PHIR    = 0.
      PHIRD   = 0.
      DEL3    = 0.
      DEL3DT  = 0.
      SEL3    = 0.25
      SEL3DT  = 69.0
      SEL4    = 0.90
      SEL4DT  = 70.0
      GOTO 2
```

```
*
* THE FOLLOWING PARAMETERS ARE USED IF AXLE IS SOLID
*
1     SEL3   = 0.
      SEL3DT = 0.
      SEL4   = 0.
      SEL4DT = 0.
      PHIR   = 0.01695
      PHIRD  = 0.55
      DEL3   = 0.8
      DEL3DT = 20.
*
*SYSTEM EQUATIONS
*
*SUSPENSION FORCE EQUATIONS
*
2     FSA1   =33.1
      FSA2   =48.0
      FSA3   = 186.1
      IF(AXLE.EQ.1) FSA3=95.9
      FSA4   = 188.0
      IF(AXLE.EQ.1) FSA4=50.0
      F2F1   =20.0
      F2F2   =97.41
      F1F1   =CFP
      F1F2   =CFP
      F2R3   = 25.0
      IF(AXLE.EQ.1) F2R3 = 114.0
      F2R4   = 90.0
      IF(AXLE.EQ.1) F2R4=46.02
      F1R3   =CRP
      F1R4   =CRP
*
*ERR1,ERR2 DENOTE LIMITER SETTINGS
*
      AUXRL1 =((DEL2-DEL1)-ERR1)*(RF/(TF*TF))
      AUXRL2 =(-(DEL2-DEL1)-ERR2)*(RF/(TF*TF))
      S1P    = AUXRL1 - FSA1 - F2F1 - F1F1
      S2P    = AUXRL2   - FSA2 - F2F2 - F1F2
      IF(AXLE.EQ.1) S3P=-FSA3-F2R3-F1R3-(RR/TS)*PHIR
      IF(AXLE.NE.1) S3P=-FSA3-F2R3-F1R3+(SEL4-SEL3)*RR/TR**2
      IF(AXLE.EQ.1) S4P=-FSA4-F2R4-F1R4+(RR/TS)*PHIR
      IF(AXLE.NE.1) S4P=-FSA4-F2R4-F1R4-(SEL4-SEL3)*RR/TR**2
      SMP    = S1P + S2P + S3P + S4P
      S1     = S1P+B*AMS*G/(2.*(A+B))
      S2     = S2P+B*AMS*G/(2.*(A+B))
      S3     = S3P+A*AMS*G/(2.*(A+B))
      S4     = S4P+A*AMS*G/(2.*(A+B))
      ZET3   = (TS/2.)*PHIR + DEL3
      IF(AXLE.NE.1) ZET3=SEL3
      ZET3DT = (TS/2.)*PHIRD + DEL3DT
      IF(AXLE.NE.1) ZET3DT=SEL3DT
      ZET4   = -(TS/2.)*PHIR + DEL3
      IF(AXLE.NE.1) ZET4=SEL4
      ZET4DT = -(TS/2.)*PHIRD + DEL3DT
      IF(AXLE.NE.1) ZET4DT=SEL4DT
*
*RADIAL TIRE FORCE AND ROLLING RADIUS EQUATIONS
*
      Z1     = DEL1+ZF+ZO-A*THEO+TF*0.5*PHIO
```

```
      Z2      = DEL2+ZF+ZO-A*THEO-TF*0.5*PHIO
      Z3      = ZO+B*THEO+TR*0.5*PHIO+ZR+SEL3
      IF(AXLE.EQ.1) Z3=ZO+B*THEO+TR*0.5*PHIO+ZR+TR*0.5*PHIR+DEL3
      Z4      = ZO+B*THEO-TR*0.5*PHIO+ZR+SEL4
      IF(AXLE.EQ.1) Z4=ZO+B*THEO-TR*0.5*PHIO+ZR-TR*0.5*PHIR+DEL3
      H1      = -Z1
      H2      = -Z2
      H3      = -Z3
      H4      = -Z4
      RHO1    = RW-H1
      RHO2    = RW-H2
      RHO3    = RW-H3
      RHO4    = RW-H4
      FR1     = 0.
      IF((RW+Z1).GT.0.) FR1=AKT1*(RW+Z1)
      FR2     = 0.
      IF((RW+Z2).GT.0.) FR2=AKT2*(RW+Z2)
      FR3     = 0.
      IF((RW+Z3).GT.0.) FR3=AKT3*(RW+Z3)
      FR4     = 0.
      IF((RW+Z4).GT.0.) FR4=AKT4*(RW+Z4)
      FXU1    = FR1*(THEO-U1P*COS(PSI1)-F1*AMU1*SIN(PSI1)*GB1)
      FXU2    = FR2*(THEO-U2P*COS(PSI2)-F2*AMU2*SIN(PSI2)*GB2)
      FXU3    = FR3*(THEO-U3P*COS(PSI3)-F3*AMU3*SIN(PSI3)*GB3)
      FXU4    = FR4*(THEO-U4P*COS(PSI4)-F4*AMU4*SIN(PSI4)*GB4)
      FYU1    = FR1*(-PHIO-U1P*SIN(PSI1)+F1*AMU1*COS(PSI1)*GB1)
      FYU2    = FR2*(-PHIO-U2P*SIN(PSI2)+F2*AMU2*COS(PSI2)*GB2)
      FYU3    = FR3*(-PHIO-U3P*SIN(PSI3)+F3*AMU3*COS(PSI3)*GB3)
      FYU4    = FR4*(-PHIO-U4P*SIN(PSI4)+F4*AMU4*COS(PSI4)*GB4)
      NPHIR   = -FR3*(TR*0.5+Z3*PHIR)+FR4*(TR*0.5-Z4*PHIR)-FYU3*...
                 (TR*0.5*PHIR-Z3)-FYU4*(-TR*0.5*PHIR-Z4)+(S3-S4)*TS*0.5
*
*FRONT WHEEL EQUATIONS OF MOTION
*
      DEL1DD = SMP/AMS-TF*0.5*PDTO+A*QDTO+2./AMUF*(-FR1+S1-FYU1*...
                TAN(2.*HFC/TF))+G
      DEL2DD = SMP/AMS+TF*0.5*PDTO+A*QDTO+2./AMUF*(-FR2+S2-FYU2*...
               TAN(2.*HFC/TF))+G
*
*REAR WHEELS AND AXIE COMBINATION
*
*SOLID
*
      DEL3DD = SMP/AMS+G+(S3+S4-FR3-FR4+(FXU3+FXU4)*TANP)/AMUR-B*QDTO
      PHIRDD = -PDTO+(NPHIR-(FYU3+FYU4)*(CRRC*DEL3+HRC)-TS*0.5*...
                (FYU3-FXU4)*TANP)/AIR
*
*SPLIT
*
      SEL3DD = SMP/AMS-TR*0.5*PDTO-B*QDTO+2./AMUR*(-FR3+S3-FYU3*...
                TAN(2.*HRC/TR))+G
      SEL4DD = SMP/AMS+TR*0.5*PDTO-B*QDTO+2./AMUR*(-FR4+S4+FYU4*...
                TAN(2.*HRC/TR))+G
*
*STEERING SYSTEM EQUATIONS
*ESP,EP1,EP2 DENOTE LIMITER SETTINGS
      TP      = ANG*AKSC*(DELSWO-ANG*YCR/AP-ESP/2.)
      AMSS1   = AKSL1*((DFW1-YCR/AA1)-EP1/2.)
      AMSS2   = AKSL2*((DFW2-YCR/AA2)-EP2/2.)
*
```

```
      DFW1DD =  (-AH1*DFW1DT+MT1-AMSS1)/AIFW-RDTO
      DFW2DD =  (-AH2*DFW2DT+MT2-AMSS2)/AIFW-RDTO
      YCRDD  =  (1./AMCR)*(-CFCR - CCR*YCRDT + TP/AP + AMSS1/AA1 +  ...
                AMSS2/AA2)
*
*WHEEL ROTATIONAL EQUATIONS
*
*
* CIRCUMFERENTIAL FRICTION COEFFICIENT
*
      U1      = UO-TF*0.5*RO+ZF*QO
      U2      = UO+TF*0.5*RO+ZF*QO
      U3      = UO-TR*0.5*RO+ZR*QO
      U4      = UO+TR*0.5*RO+ZR*QO
      V1      = VO+A*RO-ZF*PO+Z1*PO
      V2      = VO+A*RO-ZF*PO+Z2*PO
      V3      = VO-B*RO-ZR*PO+Z3*PO
      IF(AXLE.EQ.1)  V3=V3+Z3*PHIRD
      V4      = VO-B*RO-ZR*PO+Z4*PO
      IF(AXLE.EQ.1)  V4=V4+Z4*PHIRD
      W1      = WO-A*QO+TF*0.5*PO-DEL1DT
      W2      = WO-A*QO-TF*0.5*PO+DEL2DT
      W3      = WO-B*QO+DEL3DT+TR*0.5*PO
      IF(AXLE.EQ.1)  W3=WO-B*QO+DEL3DT+(PHIRD+PO)*TR*0.5
      W4      = WO+B*QO+DEL4DT-TR*0.5*PO
      IF(AXLE.EQ.1)  W4=WO+B*QO+DEL3DT-(PHIRD+PO)*TR*0.5
      UG1     = U1+THEO*W1
      UG2     = U2+THEO*W2
      UG3     = U3+THEO*W3
      UG4     = U4+THEO*W4
      VG1     = V1-PHIO*W1
      VG2     = V2-PHIO*W2
      VG3     = V3-PHIO*W3
      VG4     = V4-PHIO*W4
      XI1     = 1.+RPS1*Z1/(UG1*COS(PSI1)+VG1*SIN(PSI1))
      XI2     = 1.+RPS2*Z2/(UG2*COS(PSI2)+VG2*SIN(PSI2))
      XI3     = 1.+RPS3*Z3/(UG3+VG3*PSI3)
      XI4     = 1.+RPS4*Z4/(UG4+VG4*PSI4)
*
*WHEEL SLIP

      SLIP1   = XI1
      IF(ABS(XI1).GT.1.)  SLIP1=SIGN(1.,XI1)
      SLIP2   = XI2
      IF(ABS(XI2).GT.1.)  SLIP2=SIGN(1.,XI2)
      SLIP3   = XI3
      IF(ABS(XI3).GT.1.)  SLIP3=SIGN(1.,XI3)
      SLIP4   = XI4
      IF(ABS(XI4).GT.1.)  SLIP4=SIGN(1.,XI4)
* ### TIRE CIRCUMFERENTIAL FORCE ###
      AM21    = U11-U01
      AM22    = U12-U02
      AM23    = U13-U03
      AM24    = U14-U04
      SI1     = U01/(AM11-AM21)
      SI2     = U02/(AM12-AM22)
      SI3     = U03/(AM13-AM23)
      SI4     = U04/(AM14-AM24)
      U1P     = AM11*SLIP1
      IF(SLIP1.GT.SI1)  U1P=AM21*SLIP1+U01
```

```
      U2P    = AM12*SLIP2
      IF(SLIP2.GT.SI2) U2P=AM22*SLIP2+U02
      U3P    = AM13*SLIP3
      IF(SLIP3.GT.SI3) U3P=AM23*SLIP3+U03
      U4P    = AM14*SLIP4
      IF(SLIP4.GT.SI4) U4P=AM24*SLIP4+U04
      FC1    = -U1P*FR1
      FC2    = -U2P*FR2
      FC3    = -U3P*FR3
      FC4    = -U4P*FR4
      RPS1DT = -(FC1*H1-TQFBR*LB1)/AIWF
      RPS2DT = -(FC2*H2-TQFBR*LB2)/AIWF
      DENOM = AIWR + AID*ARBR*ARBR/4.
      TERM   = AID*ARBR*ARBR/4.
      RPS4DT = -(FC4*H4-TQRBR*LB4+TERM*XPS3DT)/DENOM
      RPS3DT = -(FC3*H3-TQRBR*LB3+TERM*XPS4DT)/DENOM
*
*SPARE TIRES
*
      TIN    =1E-04
      THER1  =THETA1/57.3
      THER2  =THETA2/57.3
      THE1DT =57.3*RPS1
      THE2DT =57.3*RPS2
TERMINAL
*
* 231-R POTS
*
      Q200    =AKF1*10.0*TIN
      Q201    =.5512
      Q202   = 1.0/(20.0*AMCR)*BETA
      Q203    =.6755
      Q204   = 2.0/3.0*BETA
      Q205    =YCRDT/200.
      Q206    =YCR/3.
      Q207 = .2000
      Q208    =DFW2DT/100.
      Q209    =2.*DFW2
      Q210     =AKR3*10.0*TIN
      Q211   =.9999
      Q212   = AH2/(100.0*AIFW)*BETA
      Q213     =.9313
      Q214   = AKSL2/(40000.0*AIFW)*BETA
      Q215     =AKR4*10.0*TIN
      Q216   =.9999
      Q218     =.9218
      Q219   =(AKSC*ANG/(AP*2000.0))/20.
      Q220     =AKF2*10.0*TIN
      Q221     =.5512
      Q222   = AH1/(100.0*AIFW)*BETA
      Q223    =.6754
      Q224   = AKSL1/(40000.0*AIFW)*BETA
      Q235    =DFW1DT/100.
      Q236    =2.*DFW1
      Q255   =.8100
      Q256   =.7152
      Q257   = CFCR/20000.0
      Q258   = CCR/100.0
      Q265   =.7652
      Q266   =.7056
```

```
      Q267   = AKSL2/(AA2*40000.0)                                          MAIN3000
      Q268   =3.0/AA2                                                       MAIN3010
      Q275   =.8102                                                         MAIN3020
      Q276   =.7183                                                         MAIN3030
      Q285   =.7652                                                         MAIN3040
      Q286   =.7038                                                         MAIN3050
      Q287   =3.0/AA1                                                       MAIN3060
      Q288   = AKSL1/(AA1*40000.0)                                          MAIN3070
      P201   =.4724                                                         MAIN3080
      P215   =.9999*BETA                                                    MAIN3090
      P217   = 3.0*ANG/(10.0*AP)                                            MAIN3100
      P221   =.4724                                                         MAIN3110
      P230   =.9999*BETA                                                    MAIN3120
*                                                                           MAIN3130
*231-R AMP'S                                                                MAIN3140
*                                                                           MAIN3150
      A250   =YCRDT/200.                                                    MAIN3160
      A251   =-YCR/3.                                                       MAIN3170
      A260   =-DFW2DT/100.                                                  MAIN3180
      A261   =2.*DFW2                                                       MAIN3190
      A280   =-DFW1DT/100.                                                  MAIN3200
      A281   =2.*DFW1                                                       MAIN3210
      A200   =DEL1/10.                                                      MAIN3220
      A201   =-F2F1/1000.                                                   MAIN3230
      A210   =ZET3/10.                                                      MAIN3240
      A211   =-F2R3/1000.                                                   MAIN3250
      A215   =ZET4/10.                                                      MAIN3260
      A216   =-F2R4/1000.                                                   MAIN3270
      A220   =DEL2/10.                                                      MAIN3280
      A221   =-F2F2/1000.                                                   MAIN3290
      A227   =-.2*DFW2                                                      MAIN3300
      A230   =-FSA1/1000.                                                   MAIN3310
      A231   =-FSA2/1000.                                                   MAIN3320
      A232   =-FSA3/1000.                                                   MAIN3330
      A233   =-FSA4/1000.                                                   MAIN3340
      A237   =-.2*DFW1                                                      MAIN3350
      A238  =-(-MT1/AIFW+RDTO)*BETA                                         MAIN3360
      A239  =-(-MT2/AIFW+RDTO)*BETA                                         MAIN3370
      A240   =DEL1DT/100.                                                   MAIN3380
      A241   =DEL2DT/100.                                                   MAIN3390
      A242   =-ZET3DT/100.                                                  MAIN3400
      A243   =ZET3DT/100.                                                   MAIN3410
      A244   =-ZET4DT/100.                                                  MAIN3420
      A245   =ZET4DT/100.                                                   MAIN3430
      A252   =-(AMCR*YCRDD/20000.)                                          MAIN3440
      A253   =-CFCR/20000.                                                  MAIN3450
      A254  =-CFCR/20000.                                                   MAIN3460
      A262   =-2.*(DFW2-(YCR/AA2))                                          MAIN3470
      A263   =2.*AMSS2/AKSL2                                                MAIN3480
      A264   =-A263                                                         MAIN3490
      A270   = -(DELSWO-(ANG*YCR)/AP)/10.                                   MAIN3500
      A271   =(ESP/2.)/10.                                                  MAIN3510
      A272   =-(A270+A271)                                                  MAIN3520
      A273   =-A250                                                         MAIN3530
      A282   =-2.*(DFW1-(YCR/AA1))                                          MAIN3540
      A283   =2.*AMSS1/AKSL1                                                MAIN3550
      A284   =-A283                                                         MAIN3560
      A292   =2.*(EP1/2.)                                                   MAIN3570
      A293   =2.*(EP2/2.)                                                   MAIN3580
*                                                                           MAIN3590
```

```
*231 DERIVATIVES
*
      D250    =YCRDD/20000.*BETA
      D251    =-YCRDT/30.*BETA
      D260    =-DFW2DD/1000.*BETA
      D261    =DFW2DT/5.*BETA
      D280    =-DFW1DD/1000.*BETA
      D281    =DFW1DT/5.*BETA
*
*680 POTS
*REMAINING 680 POTS OBTAINED FROM IPOT SUBROUTINE
*
      P00       =DEL1DT/100.
      P18       =DEL3/10.
      P20       =4.*PHIR
      P23       =PHIRD
      P30       =DEL1/10.
      P37       =DEL2DT/100.
      P38       =DEL2/10.
      P43       =DEL3DT/100.
      P48       =SEL3DT/100.
      P57       =SEL3/10.
      P77       =SEL4DT/100.
      P78       =SEL4/10.
      P90       =THETA1/200.
      P95       =THETA2/200.
      P101      =RPS1/100
      P104      =RPS2/100
      P110      =RPS3/100
      P114      =RPS4/100
*
*UNSCALED DAC VALUES FOR SYSTEM EQUATIONS
*
      DAC00   = -MT1/AIFW+RDTO
      DAC01   = RW+ZF+ZO-A*THEO+TF*0.5*PHIO
      DAC02   = -MT2/AIFW+RDTO
      DAC03   = RW+ZF+ZO-A*THEO-TF*0.5*PHIO
      DAC04   = AM21-AM11
      DAC05   = -TF*0.5*PDTO+A*QDTO+B*AMS*G/((A+B)*AMUF)+G-2.*FYU1*...
                TAN(2.*HFC/TF)/AMUF
      DAC06   = AM22-AM12
      DAC07   = TF*0.5*PDTO+A*QDTO+B*AMS*G/((A+B)*AMUF)+G-2.*FYU2*...
                TAN(2.*HFC/TF)/AMUF
      DAC08   = -TQFBR
      DAC09   = -TQRBR
      DAC10   = DELSWO
      DAC11   = -TR*0.5*PDTO-B*QDTO+A*AMS*G/((A+B)*AMUR)+G-2.*FYU3*...
                TAN(2.*HRC/TR)/AMUR
      DAC12   = (-TR*0.5-Z3*PHIR)*AKT3/AIR
      DAC13   = G-B*QDTO+(A*AMS*G/(A+B)+(FXU3+FXU4)*TANP)/AMUR
      DAC14   = (TR*0.5-Z4*PHIR)*AKT4/AIR
      DAC15   = -PDTO+(-(FYU3+FYU4)*(CRRC*DEL3+HRC)-TS*0.5*(FXU3-FXU4)...
               *TANP-FYU3*(TR*0.5*PHIR-Z3)-FYU4*(-TR*0.5*PHIR-Z4))/AIR
      DAC16   = AM23-AM13
      DAC17   = RW+ZF+ZO+B*THEO+PHIO*TR*0.5
      DAC18   = AM24-AM14
      DAC19   = RW+ZF+ZO+B*THEO-PHIO*TR*0.5
      DAC20   = AM14
      DAC21   = AM13
      DAC22   = AM11
```

```
      DAC23   = AM12
      DAC24   = UG1*COS(PSI1)+VG1*SIN(PSI1)
      DAC25   = UG2*COS(PSI2)+VG2*SIN(PSI2)
      DAC26   = UG3+VG3*PSI3
      DAC27   = U03
      DAC28   = UG4+VG4*PSI4
      DAC29   = U04
      DAC30   = U02
      DAC31   = U01
      DAC32   = -SI1
      DAC33   = -SI2
      DAC34   = -SI3
      DAC35   = -SI4
      DAC36   = TR*0.5*PDTO-B*QDTO+A*AMS*G/((A+B)*AMUR)+G+2.*FYU4*...
                TAN(2.*HRC/TR)/AMUR
*
* SCALE FACTORS FOR D/A CONVERTERS
*
      DA00    = DAC00/10000.*BETA
      DA01    = DAC01/10.
      DA02    = DAC02/10000.*BETA
      DA03    = DAC03/10.
      DA04    = DAC04/20.
      DA05    = DAC05/10000.
      DA06    = DAC06/20.
      DA07    = DAC07/10000.
      DA08    = DAC08/40000.
      DA09    = DAC09/40000.
      DA10    = DAC10/10.
      DA11    = DAC11/10000.
      DA12    = DAC12/100.
      DA13    = DAC13/10000.
      DA14    = DAC14/100.
      DA15    = DAC15/100.
      DA16    = DAC16/20.
      DA17    = DAC17/10.
      DA18    = DAC18/20.
      DA19    = DAC19/10.
      DA20    = DAC20/20.
      DA21    = DAC21/20.
      DA22    = DAC22/20.
      DA23    = DAC23/20.
      DA24    = DAC24/1500.
      DA25    = DAC25/1500.
      DA26    = DAC26/1500.
      DA27    = DAC27/20.
      DA28    = DAC28/1500.
      DA29    = DAC29/20.
      DA30    = DAC30/20.
      DA31    = DAC31/20.
      DA32    = DAC32
      DA33    = DAC33
      DA34    = DAC34
      DA35    = DAC35
      DA36    = DAC36/10000.
*
*  680 AMP'S
      A000    =-DEL1DT/100.
      A002    =DEL1/10.
      A005    =-DEL2DT/100.
```

```
A007     =DEL2/10.
A010     =-DEL3DT/100.
A012     =DEL3/10.
A015     =-PHIRD
A017     =4.*PHIR
A040     =-SEL3DT/100.
A050     =SEL3/10.
A080     =-SEL4DT/100.
A085     =SEL4/10.
A090     =THETA1/200.
A095     =THETA2/200.
A100     =RPS1/100.
A105     =RPS2/100.
A110     =-RPS3/100.
A115     =-RPS4/100.
T51      =A237
T52      =A227
T80      =A230
T82      =A232
T83      =A233
T84      =A201
T85      =A221
T86      =A211
T87      =A216
T88      =A231
A003     =-DEL1/10.
A004     =SIN(THER1)
A006     =-RPS2/100.
A008     =(-H1*RPS1/(UG1*COS(PSI1)+VG1*SIN(PSI1)))/2.
A009     =COS(THER2)
A011     =AUXRL2/1000.
A014     =-COS(THER1)
A016     =-S1P/1000.
A018     =H1*RPS1/1500.
A019     =S1P/1000.
A020     =SLIP4
A021     =-S2P/1000.
A022     =RPS4DT/10000.
A023     =-FC1/(4.*AKT1)
A024     =S2P/1000.
A026     =-S3P/1000.
A028     =-(H1*FR1*U1P)/(60.*AKT1)
A029     =S3P/1000.
A030     =U3P/2.
A032     =SHAPE1
A033     =SHAPE2
A034     =SIN(THER1)
A035     =ZET4DT/100.
A036     =-ZET3/10.
A037     =SIN(THER1)
A038     =SHAPE3
A039     =SIN(THER2)
A041     =U4P/2.
A042     =SIN(THER2)
A044     =SHAPE4
A045     =-ZET4/10.
A046     =ZET3DT/100.
A048     =RHO3/2.
A049     =-H3/15.
A051     =-S4P/1000.
```

```
      A052     =-A050                                                          MAIN5400
      A053     =H2*RPS2/1500.                                                  MAIN5410
      A054     =S4P/1000.                                                      MAIN5420
      A055     =(S3P-S4P)/2000.                                                MAIN5430
      A056     =-RPS1/100.                                                     MAIN5440
      A057     =-A039                                                          MAIN5450
      A058     =RHO4/2.                                                        MAIN5460
      A059     =-H4/15.                                                        MAIN5470
      A060     =AUXRL1/1000.                                                   MAIN5480
      A061     =ERR2/10.                                                       MAIN5490
      A062    =-A014                                                           MAIN5500
      A063     =-(H2*FR2*U2P)/(60.*AKT2)                                       MAIN5510
      A064     =-SLIP3                                                         MAIN5520
      A065     =-(DEL2-DEL1)/10.                                               MAIN5530
      A066     =SMP/1000.                                                      MAIN5540
      A068     =-FC2/(4.*AKT2)                                                 MAIN5550
      A069     =-A034                                                          MAIN5560
      A070     =ERR1/10.                                                       MAIN5570
      A071     =-(SEL4-SEL3)/10.                                               MAIN5580
      A072     =-SIN(THER1)                                                    MAIN5590
      A073     =(-H3*RPS3/(UG3+VG3*PSI3))/2.                                   MAIN5600
      A074     =(SEL4-SEL3)*RR/(TP**2*1000.)                                   MAIN5610
      A075     = -(SLIP4*(AM24-AM14)+U04)/20.                                  MAIN5620
      A076     =RPS3DT/10000.                                                  MAIN5630
      A077     =COS(THER1)                                                     MAIN5640
      A078     =H3*RPS3/1500.                                                  MAIN5650
      A079     =-A074                                                          MAIN5660
      A081     =SLIP2                                                          MAIN5670
      A082     =-SIN(THER2)                                                    MAIN5680
      A083     =-(H3*FR3*U3P)/(60.*AKT3)                                       MAIN5690
      A084     =-H2/15.                                                        MAIN5700
      A086     =-RHO1/2.                                                       MAIN5710
      A087     =COS(THER2)                                                     MAIN5720
      A088     =-FC3/(4.*AKT3)                                                 MAIN5730
      A089     =-H1/15.                                                        MAIN5740
      A091     =U1P/2.                                                         MAIN5750
      A092     =SLIP3                                                          MAIN5760
      A093     =(-H2*RPS2/(UG2*COS(PSI2)+VG2*SIN(PSI2)))/2.                    MAIN5770
      A094     = -(SLIP3*(AM23-AM13)+U03)/20.                                  MAIN5780
      A096     =-RHO2/2.                                                       MAIN5790
      A097     =-SLIP4                                                         MAIN5800
      A099     =SIN(THER2)                                                     MAIN5810
      A101     =SLIP1                                                          MAIN5820
      A102     =-SLIP1                                                         MAIN5830
      A103     =(-H4*RPS4/(UG4+VG4*PSI4))/2.                                   MAIN5840
      A104     = -(SLIP1*(AM21-AM11)+U01)/20.                                  MAIN5850
      A106     =-RHO3/2.                                                       MAIN5860
      A108     =H4*RPS4/1500.                                                  MAIN5870
      A109     = -(SLIP2*(AM22-AM12)+U02)/20.                                  MAIN5880
      A111     =U2P/2.                                                         MAIN5890
      A113     =-(H4*FR4*U4P)/(60.*AKT4)                                       MAIN5900
      A114     =-SLIP2                                                         MAIN5910
      A116     =-RHO4/2.                                                       MAIN5920
      A117     =-A087                                                          MAIN5930
      A118     =-FC4/(4.*AKT4)                                                 MAIN5940
*    680 DERIVATIVES                                                           MAIN5950
      D000     =DEL1DD/1000.                                                   MAIN5960
      D002     =-DEL1DT/100.                                                   MAIN5970
      D005     =DEL2DD/1000.                                                   MAIN5980
      D007     =-DEL2DT/100.                                                   MAIN5990
```

```
      D010   =DEL3DD/1000.
      D012   =-DEL3DT/100.
      D015   =PHIRDD/10.
      D017   =-PHIRD/2.5
      D040   =SEL3DD/1000.
      D050   =-SEL3DT/100.
      D080   =SEL4DD/1000.
      D085   =-SEL4DT/100.
      D090   =THE1DT/2000.
      D095   =THE2DT/2000.
      D100   =-RPS1DT/1000.
      D105   =-RPS2DT/1000.
      D110   =RPS3DT/1000.
      D115   =RPS4DT/1000.
      DUMMY  =  DEBUG(1.,0.)
      CALL PUNCH
END
PARAM AXLE=0
END
STOP
```

```
        *** DSL/91  SIMULATION DATA ***                                                    74.183        12:31:15.15
    TITLE === PROB052 VEHICLE SIMULATION ===
    INCON  SHAPE1=-.0065,SHAPE2=-.0037,SHAPE3=.0050 ,SHAPE4=.0029
    INCON  DEL1DT=10.    ,DEL1  =.3830 ,DEL2DT=15.    ,DEL2  = 1.866
    INCON  THETA1=60.    ,THETA2=37.5  ,ERR1  =1.     ,ERR2  =-0.6
    INCON  DFW2DT=37.    ,DFW2  =0.15  ,YCRDT =80.    ,YCR   =2.55
    INCON  RPS1  =43.06 ,RPS2  =43.06 ,RPS3  =43.057,XPS3DT=10000.
    INCON  RPS4  =43.057,XPS4DT=10000.,DFW1DT=30.    ,DFW1  =0.35
    INCON  PSI1  =.2140 ,PSI2  =.2040 ,PSI3  =.01667,PSI4  =-.0150
    INCON  ZO    =-23.4 ,THEO  =.00209,PHIO  =.00300,RDTO  =-500.0
    INCON  U01   =.120  ,U02   =1.01  ,U03   =.900  ,U04   =2.000
    INCON  U11   =-.6133,U12   =1.11  ,U13   =1.621 ,U14   =1.700
    INCON  AM11  =5.25  ,AM12  =-7.40 ,AM13  =-7.50 ,AM14  =-8.30
    INCON  TQFBR =8000. ,TQRBR =7100. ,MT1   =-164.3,MT2   =164.3
    INCON  PDTO  =-.12  ,QDTO  =.0900 ,UO    =704.  ,VO    =.1300
    INCON  WO    =.0050 ,PO    =.0200 ,QO    =-.0370,RO    =.0110
    INCON  F1    =.9    ,F2    =.8    ,F3    =-.3   ,F4    =.6
    INCON  GB1   =.2    ,GB2   =.4    ,GB3   =.5    ,GB4   =.85
    PARAM  AMS   =5.162 ,AMUF  =0.359 ,AMUR  =0.574 ,TS    = 35.86
    PARAM  ATR   =800.  ,RF    =81E03 ,TF    =54.3  ,RR    =50E03
    PARAM  RW    =12.85 ,AIFW  =5.815 ,AH1   =200.  ,AH2   =200.
    PARAM  AKT1  =812.  ,AKT2  =812.  ,AKT3  =1192. ,AKT4  =1192.
    PARAM  AMCR  =0.08  ,CFCR  =200.  ,CCR   =11.   ,AP    =6.06
    PARAM  AA1   =5.53  ,AA2   =5.53  ,ANG   =17.5  ,AKSC  =610.
    PARAM  ESP   =-6.   ,AKSL1 =1.17E5,AKSL2 =1.17E5,EP1   =-.2000
    PARAM  EP2   =-.1   ,AIWF  =7.3777,AID   =0.3   ,ARBR  =4.125
    PARAM  AIWR  =7.3777,AKF   =133.  ,AKR   =185.  ,ALAMF =5.1
    PARAM  ORT   =2.2   ,CFP   =25.   ,CRP   =45.   ,TP    =53.3
    PARAM  AKF1  =52.2  ,AKF2  =52.2  ,AKF3  =100.  ,AKF4  =100.
    PARAM  AKR3  =100.  ,AKR4  =100.
    PARAM  A     =56.3  ,B     =39.0  ,G     =386.4 ,ZF    =10.8
    PARAM  ZR    =10.6  ,AMU1  =.1795 ,AMU2  =.1795 ,AMU3  =.2870
    PARAM  AMU4  =.2870 ,AMUF  =.3590 ,AMUR  =.5740 ,HFC   =7.20
    PARAM  HRC   =4.70  ,CRRC  =0.0110,TANP  =0.0   ,DELSWO=1.425
    PARAM  LB1   =1.65  ,LB2   =1.65  ,LB3   =1.0   ,LB4   =1.0
    PARAM  AXLE  =1
    PARAM  BETA  =0.25
    CONTRL TSTART=0.0,FINTIM=.001,DELT=.001
    END

***DSL MESSAGE 20***   NO OUTPUT REQUESTED...WARNING ONLY.

DSL/91  SIMULATION TIME=   0.0  SECONDS.                                                  74.183        12:31:16.04

 DEBUG OUTPUT, BLOCK   3 AT TIME=  0.1000E-02

 TIME     1.0000E-03  DELT      1.0000E-03  DELMIN     0.0         DELMAX     7.2370E 75  TSTART     0.0         FINTIM     1.0000E-03
 CLKTIM   0.0         NALARM    0.0         DELS       0.0         DELNIX     7.2370E 75  DFLADC     7.2370E 75  DELDAC     7.2370E 75
 DELSTP   7.2370E 75  DELMRK    7.2370E 75  SHAPE1    -6.5000E-03  SHAPE2    -3.7000E-03  SHAPE3     5.0000E-03  SHAPE4     2.9000E-03
 DEL1DT   1.0000E 01  DEL1      3.8300E-01  DEL2DT     1.5000E 01  DEL2       1.8660E 00  THETA1     6.0000E 01  THETA2     3.7500E 01
 ERR1     1.0000E 00  ERR2     -6.0000E-01  DFW2DT     3.7000E 01  DFW2       1.5000E-01  YCRDT      8.0000E 01  YCR        2.5500E 00
 RPS1     4.3060E 01  RPS2      4.3060E 01  RPS3       4.3057E 01  XPS3DT     1.0000E 04  RPS4       4.3057E 01  XPS4DT     1.0000E 04
 DFW1DT   3.0000E 01  DFW1      3.5000E-01  PSI1       2.1400E-01  PSI2       2.0400E-01  PSI3       1.6670E-02  PSI4      -1.5000E-02
 ZO      -2.3400E 01  THEO      2.0900E-03  PHIO       3.0000E-03  RDTO      -5.0000E 02  U01        1.2000E-01  U02        1.0100E 00
 U03      9.0000E-01  U04       2.0000E 00  U11       -6.1330E-01  U12        1.1100E 00  U13        1.6210E 00  U14        1.7000E 00
 AM11     5.2500E 00  AM12     -7.4000E 00  AM13      -7.5000E 00  AM14      -8.3000E 00  TQFBR      8.0000E 03  TQRBR      7.1000E 03
 MT1     -1.6430E 02  MT2       1.6430E 02  PDTO      -1.2000E-01  QDTO       9.0000E-02  UO         7.0400E 02  VO         1.3000E-01
 WO       5.0000E-03  PO        2.0000E-02  QO        -3.7000E-02  RO         1.1000E-02  F1         9.0000E-01  F2         8.0000E-01
 F3      -3.0000E-01  F4        6.0000E-01  GB1        2.0000E-01  GB2        4.0000E-01  GB3        5.0000E-01  GB4        8.5000E-01
 AMS      5.1620E 00  AMUF      3.5900E-01  AMUR       5.7400E-01  TS         3.5860E 01  ATR        8.0000E 02  RF         8.1000E 04
 TF       5.4300E 01  RR        5.0000E 04  RW         1.2850E 01  AIFW       5.8150E 00  AH1        2.0000E 02  AH2        2.0000E 02
 AKT1     8.1200E 02  AKT2      8.1200E 02  AKT3       1.1920E 03  AKT4       1.1920E 03  AMCR       8.0000E-02  CFCR       2.0000E 02
```

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CCR | 1.1000E 01 | AR | 6.0600E 00 | AA1 | 5.5300E 00 | AA2 | 5.5300E 00 | ANG | 1.7500E 01 | AKSC | 6.1000E 02 |
| ESP | -6.0000E 00 | AKSL1 | 1.1700E 05 | AKSL2 | 1.1700E 05 | EP1 | -2.0000E-01 | EP2 | -1.0000E-01 | AIWF | 7.3777E 00 |
| AID | 3.0000E-01 | ARRR | 4.1250E 00 | AIWR | 7.3777E 00 | AKF | 1.3300E 02 | AKR | 1.8500E 02 | ALAMF | 5.1000E 00 |
| ORT | 2.2000E 00 | CFP | 2.5000E 01 | CRP | 4.5000E 01 | TR | 5.3300E 01 | AKF1 | 5.2200E 01 | AKF2 | 5.2200E 01 |
| AKF3 | 1.0000E 02 | AKF4 | 1.0000E 02 | AKR3 | 1.0000E 02 | AKR4 | 1.0000E 02 | A | 5.6300E 01 | B | 3.9000E 01 |
| G | 3.8640E 02 | ZF | 1.0800E 01 | ZR | 1.0600E 01 | AMU1 | 1.7950E-01 | AMU2 | 1.7950E-01 | AMU3 | 2.8700E-01 |
| AMU4 | 2.8700E-01 | HFC | 7.2000E 00 | HRC | 4.7000E 00 | CRRC | 1.1000E-02 | TANP | 0.0 | DELSWO | 1.4250E 00 |
| LB1 | 1.6500E 00 | LB2 | 1.6500E 00 | LB3 | 1.0000E 00 | LB4 | 1.0000E 00 | AXLE | 1.0000E 00 | BETA | 2.5000E-01 |
| S3P | -2.8132E 02 | S4P | -1.1460E 02 | ZZ0001 | 0.0 | ZZ0002 | 0.0 | PHIR | 1.8950E-02 | PHIRD | 5.5000E-01 |
| DEL3 | 8.0000E-01 | DEL3DT | 2.0000E 01 | SEL3 | 0.0 | SEL3DT | 0.0 | SEL4 | 0.0 | SEL4DT | 0.0 |
| FSA1 | 3.3100E 01 | FSA2 | 4.8000E 01 | FSA3 | 9.5900E 01 | FSA4 | 5.0000E 01 | F2F1 | 2.0000E 01 | F2F2 | 9.7410E 01 |
| F1F1 | 2.5000E 01 | F1F2 | 2.5000E 01 | F2R3 | 1.1400E 02 | F2R4 | 4.6020E 01 | F1R3 | 4.5000E 01 | F1R4 | 4.5000E 01 |
| AUXRL1 | 1.3269E 01 | AUXRL2 | -2.4257E 01 | S1P | -6.4831E 01 | S2P | -1.9467E 02 | SMP | -6.5542E 02 | S1 | 3.4330E 02 |
| S2 | 2.1346E 02 | S3 | 3.0785E 02 | S4 | 4.7457E 02 | ZET3 | 1.1398E 00 | ZET3DT | 2.9861E 01 | ZET4 | 4.6023E-01 |
| ZET4DT | 1.0139E 01 | Z1 | -1.2253E 01 | Z2 | -1.0933E 01 | Z3 | -1.1334E 01 | Z4 | -1.2503E 01 | H1 | 1.2253E 01 |
| H2 | 1.0933E 01 | H3 | 1.1334E 01 | H4 | 1.2503E 01 | RHO1 | 5.9679E-01 | RHO2 | 1.9169E 00 | RHO3 | 1.5165E 00 |
| RHO4 | 3.4656E-01 | FR1 | 4.8459E 02 | FR2 | 1.5565E 03 | FR3 | 1.8077E 03 | FR4 | 4.1310E 02 | FXU1 | 2.1540E 01 |
| FXU2 | -1.6027E 03 | FXU3 | -2.0205E 03 | FXU4 | -7.9518E 02 | FYU1 | 1.9030E 01 | FYU2 | -2.4560E 02 | FYU3 | -1.1700E 02 |
| FYU4 | 7.1174E 01 | NPHIR | -3.9137E 04 | DEL1DD | -5.4820E 02 | DEL2DD | -6.8493E 03 | DEL3DD | -2.2499E 03 | PHIRDD | -4.8532E 01 |
| SEL3DD | -4.8940E 03 | SEL4DD | 5.1111E 02 | TP | -3.1372E 04 | AMSS1 | -1.3012E 03 | AMSS2 | -3.0551E 04 | DFW1DD | -3.3630E 02 |
| DFW2DD | 4.5095E 03 | YCRDD | -1.5021E 05 | U1 | 7.0330E 02 | U2 | 7.0390E 02 | U3 | 7.0331E 02 | U4 | 7.0390E 02 |
| V1 | 2.8824E-01 | V2 | 3.1464E-01 | V3 | -6.9711E 00 | V4 | -7.6380E 00 | W1 | -7.3689E 00 | W2 | 1.6545E 01 |
| W3 | 3.6638E 01 | W4 | 3.3715E 00 | UG1 | 7.0329E 02 | UG2 | 7.0393E 02 | UG3 | 7.0339E 02 | UG4 | 7.0391E 02 |
| VG1 | 3.1034E-01 | VG2 | 2.6500E-01 | VG3 | -7.0810E 00 | VG4 | -7.6481E 00 | XI1 | 2.3234E-01 | XI2 | 3.1711E-01 |
| XI3 | 3.0612E-01 | XI4 | 2.3531E-01 | SLIP1 | 2.3234E-01 | SLIP2 | 3.1711E-01 | SLIP3 | 3.0612E-01 | SLIP4 | 2.3531E-01 |
| AM21 | -7.3330E-01 | AM22 | 1.0000E-01 | AM23 | 7.2100E-01 | AM24 | -3.0000E-01 | SI1 | 2.0056E-02 | SI2 | -1.3467E-01 |
| SI3 | -1.0948E-01 | SI4 | -2.5000E-01 | U1P | -5.0371E-02 | U2P | 1.0417E 00 | U3P | 1.1207E 00 | U4P | 1.9294E 00 |
| FC1 | 2.4410E 01 | FC2 | -1.6014E 03 | FC3 | -2.0259E 03 | FC4 | -7.9704E 02 | RPS1DT | 1.7486E 03 | RPS2DT | 4.1920E 03 |
| DENOM | 8.6539E 00 | TERM | 1.2762E 00 | RPS4DT | 4.9735E 02 | RPS3DT | 1.9989E 03 | TIN | 1.0000E-04 | THER1 | 1.0471E 00 |
| THER2 | 6.5445E-01 | THE1DT | 2.4673E 03 | THE2DT | 2.4673E 03 | ZZ0003 | 0.0 | ZZ0004 | 0.0 | Q200 | 5.2200E-02 |
| Q201 | 5.5120E-01 | Q202 | 1.5625E-01 | Q203 | 6.7550E-01 | Q204 | 1.6667E-01 | Q205 | 4.0000E-01 | Q206 | 8.5000E-01 |
| Q207 | 2.0000E-01 | Q208 | 3.7000E-01 | Q209 | 3.7000E-01 | Q210 | 1.0000E-01 | Q211 | 9.9990E-01 | Q212 | 8.5984E-02 |
| Q213 | 9.3130E-01 | Q214 | 1.2575E-01 | Q215 | 1.0000E-01 | Q216 | 9.9990E-01 | Q218 | 9.2180E-01 | Q219 | 4.4039E-02 |
| Q220 | 5.2200E-02 | Q221 | 5.5120E-01 | Q222 | 8.5984E-02 | Q223 | 6.7540E-01 | Q224 | 1.2575E-01 | Q235 | 3.0000E-01 |
| Q236 | 7.0000E-01 | Q255 | 8.1000E-01 | Q256 | 7.1520E-01 | Q257 | 1.0000E-02 | Q258 | 1.1000E-01 | Q265 | 7.6520E-01 |
| Q266 | 7.0560E-01 | Q267 | 5.2893E-01 | Q268 | 5.4250E-01 | Q275 | 8.1020E-01 | Q276 | 7.1830E-01 | Q285 | 7.6520E-01 |
| Q286 | 7.0380E-01 | Q287 | 5.4250E-01 | Q288 | 5.2893E-01 | P201 | 4.7240E-01 | P215 | 2.4997E-01 | P217 | 8.6634E-01 |
| P221 | 4.7240E-01 | P230 | 2.4997E-01 | A250 | 4.0000E-01 | A251 | -8.5000E-01 | A260 | -3.7000E-01 | A261 | 3.0000E-01 |
| A280 | -3.0000E-01 | A281 | 7.0000E-01 | A200 | 3.3300E-02 | A201 | -2.0000E-02 | A210 | 1.1398E-01 | A211 | -1.1400E-01 |
| A215 | 4.5023E-02 | A216 | -4.6020E-02 | A220 | 1.8660E-01 | A221 | -9.7410E-02 | A227 | -3.0000E-02 | A230 | -3.3100E-02 |
| A231 | -4.8000E-02 | A232 | -9.5900E-02 | A233 | -5.0000E-02 | A237 | -7.0000E-02 | A238 | 1.1794E 02 | A239 | 1.3206E 02 |
| A240 | 1.0000E-01 | A241 | 1.5009E-01 | A242 | -2.9861E-01 | A243 | 2.9861E-01 | A244 | -1.0138E-01 | A245 | 1.0138E-01 |
| A252 | 6.0084E-01 | A253 | -1.0000E-02 | A254 | -1.0000E-02 | A262 | 6.2224E-01 | A263 | -5.2224E-01 | A264 | 5.2224E-01 |
| A270 | 5.9389E 01 | A271 | -3.0000E-01 | A272 | -2.9389E-01 | A273 | -4.0000E-01 | A282 | 2.2224E-01 | A283 | -2.2242E-02 |
| A284 | 2.2242E-02 | A292 | -2.0000E-01 | A293 | -1.0000E-01 | D250 | -1.8776E 00 | D251 | -6.6667E-01 | D260 | -1.1274E 00 |
| D261 | 1.8500E 00 | D280 | 4.4078E-02 | D281 | 1.5000E 00 | P00 | 1.0000E-01 | P18 | 8.0000E-02 | P20 | 7.5800E-02 |
| P23 | 5.5000E-01 | P30 | 3.2300E-02 | P37 | 1.5000E-01 | P38 | 1.8660E-01 | P43 | 2.0000E-01 | P48 | 0.0 |
| P57 | 0.0 | P77 | 0.0 | P78 | 0.0 | P90 | 3.0000E-01 | P95 | 1.8750E-01 | P101 | 4.3060E-01 |
| P104 | 4.3060E-01 | P110 | 4.3057E-01 | P114 | 4.3057E-01 | DAC00 | -4.7175E 02 | DAC01 | 2.1378E-01 | DAC02 | -5.2835E 02 |
| DAC03 | 5.0883E-02 | DAC04 | -5.9833E 00 | DAC05 | 2.6396E 03 | DAC06 | 7.5000E 00 | DAC07 | 3.0335E 03 | DAC08 | -3.0000E 03 |
| DAC09 | -7.1000E 03 | DAC10 | 1.4250E 00 | DAC11 | 2.5116E 03 | DAC12 | -3.9388E 01 | DAC13 | 2.4357E 03 | DAC14 | 4.0062E 01 |
| DAC15 | 1.0537E 00 | DAC16 | 8.2210E 00 | DAC17 | 2.1146E-01 | DAC18 | 8.0000E 00 | DAC19 | 5.1563E-02 | DAC20 | -8.3000E 00 |
| DAC21 | -7.5000E 00 | DAC22 | [illegible].7500E 00 | DAC23 | -7.4000E 00 | DAC24 | 6.8731E 02 | DAC25 | 6.8939E 02 | DAC26 | 7.0327E 02 |
| DAC27 | 9.0000E-01 | DAC28 | 7.0402E 02 | DAC29 | 2.0000E 00 | DAC30 | 1.0100E 00 | DAC31 | 1.2000E-01 | DAC32 | -2.0056E-02 |
| DAC33 | 1.3467E-01 | DAC34 | 1.0948E-01 | DAC35 | 2.5000E-01 | DAC36 | 2.4767E 03 | DA00 | -1.1794E-02 | DA01 | 2.1378E-02 |
| DA02 | -1.3206E-02 | DA03 | 5.0883E-03 | DA04 | -2.9516E-01 | DA05 | 2.6396E-01 | DA06 | 3.7500E-01 | DA07 | 3.0335E-01 |
| DA08 | -2.0000E-01 | DA09 | -1.7750E-01 | DA10 | 1.4250E-01 | DA11 | 2.5116E-01 | DA12 | -3.9388E-01 | DA13 | 2.4357E 01 |
| DA14 | 4.0062E-01 | DA15 | 1.0537E-02 | DA16 | 4.1175E-01 | DA17 | 2.1146E-02 | DA18 | 4.0000E-01 | DA19 | 5.1563E-03 |
| DA20 | -4.1500E-01 | DA21 | -3.7500E-01 | DA22 | 2.5250E-01 | DA23 | -3.7000E-01 | DA24 | 4.5821E-01 | DA25 | 4.5159E-01 |
| DA26 | 4.6885E-01 | DA27 | 4.5000E-02 | DA28 | 4.6935E-01 | DA29 | 1.0000E-01 | DA30 | 5.0500E-02 | DA31 | 6.0000E-03 |
| DA32 | -2.0056E-02 | DA33 | 1.3467E-01 | DA34 | 1.0948E-01 | DA35 | 2.5000E-01 | DA36 | 2.4767E-01 | A000 | -1.0000E-01 |
| A002 | 3.8300E-02 | A005 | -1.5000E-01 | A007 | 1.8660E-01 | A010 | -2.0000E-01 | A012 | 8.0000E-02 | A015 | -5.5000E-01 |
| A017 | 7.5800E-02 | A040 | 0.0 | A050 | 0.0 | A080 | 0.0 | A085 | 0.0 | A090 | 3.[illegible]000E-01 |
| A095 | 1.8750E-01 | A100 | 4.3060E-01 | A105 | 4.3060E-01 | A110 | -4.3057E-01 | A115 | -4.3057E-01 | T51 | -7.0000E-02 |
| T52 | -3.0000E-02 | T80 | -3.3100E-02 | T82 | -9.5900E-02 | T83 | -5.0000E-02 | T84 | -2.0000E-02 | T85 | -9.7410E-02 |
| T86 | -1.1400E-01 | T87 | -4.6020E-02 | T88 | -4.8000E-02 | A003 | -3.8300E-02 | A004 | 8.6599E-01 | A006 | -4.[illegible]060E-01 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A008 | -3.8383E-01 | A009 | 7.9338E-01 | A011 | -2.4257E-02 | A014 | -5.0007E-01 | A016 | 6.4831E-02 | A018 | 3.5175E-01 |
| A019 | -6.4831E-02 | A020 | 2.3531E-01 | A021 | 1.9467E-01 | A022 | 4.9735E-02 | A023 | -7.5152E-03 | A024 | -1.9467E-01 |
| A026 | 2.8132E-01 | A028 | 6.1391E-03 | A029 | -2.8132E-01 | A030 | 5.6036E-01 | A032 | -6.5000E-03 | A033 | -3.7000E-03 |
| A034 | 8.6599E-01 | A035 | 1.0138E-01 | A036 | -1.1398E-01 | A037 | 8.6599E-01 | A038 | 5.0000E-03 | A039 | 6.0872E-01 |
| A041 | 9.6470E-01 | A042 | 6.0872E-01 | A044 | 2.9000E-03 | A045 | -4.6023E-02 | A046 | 2.9861E-01 | A048 | 7.5825E-01 |
| A049 | -7.5557E-01 | A051 | 1.1460E-01 | A052 | 0.0 | A053 | 3.1385E-01 | A054 | -1.1460E-01 | A055 | -8.3362E-02 |
| A056 | -4.3060E-01 | A057 | -6.0872E-01 | A058 | 1.7328E-01 | A059 | -8.3356E-01 | A060 | 1.3269E-02 | A061 | -6.0000E-02 |
| A062 | 5.0007E-01 | A063 | -3.6386E-01 | A064 | -3.0612E-01 | A065 | -1.4830E-01 | A066 | -6.5542E-01 | A068 | 4.9921E-01 |
| A069 | -8.6599E-01 | A070 | 1.0000E-01 | A071 | 0.0 | A072 | -8.6599E-01 | A073 | -3.4694E-01 | A074 | 0.0 |
| A075 | -1.9412E-01 | A076 | 1.9989E-01 | A077 | 5.0007E-01 | A078 | 3.2532E-01 | A079 | 0.0 | A081 | 3.1711E-01 |
| A082 | -6.0872E-01 | A083 | -3.2103E-01 | A084 | -7.2887E-01 | A086 | -2.9839E-01 | A087 | 7.9338E-01 | A088 | 4.2489E-01 |
| A089 | -8.1688E-01 | A091 | -2.5186E-02 | A092 | 3.0612E-01 | A093 | -3.4145E-01 | A094 | -1.7083E-01 | A096 | -9.5844E-01 |
| A097 | -2.3531E-01 | A099 | 6.0872E-01 | A101 | 2.3234E-01 | A102 | -2.3234E-01 | A103 | -3.8235E-01 | A104 | 6.3506E-02 |
| A106 | -7.5825E-01 | A108 | 3.5891E-01 | A109 | -1.6942E-01 | A111 | 5.2085E-01 | A113 | -1.3934E-01 | A114 | -3.1711E-01 |
| A116 | -1.7328E-01 | A117 | -7.9338E-01 | A118 | 1.6716E-01 | D000 | -5.4820E-01 | D002 | -1.0000E-01 | D005 | -6.8493E 00 |
| D007 | -1.5000E-01 | D010 | -2.2499E 00 | D012 | -2.0000E-01 | D015 | -4.8532E 00 | D017 | -2.2000E-01 | D040 | -4.8940E 00 |
| D050 | 0.0 | D080 | 5.1111E-01 | D085 | 0.0 | D090 | 1.2337E 00 | D095 | 1.2337E 00 | D100 | -1.7486E 00 |
| D105 | -4.1920E 00 | D110 | 1.9989E 00 | D115 | 4.9735E-01 | DUMMY | 0.0 | | | | |

*** DSL/91 SIMULATION DATA *** 74.183 12:31:22.25

PARAM AXLE=0
END

***DSL MESSAGE 20*** NO OUTPUT REQUESTED...WARNING ONLY.

DSL/91 SIMULATION TIME= 0.0 SECONDS. 74.183 12:31:22.26

DEBUG OUTPUT, BLOCK 3 AT TIME= 0.1000E-02

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| TIME | 1.0000E-03 | DELT | 1.0000E-03 | DELMIN | 0.0 | DELMAX | 7.2370E 75 | TSTART | 0.0 | FINTIM | 1.0000E-03 |
| CLKTIM | 0.0 | NALARM | 0.0 | DELS | 0.0 | DELNIX | 7.2370E 75 | DELADC | 7.2370E 75 | DELDAC | 7.2370E 75 |
| DELSTP | 7.2370E 75 | DELMRK | 7.2370E 75 | SHAPE1 | -6.5000E-03 | SHAPE2 | -3.7000E-03 | SHAPE3 | 5.0000E-03 | SHAPE4 | 2.9000E-03 |
| DEL1DT | 1.0000E 01 | DEL1 | 3.8370E-01 | DEL2DT | 1.5000E 01 | DEL2 | 1.8660E 00 | THETA1 | 6.0000E 01 | THETA2 | 3.7500E 01 |
| ERR1 | 1.0000E 00 | ERR2 | -6.0000E-01 | DFW2DT | 3.7000E 01 | DFW2 | 1.5000E-01 | YCRDT | 8.0000E 01 | YCR | 2.5500E 00 |
| RPS1 | 4.3060E 01 | RPS2 | 4.3060E 01 | RPS3 | 4.3057E 01 | XPS3DT | 1.0000E 04 | RPS4 | 4.3057E 01 | XPS4DT | 1.0000E 04 |
| DFW1DT | 3.0000E 01 | DFW1 | 3.5000E-01 | PST1 | 2.1400E-01 | PS12 | 2.0400E-01 | PS13 | 1.6670E-02 | PS14 | -1.5000E-02 |
| ZO | -2.3400E 01 | THETO | 2.0900E-03 | PHIO | 3.0000E-03 | ROTO | -5.0000E 02 | U01 | 1.2000E-01 | U02 | 1.0100E 00 |
| U03 | 9.0000E-01 | U04 | 2.0000E 00 | U11 | -6.1330E-01 | U12 | 1.1100E 00 | U13 | 1.6210E 00 | U14 | 1.7000E 00 |
| AM11 | 5.2500E 00 | AM12 | -7.4000E 00 | AM13 | -7.5000E 00 | AM14 | -8.3000E 00 | TOFBR | 8.0000E 03 | TQRBR | 7.1000E 03 |
| MT1 | -1.6430E 02 | MT2 | 1.6430E 02 | PDTO | -1.2000E-01 | QDTO | 9.0000E-02 | UO | 7.0400E 02 | VO | 1.3000E-01 |
| WO | 5.0000E-03 | PO | 2.0000E-02 | QO | -3.7000E-02 | RO | 1.1000E-02 | F1 | 9.0000E-01 | F2 | 8.0000E-01 |
| F3 | -3.0000E-01 | F4 | 6.0000E-01 | GB1 | 2.0000E-01 | GB2 | 4.0000E-01 | GB3 | 5.0000E-01 | GB4 | 8.5000E-01 |
| AMS | 5.1620E 00 | AMUF | 3.5900E-01 | AMUR | 5.7400E-01 | TS | 3.5860E 01 | ATR | 8.0000E 02 | RF | 8.1000E 04 |
| TF | 5.4300E 01 | RR | 5.0000E 04 | LW | 1.2850E 01 | AIFW | 5.8150E 00 | AH1 | 2.0000E 02 | AH2 | 2.0000E 02 |
| AKT1 | 8.1200E 02 | AKT2 | 8.1200E 02 | AKT3 | 1.1920E 03 | AKT4 | 1.1920E 03 | AMCR | 8.0000E-02 | CFCR | 2.0000E 02 |
| CCR | 1.1000E 01 | EP | [illegible] | AA1 | 5.5300E 00 | AA2 | 5.5300E 00 | ANG | 1.7500E 01 | AKSC | 6.1000E 02 |
| ESP | -6.0000E 00 | AKSL1 | 1.1700E 05 | AKSL2 | 1.1700E 05 | EP1 | -2.0000E-01 | EP2 | -1.0000E-01 | AIWF | 7.3777E 00 |
| AIO | 3.0000E-01 | AWR | 4.1250E 05 | AIWR | 7.3777E 00 | AKF | 1.3300E 02 | AKR | 1.8500E 02 | ALAMF | 5.1000E 00 |
| ORT | 2.2000E 00 | CFP | 2.5000E 01 | CRP | 4.5000E 01 | TR | 5.3300E 01 | AKF1 | 5.2200E 01 | AKF2 | 5.2200E 01 |
| AKR3 | 1.0000E 02 | AKR4 | 1.0000E 02 | AKR3 | 1.0000E 02 | AKR4 | 1.0000E 02 | A | 5.6300E 01 | B | 3.9000E 01 |
| G | 3.8540E 02 | ZF | 1.1200E 01 | ZR | 1.0600E 01 | AMU1 | 1.7950E-01 | AMU2 | 1.7950E-01 | AMU3 | 2.8700E-01 |
| AMU4 | 2.8700E-01 | HF | 7.2000E 00 | HRC | 4.7000E 00 | CRRC | 1.1000E-02 | TANP | 0.0 | DELSWD | 1.4250E 00 |
| LH1 | 1.6500E 00 | LH2 | 1.6500E 00 | LH3 | 1.0000E 00 | LH4 | 1.0000E 00 | AXLE | 0.0 | BETA | 2.5000E-01 |
| S3P | -2.4465E 02 | S4P | -3.3440E 02 | ZZ0001 | 0.0 | ZZ0002 | 0.0 | PHIR | 0.0 | PHIRD | 0.0 |
| DEL3 | 0.0 | DEL3DT | 0.0 | SEL3 | 2.5000E-01 | SEL3DT | 6.9000E 01 | SEL4 | 9.0000E-01 | SEL4DT | 7.0000E 01 |
| FSA1 | 3.3100E 01 | FSA2 | 4.8000E 01 | FSA3 | 1.8610E 02 | FSA4 | 1.8800E 02 | F2F1 | 2.0000E 01 | F2F2 | 9.7410E 01 |
| F1F1 | 2.5000E 01 | F1F2 | 2.5000E 01 | F2R3 | 2.5000E 01 | F2R4 | 9.0000E 01 | F1R3 | 4.5000E 01 | F1R4 | 4.5000E 01 |
| AUXRL1 | 1.3269E 01 | AUXRL2 | -2.4257E 01 | S1P | -5.4831E 01 | S2P | -1.9467E 02 | SMP | -8.3860E 02 | S1 | 3.4330E 02 |
| S2 | 2.1346E 02 | S3 | 3.4451E 02 | S4 | 2.5473E 02 | ZET3 | 2.5000E-01 | ZET3DT | 6.9000E 01 | ZET4 | 9.0000E-01 |
| ZET4DT | 7.0000E 01 | Z1 | -1.2253E 01 | Z2 | -1.0933E 01 | Z3 | -1.2389E 01 | Z4 | -1.1898E 01 | H1 | 1.2253E 01 |
| H2 | 1.0933E 01 | H3 | 1.2389E 01 | H4 | 1.1898E 01 | RHO1 | 5.4679E-01 | RHO2 | 1.9169E 00 | RHO3 | 4.6147E-01 |
| RHO4 | 5.5158E-01 | FR1 | 4.3459E 02 | FR2 | 1.5565E 03 | FR3 | 5.5008E 02 | FR4 | 1.1343E 03 | FXU1 | 2.1540E 01 |
| FXU2 | -1.6027E 03 | FXU3 | -5.8631E 02 | FXU4 | -2.1708E 03 | FYU1 | 1.9030E 01 | FYU2 | -2.4556E 02 | FYU3 | -3.5178E 01 |
| FYU4 | 1.9524E 02 | NPHIR | 1.5292E 04 | DEL1DD | -5.8369E 02 | DEL2DD | -6.8848E 03 | DEL3DD | -1.6700E 03 | PHIRDD | 1.8294E 01 |
| SEL3DD | -4.7079E 02 | SEL4DD | -2.7262E 03 | TP | -3.1372E 04 | AMSS1 | -1.3012E 03 | AMSS2 | -3.0551E 04 | DFW1DD | -3.3630E 02 |
| DFW2DD | 4.5095E 03 | YCRDD | -1.5621E 05 | U1 | 7.0310E 02 | U2 | 7.0390E 02 | U3 | 7.0331E 02 | U4 | 7.0390E 02 |
| V1 | 2.9824E-01 | V2 | 3.1464E-01 | V3 | -7.5877E-01 | V4 | -7.4897E-01 | W1 | -7.3689E 00 | W2 | 1.6545E 01 |
| W3 | 7.0981E 01 | W4 | 6.8024E 01 | UG1 | 7.0329E 02 | UG2 | 7.0343E 02 | UG3 | 7.0346E 02 | UG4 | 7.0404E 02 |
| VG1 | 3.1034E-01 | VG2 | 2.6500E-01 | VG3 | -9.7171E-01 | VG4 | -9.5305E-01 | X11 | 2.3234E-01 | X12 | 3.1711E-01 |
| X13 | 2.4172E-01 | X14 | 2.7235E-01 | SLIP1 | 2.3234E-01 | SLIP2 | 3.1711E-01 | SLIP3 | 2.4172E-01 | SLIP4 | 2.7235E-01 |
| AM21 | -7.3330E-01 | AM22 | 1.0000E-01 | AM23 | 7.2100E-01 | AM24 | -3.0000E-01 | ST1 | 2.0056E-02 | ST2 | -1.3467E-01 |
| ST3 | -1.0948E-01 | ST4 | -2.5000E-01 | U1P | -5.0371E-02 | U2P | 1.0417E 00 | U3P | 1.0743E 00 | U4P | 1.9183E 00 |
| FC1 | 2.4410E 01 | FC2 | -1.6214E 03 | FC3 | -5.9093E 02 | FC4 | -2.1759E 03 | RPS1DT | 1.7486E 03 | RPS2DT | 4.1920E 03 |
| DENOM | 8.6539E 00 | TERM | 1.2752E 00 | RPS4DT | 2.3374E 03 | RPS3DT | 1.9172E 02 | TT | 1.0000E-04 | THER1 | 1.0471E 00 |
| THER2 | 6.5445E-01 | THE1DT | 2.4673E 03 | THE2DT | 2.4573E 03 | ZZ0003 | 0.0 | ZZ0004 | 0.0 | Q200 | 5.2200E-02 |
| Q201 | 5.5120E-01 | Q202 | 1.5525E-01 | Q203 | 6.1550E-01 | Q204 | 1.6667E-01 | Q205 | 4.0000E-01 | Q206 | 8.5000E-01 |
| Q207 | 2.0000E-01 | Q208 | 3.7000E-01 | Q209 | 3.0000E-01 | Q210 | 1.0000E-01 | Q211 | 9.9990E-01 | Q212 | 8.5984E-02 |
| Q213 | 9.3130E-01 | Q214 | 1.2575E-01 | Q215 | 1.0000E-01 | Q216 | 9.9990E-01 | Q218 | 9.2180E-01 | Q219 | 4.4034E-02 |
| Q220 | 5.2200E-02 | Q221 | 5.5120E-01 | Q222 | 8.5984E 02 | Q223 | 6.7540E-01 | Q224 | 1.2575E-01 | Q235 | 3.0000E-01 |
| Q236 | 7.0000E-01 | Q255 | 8.1000E-01 | Q256 | 7.1520E-01 | Q257 | 1.0000E-02 | Q258 | 1.1000E-01 | Q265 | 7.6520E-01 |
| Q266 | 7.0560E-01 | Q267 | 5.2693E-01 | Q268 | 5.4250E-01 | Q275 | 8.1020E-01 | Q276 | 7.1830E-01 | Q285 | 7.6520E-01 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Q286 | 7.0380E-01 | Q287 | 5.4250E-01 | Q288 | 5.2893E-01 | P201 | 4.7240E-01 | P215 | 2.4997E-01 |
| P217 | 8.6634E-01 | P221 | 4.7240E-01 | P230 | 2.4997E-01 | A250 | 4.0000E-01 | A251 | -8.5000E-01 |
| A260 | -3.7000E-01 | A261 | 3.0000E-01 | A230 | -3.0000E-01 | A281 | 7.0000E-01 | A200 | 3.8300E-02 |
| A201 | -2.0000E-02 | A210 | 2.5000E-02 | A211 | -2.5000E-02 | A215 | 9.0000E-02 | A216 | -9.0000E-02 |
| A220 | 1.8660E-01 | A221 | -9.7410E-02 | A227 | -3.0000E-02 | A230 | -3.3100E-02 | A231 | -4.8000E-02 |
| A232 | -1.8610E-01 | A233 | -1.8800E-01 | A237 | -7.0000E-02 | A238 | 1.1794E 02 | A239 | 1.3206E 02 |
| A240 | 1.0000E-01 | A241 | 1.5000E-01 | A242 | -6.9000E-01 | A243 | 6.9000E-01 | A244 | -7.0000E-01 |
| A245 | 7.0000E-01 | A252 | 6.0084E-01 | A253 | -1.0000E-02 | A254 | -1.0000E-02 | A262 | 6.2224E-01 |
| A263 | -5.2224E-01 | A264 | 5.2224E-01 | A270 | 5.9389E-01 | A271 | -3.0000E-01 | A272 | -2.9389E-01 |
| A273 | -4.0000E-01 | A282 | 2.2224E-01 | A283 | -2.2242E-02 | A284 | 2.2242E-02 | A292 | -2.0000E-01 |
| A293 | -1.0000E-01 | D250 | -1.8776E 00 | D251 | -6.6667E-01 | D260 | -1.1274E 00 | D261 | 1.8500E 00 |
| D280 | 8.4076E-02 | D281 | 1.5000E 00 | P00 | 1.0000E-01 | P18 | 0.0 | P20 | 0.0 |
| P23 | 0.0 | P30 | 3.8300E-02 | P37 | 1.5000E-01 | P38 | 1.8660E-01 | P43 | 0.0 |
| P48 | 6.9000E-01 | P57 | 2.5000E-02 | P77 | 7.0000E-01 | P78 | 9.0000E-02 | P90 | 3.0000E-01 |
| P95 | 1.8750E-01 | P101 | 4.3060E-01 | P104 | 4.3060E-01 | P110 | 4.3057E-01 | P114 | 4.3057E-01 |
| DAC00 | -4.7175E 02 | DAC01 | 2.1378E-01 | DAC02 | -5.2825E 02 | DAC03 | 5.0883E-02 | DAC04 | -5.983[illegible] 00 |
| DAC05 | 2.6396E 03 | DAC06 | 7.5000E 00 | DAC07 | 3.0335E 03 | DAC08 | -8.0000E 03 | DAC09 | -7.1000E 03 |
| DAC10 | 1.4250E 00 | DAC11 | 2.4608E 03 | DAC12 | -3.9708E 01 | DAC13 | 2.4357E 03 | DAC14 | 3.9708E 01 |
| DAC15 | -3.1794E 00 | DAC16 | 8.2210E 00 | DAC17 | 2.1146E-01 | DAC18 | 8.0000E 00 | DAC19 | 5.1563E-02 |
| DAC20 | -8.3000E 00 | DAC21 | -7.5000E 00 | DAC22 | 5.2500E 00 | DAC23 | -7.4000E 00 | DAC24 | 6.8731E 02 |
| DAC25 | 6.8939E 02 | DAC26 | 7.0345E 02 | DAC27 | 9.0000E-01 | DAC28 | 7.0406E 02 | DAC29 | 2.0000E 00 |
| DAC30 | 1.0100E 00 | DAC31 | 1.2000E-01 | DAC32 | -2.0056E-02 | DAC33 | 1.3467E-01 | DAC34 | 1.0948E-01 |
| DAC35 | 2.5000E-01 | DAC36 | 2.5538E 03 | DA00 | -1.1794E-02 | DA01 | 2.1378E-02 | DA02 | -1.3206E-02 |
| DA03 | 5.0883E-03 | DA04 | -2.9916E-01 | DA05 | 2.6396E-01 | DA06 | 3.7500E-01 | DA07 | 3.0335E-01 |
| DA08 | -2.0000E-01 | DA09 | -1.7750E-01 | DA10 | 1.4250E-01 | DA11 | 2.4608E-01 | DA12 | -3.9708E-01 |
| DA13 | 2.4357E-01 | DA14 | 3.9708E-01 | DA15 | -3.1794E-02 | DA16 | 4.1105E-01 | DA17 | 2.1146E-02 |
| DA18 | 4.0000E-01 | DA19 | 5.1563E-03 | DA20 | -4.1500E-01 | DA21 | -3.7500E-01 | DA22 | 2.6250E-01 |
| DA23 | -3.7000E-01 | DA24 | 4.5821E-01 | DA25 | 4.5959E-01 | DA26 | 4.6896E-01 | DA27 | 4.5000E-02 |
| DA28 | 4.6937E-01 | DA29 | 1.0000E-01 | DA30 | 5.0500E-02 | DA31 | 6.0000E-03 | DA32 | -2.0056E-02 |
| DA33 | 1.3467E-01 | DA34 | 1.0948E-01 | DA35 | 2.5000E-01 | DA36 | 2.5538E-01 | A000 | -1.0000E-01 |
| A002 | 3.8300E-02 | A005 | -1.5000E-01 | A007 | 1.8660E-01 | A010 | 0.0 | A012 | 0.0 |
| A015 | 0.0 | A017 | 0.0 | A040 | -6.9000E-01 | A050 | 2.5000E-02 | A080 | -7.0000E-01 |
| A085 | 9.0000E-02 | A090 | 3.0000E-01 | A095 | 1.8750E-01 | A100 | 4.3060E-01 | A105 | 4.3060E-01 |
| A110 | -4.3057E-01 | A115 | -4.3057E-01 | T51 | -7.0000E-02 | T52 | -3.0000E-02 | T80 | -3.3100E-02 |
| T82 | -1.8610E-01 | T83 | -1.8800E-01 | T84 | -2.0000E-02 | T85 | -9.7410E-02 | T86 | -2.5000E-02 |
| T87 | -9.0000E-02 | T88 | -4.8000E-02 | A003 | -3.8300E-02 | A004 | 8.6599E-01 | A006 | -4.3060E-01 |
| A008 | -3.8383E-01 | A009 | 7.9338E-01 | A011 | -2.4257E-02 | A014 | -5.0007E-01 | A016 | 6.4831E-02 |
| A018 | 3.5175E-01 | A019 | -6.4831E-02 | A020 | 2.7235E-01 | A021 | 1.9467E-01 | A022 | 2.3374E-01 |
| A023 | -7.5152E-03 | A024 | -1.9467E-01 | A026 | 2.4466E-01 | A028 | 6.1391E-03 | A029 | -2.4466E-01 |
| A030 | 5.3714E-01 | A032 | -6.5000E-03 | A033 | -3.7000E-03 | A034 | 8.6599E-01 | A035 | 7.0000E-01 |
| A036 | -2.5000E-02 | A037 | 8.6599E-01 | A038 | 5.0000E-03 | A039 | 6.0872E-01 | A041 | 9.5915E-01 |
| A042 | 6.0872E-01 | A044 | 2.9000E-03 | A045 | -9.0000E-02 | A046 | 6.9000E-01 | A048 | 2.3074E-01 |
| A049 | -8.2590E-01 | A051 | 3.3444E-01 | A052 | -2.5000E-02 | A053 | 3.1385E-01 | A054 | -3.3444E-01 |
| A055 | 4.4890E-02 | A056 | -4.3060E-01 | A057 | -6.0872E-01 | A058 | 4.7579E-01 | A059 | -7.9323E-01 |
| A060 | 1.3269E-02 | A061 | -6.0000E-02 | A062 | 5.0007E-01 | A063 | -3.6386E-01 | A064 | -2.4172E-01 |
| A065 | -1.4830E-01 | A066 | -8.3860E-01 | A068 | 4.9921E-01 | A069 | -8.6599E-01 | A070 | 1.0000E-01 |
| A071 | -6.5000E-02 | A072 | -8.6599E-01 | A073 | -3.7914E-01 | A074 | 1.1440E-02 | A075 | -2.0894E-01 |
| A076 | 1.9172E-02 | A077 | 5.0007E-01 | A078 | 3.5561E-01 | A079 | -1.1440E-02 | A081 | 3.1711E-01 |
| A082 | -6.0872E-01 | A083 | -1.0236E-01 | A084 | -7.2887E-01 | A086 | -2.9839E-01 | A087 | 7.9338E-01 |
| A088 | 1.2394E-01 | A089 | -8.1688E-01 | A091 | -2.5186E-02 | A092 | 2.4172E-01 | A093 | -3.4145E-01 |
| A094 | -1.4436E-01 | A096 | -9.5844E-01 | A097 | -2.7235E-01 | A099 | 6.0872E-01 | A101 | 2.3234E-01 |
| A102 | -2.3234E-01 | A103 | -3.6383E-01 | A104 | 6.3506E-02 | A106 | -2.30[illegible]E-01 | A108 | 3.4154E-01 |
| A109 | -1.6942E-01 | A111 | 5.2085E-01 | A113 | -3.6199E-01 | A114 | -3.1711E-01 | A116 | -4.7579E-01 |
| A117 | -7.9338E-01 | A118 | 4.5635E-01 | D000 | -5.8369E-01 | D002 | -1.0000E-01 | D005 | -6.8848E 00 |
| D007 | -1.5000E-01 | D010 | -1.6700E 00 | D012 | 0.0 | D015 | 1.8294E 00 | D017 | 0.0 |
| D040 | -4.7079E-01 | D050 | -6.9000E-01 | D080 | -2.7262E 00 | D085 | -7.0000E-01 | D090 | 1.2337E 00 |
| D095 | 1.2337E 00 | D100 | -1.7486E 00 | D105 | -4.1920E 00 | D110 | 1.9172E-01 | D115 | 2.3374E 00 |
| DUMMY | 0.0 | | | | | | | | |

2. PRESENTED HERE IS THE COMPUTER LISTING OF THE IBM 360/91 FORTRAN DIGITAL PROGRAM

2.1 SUBROUTINES

## 2.1.1 MAIN

PRESENTED HERE IS THE FORTRAN LISTING FOR THE MAIN SUBPROGRAM. THE FOLLOWING IS PERFORMED IN MAIN:

1) Communication initialization with the hybrid operator's station.

2) Reading of the input data deck.

3) Setting of potentiometers.

4) Simulation control via the interactive routines using the OPTION command.

```
C     VEHICLE HANDLING  MODEL C
      DIMENSION  ADC1(24),ADC2(4)
      DIMENSION  JDATE(3)
      DIMENSION ARIGH(10),ATRACK(2000),ASTEP(10)
      DIMENSION INCA(10),VINC(10)
      DIMENSION BVALUE(2)
      COMMON/START/ ZDUMMY(4)
      COMMON/TABBS/ ITABP,ITABI,ITNAM,TABNUM
      COMMON/EMON/IERDAC(10),TERDAC(10),IDACK,IENDE(2 ),IOP
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1    YO,ZO,THEO,PHIO,PSIO
      COMMON/INOUT/ INA(32),IOUTA(48),IN(32),DACO(48),ISW1,ISW7,
     1SFIN(32),SFOUT(48),IPRT,ITMP(48)
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/SOLDAX/DELPHI(20),PHIFNT(20),DELTHE(20),THEFNT(20),NCAM,
     1 NCAS,PSIFNT(7),PHIRR(7),THERR(7),PSIRR(7)
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/END/ STOP
      COMMON/LINE/ ALINE(3,6),TLINE(3,6),IL
      COMMON/IO/ DACPLA,ADCPLA,SCALDC,SCALAC
      COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR
      COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAFCB,TDAECB
      COMMON /ECBBLK/AD2ECB,AD1ECB,CLSECB,CLRECB,ICECB ,OPECB
      COMMON /ECBBLK/OSECB ,DONECB,SLFCB5,RLECB5
      COMMON/DELS/DELSWC
      COMMON/ALPHA/ALPH(20)
      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
     1   ANOUT,ADOUT
      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/MICKEY/IRUNTB(002),VTB(002),SNLTB(002),SWRTB(002),DSWTB(002
     1  ),BTTB(002),DTB(002),EFFTB(002),DYTB(002),PSITB  (002),NRUN,
     1   YSPEC,PSIM,XPF
      COMMON/FIND/ORNAME(400),NCOM,RSVAL(002),IORDER(400)
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,
     1               AXI,CURVAV,ABBTV,AYMAX,RMAX,DELRET,DELPST,BETAMX,
     1               TIMBMP,GETDL,TIMIN5,        TSTEP ,    IVHTP
      EQUIVALENCE (ADC1(24),IN(24))      ,(ADC2(1),IN(25))
      EQUIVALENCE (TMNAME(1),FMNAME)
      EQUIVALENCE
     1    (PARAM( 1),AMS)     , (PARAM( 2),AMUF)  , (PARAM( 3),AMUR)    ,
     1    (PARAM( 4),ZF)      , (PARAM( 5),ZR)    , (PARAM( 6),A)       ,
     1    (PARAM( 7),B)       , (PARAM( 8),TF)    , (PARAM( 9),TR)      ,
     1    (PARAM(10),TS)      , (PARAM(11),AIX)   , (PARAM(12),AIY)     ,
     1    (PARAM(13),AIZ)     , (PARAM(14),AIXZ)  , (PARAM(15),AIF)     ,
     1    (PARAM(16),CF)      , (PARAM(17),RF)    , (PARAM(18),CFP)     ,
     1    (PARAM(19),AKF)     , (PARAM(20),ALAMF) , (PARAM(21),OFC)     ,
     1    (PARAM(22),OFT)     , (PARAM(23),CR)    , (PARAM(24),RR)      ,
     1    (PARAM(25),CRP)     , (PARAM(26),AKR)   , (PARAM(27),ALAMR)   ,
     1    (PARAM(28),ORC)     , (PARAM(29),ORT)   , (PARAM(30),AKRS)    ,
     1    (PARAM(31),RW)                          , (PARAM(33),OT)      ,
     1    (PARAM(34),CA0)     , (PARAM(35),CA1)   , (PARAM(36),CA2)     ,
```

```
     1    (PARAM(37),CA3)      , (PARAM(38),CA4)     , (PARAM(39),AISW)     ,   MAIN 600
     1    (PARAM(44),AKDL)     , (PARAM(41),AKSC)    , (PARAM(42),ANG)      ,   MAIN 610
     1    (PARAM(43),WG)       , (PARAM(40),ANL2)    , (PARAM(45),AKSL)         MAIN 620
      EQUIVALENCE                                                               MAIN 630
     1    (PARAM(46),ANL1)     , (PARAM(47),AIFW)    , (PARAM(48),HDL)      ,   MAIN 640
     1    (PARAM(49),AIWF)     , (PARAM(50),AIWR)    , (PARAM(51),AID)      ,   MAIN 650
     1    (PARAM(52),ARBR)     , (PARAM(53),EPS1)    , (PARAM(54),EPS2)     ,   MAIN 660
     1    (PARAM(55),PTBR)     , (PARAM(56),YSA1)    , (PARAM(57),YSA2)     ,   MAIN 670
     1    (PARAM(58),YHS1)     , (PARAM(59),YHS2)    , (PARAM(60),AKD)      ,   MAIN 680
     1    (PARAM(61),TQDBR)    , (PARAM(62),AK)      , (PARAM(63),PIN)      ,   MAIN 690
     1    (PARAM(64),QIN)      , (PARAM(65),RIN)     , (PARAM(66),UIZ)      ,   MAIN 700
     1    (PARAM(67),VIN)      , (PARAM(68),WIN)     , (PARAM(69),XIN)      ,   MAIN 710
     1    (PARAM(70),YIN)      , (PARAM(71),ZIN)     , (PARAM(72),THEIN)    ,   MAIN 720
     1    (PARAM(73),PHIIN)    , (PARAM(74),PSIIN)   , (PARAM(75),DTIN)     ,   MAIN 730
     1    (PARAM(76),TEND)     , (PARAM(77),AKT1)    , (PARAM(78),AKT2)     ,   MAIN 740
     1    (PARAM(79),AKT3)     , (PARAM(80),AKT4)    , (PARAM(81),RPS1)     ,   MAIN 750
     1    (PARAM(82),RPS2)     , (PARAM(83),RPS3)    , (PARAM(84),RPS4)     ,   MAIN 760
     1    (PARAM(85),B1)       , (PARAM(86),B2)      , (PARAM(87),B3)           MAIN 770
      EQUIVALENCE                                                               MAIN 780
     1 (PARAM(88),B4),            (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),     MAIN 790
     1  (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN),           MAIN 800
     1    (PARAM( 94),DEL3IN), (PARAM( 95),PHIDN), (PARAM(96),PHIRN),           MAIN 810
     1    (PARAM( 97),DFW1IN), (PARAM( 98),DFW2IN),(PARAM( 99),U1PIN),          MAIN 820
     1    (PARAM(100),U2PIN),  (PARAM(101),U3PIN), (PARAM(102),U4PIN),          MAIN 830
     1    (PARAM(103),S1PIN),  (PARAM(104),S2PIN), (PARAM(105),S3PIN),          MAIN 840
     1    (PARAM(106),S4PIN), (PARAM(107),PPRT)                                 MAIN 850
     1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)                   MAIN 860
     1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),                   MAIN 870
     1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)                       MAIN 880
     1   ,(PARAM(119),TQRBR),(PARAM(120),TQFBR)                                 MAIN 890
     1   ,(PARAM(121),PFL),(PARAM(122),TTD),(PARAM(123),DSW)                    MAIN 900
     1    ,(PARAM(124),TSW)                                                     MAIN 910
      EQUIVALENCE                                                               MAIN 920
     1  (PARAM(130),AMCP),(PARAM(131),ESP),(PARAM(132),AKSL1),                  MAIN 930
     1  (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),                   MAIN 940
     1  (PARAM(136),CCR),(PARAM(137),CPCR),(PARAM(138),AP),                     MAIN 950
     1  (PARAM(139),EP1),(PARAM(140),EP2),(PARAM(141),ERR1),                    MAIN 960
     1  (PARAM(142),ERR2),                                                      MAIN 970
     1  (PARAM(143),AML1),(PARAM(144),AML2),(PARAM(145),FRIM),                  MAIN 980
     1    (PARAM(146),RWR)                                                      MAIN 990
     1    ,(PARAM(196),EPSK1),(PARAM(197),EPSK2)                                MAIN1000
      EQUIVALENCE                                                               MAIN1010
     1    (PARAM(284),HFC),(PARAM(285),HRC)                                     MAIN1020
C####################################                                           MAIN1030
C### PARAM(290)-(295) ADDED 8/11/72 ###                                         MAIN1040
C####################################                                           MAIN1050
      EQUIVALENCE                                                               MAIN1060
     1    (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),                   MAIN1070
     1    (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)                    MAIN1080
      EQUIVALENCE                                                               MAIN1090
     1(PARAM(296),DEL1DT),(PARAM(297),DEL2DT),(PARAM(298),DEL3DT),              MAIN1100
     1(PARAM(299),DEL1),(PARAM(300),DEL2),(PARAM(301),DEL3),                    MAIN1110
     1(PARAM(302),PHIRD),(PARAM(303),PHIR),(PARAM(304),DELFW1),                 MAIN1120
     1(PARAM(305),DELFW2),(PARAM(306),U1P),(PARAM(307),U2P),                    MAIN1130
     1(PARAM(308),U3P),(PARAM(309),U4P),(PARAM(310),S1P),                       MAIN1140
     1(PARAM(311),S2P),(PARAM(312),S3P),(PARAM(313),S4P),                       MAIN1150
     1(PARAM(314),QUAN1),(PARAM(315),QUAN2),(PARAM(316),QUAN3),                 MAIN1160
     1(PARAM(317),QUAN4),(PARAM(318),ARPS1),(PARAM(319),ARPS2),                 MAIN1170
     1(PARAM(320),WSTH1),(PARAM(321),WCTH1),(PARAM(322),WSTH2),                 MAIN1180
     1(PARAM(323),WCTH2),(PARAM(324),IOUT(1))                                   MAIN1190
```

```
      EQUIVALENCE (NAMSUR(1),ZDUMMY(1))                                 MAIN1200
      EQUIVALENCE (DVALUE(1),ZDUMMY(1))                                 MAIN1210
      REAL*8 NAMSUR(2),STOP,NAMEA(10)                                   MAIN1220
      REAL*8 ZDUMMY                                                     MAIN1230
      REAL*8 TABVAR(9,7)                                                MAIN1240
      REAL*8 QUES,CHANGE,READ,CONTRL,RETURN                             MAIN1250
      REAL*8 OPTION(15),OPTEST                                          MAIN1260
      REAL*8 BLANK,SELECT,ASELT(15),REMOVE,RESET                        MAIN1270
      REAL*8 NMES,NTESTP,NTESTO                                         MAIN1280
      REAL*8 NADCL,NDACL,NDUMP,NPARM,NNPC,NPLOT,NSTAT,NSTD               MAIN1290
      REAL*8 NTRACK,NTM,NTIMD,NTABLE                                    MAIN1300
      REAL*8 OUTNAM(21),NX,NOUT,NTERM,NRESR,NIC,NADCA                   MAIN1310
      REAL*8 NXM,UNNAM(3),MODENA(4)                                     MAIN1320
      REAL*8 ORNAME,FMNAMF                                              MAIN1330
      REAL*8 NLA                                                        MAIN1340
      REAL*8 NDACA,NMULT,CNAME,NII,NFF                                  MAIN1350
      REAL*4 VALMR(20),FINLMR(20)                                       MAIN1360
      REAL*4 TMNAME(2)                                                  MAIN1370
      REAL*4 FNUMA(10)                                                  MAIN1380
      REAL*4 IOUT(48),IN,ITMP,SCALAC(28),SCALDC(48)                     MAIN1390
      INTEGER*4 WRDVNT(9)                                               MAIN1400
      INTEGER*4 INDEXA(10)                                              MAIN1410
      INTEGER*4   OSECB       ,DONECB ,SLECB5,RLECB5                    MAIN1420
      INTEGER*4 ITABI(9)                                                MAIN1430
      INTEGER*4 ITAPP(9),TABNUM,ITNAM(9)                                MAIN1440
      INTEGER*2 INDVAR(9,7)                                             MAIN1450
      INTEGER*2 ITRAA(50),ITRNA(50),ITRIA(50)                           MAIN1460
        INTEGER*2 LOCAT(20),LOOPN(20)                                   MAIN1470
      INTEGER*2   RTSW  ,RBSW  ,LDTSW ,OPEN                             MAIN1480
      INTEGER*2 DEVICE(21),IORDER,IMODE(20)                             MAIN1490
      INTEGER*2 DACNUM,ADCNUM,DACPLA(48),ADCPLA(28)                     MAIN1500
      INTEGER*2 NAMDAC(48),NAMADC(28),IDAC(48),IADC(28)                 MAIN1510
      DATA QUES/'?   '/                                                 MAIN1520
      DATA BLANK/' '/                                                   MAIN1530
      DATA OUTNAM/'STD','TM','TABLE',17*' '/                            MAIN1540
      DATA NMES,NTESTP,NTESTO/'MES','TEST','TESTO'/                     MAIN1550
      DATA RESET,REMOVE/'RESET  ','REMOVE  '/                           MAIN1560
      DATA DEVICE/2,2,3,17*0/                                           MAIN1570
      DATA IMODE/1,1,3,17*0/,NXM/'XM'/                                  MAIN1580
      DATA UNNAM/'L.......','T.......','B.......'/                      MAIN1590
      DATA MODENA/'S.......','XEQ.....','M.......','A.......'/          MAIN1600
      DATA NLA/'LA'/                                                    MAIN1610
      DATA NX,NOUT,NTERM,NRESR,NIC/'X','OUTPUT','TERM','RE-STR','IC'/   MAIN1620
      DATA NADCA,NDACA,NII,NFF/'ADCA','DACA','I','F'/                   MAIN1630
      DATA NMULT,NADCL,NDACL/'MULTI','ADCL','DACL'/                     MAIN1640
      DATA NDUMP,NPARM,NPLOT,NSTAT/'DUMP','PARM','PLOT','STAT'/         MAIN1650
      DATA NSTD,NTRACK,NTM,NTIMD/'STD','TRACK','TM','T+D'/              MAIN1660
      DATA NTABLE,NNPC/'TABLE','PC'/                                    MAIN1670
      KEYBD=5                                                           MAIN1680
      ITTY=6                                                            MAIN1690
      LPRNT = 0                                                         MAIN1700
      ICDRD  = 1                                                        MAIN1710
      LAST=72                                                           MAIN1720
      LPTR   =2                                                         MAIN1730
      CALL TYPER2(KEYBD,ITTY,LPRNT)                                     MAIN1740
      CALL SETUP(ITTY,ICDRD)                                            MAIN1750
      DO 10 I=1,48                                                      MAIN1760
      IOUT(I)=0                                                         MAIN1770
   10 CONTINUE                                                          MAIN1780
      IPT=0                                                             MAIN1790
```

```
      IKEEP=0
      JIN=0
      ICDPN=7
      IDACK=0
      TABNUM=9
      MOPU=6
      LRUNS=0
      IRUNS=1
      ICT=0
      LSTART=1
      LAST=72
      DTIN=.02
      ADCNUM=28
      DACNUM=48
      SAVHTP=100
      ITRUNS=0
      REALT=1.
      ONTIM=1000.
      N1=295
      N2=119
      RTSW=1
         RBSW   = 0
         OPEN   = 0
      ICDPN  =7
      WRITE(ITTY,11)
      WRITE(ITTY,10070)
      WRITE(ITTY,10120)
      READ(KEYBD,11000)LL
      CALL SACN(1,ISACNE)
      CALL SAMO(1,ISAMOE)
      CALL SLMO(3,ISLMOE)
      CALL SLMO(1,ISLMOE)
11000 FORMAT(I1)
10120 FORMAT(1H ,18HTYPE CR WHEN READY)
10070 FORMAT(1HC,27HENGAGE PATCH PANEL FOR TEST)
   11 FORMAT(T10,'HYBRID VEHICLE HANDLING PROGRAM')
 8888 CONTINUE
      XPF=XIN
      YSPEC=YIN
      NRUN=1
 3333 FORMAT(20A4)
      DO 6140 I=1,48
      ITMP(I)=0
 6140 CONTINUE
      READ(ICDRD,3333) (ALPH(I),I=1,20)
      READ(ICDRD, 900) (PHIFNT(I),I=1,7)
      READ(ICDRD, 900) (THFFNT(I),I=1,7)
      READ(ICDRD,900)  (PSIFNT(I),I=1,7)
      READ(ICDRD,900) (PHIRR(I),I=1,7)
      READ(ICDRD,900)  (THERR(I),I=1,7)
      READ(ICDRD,900) (PSIRR(I),I=1,7)
      NTF=1
  200 READ(ICDRD,900)    PBF(NTF),TQBF(NTF)
      IF(PBF(NTF).GE.99999.0)GO TO 210
      NTF=NTF+1
      GO TO 200
  210 NTF=NTF-1
      NTR=1
  220 READ(ICDRD,900)  PBR(NTR),TQBR(NTR)
      IF(PBR(NTR).GE.99999.0)GO TO 230
```

```
      NTR=NTR+1
      GO TO 220
  230 NTR=NTR-1
      NFA=1
  280 READ(ICDRD,900) GAMF(NFA),AFA(NFA)
      IF(GAMF(NFA).GE.99999.0) GO TO 290
      NFA=NFA+1
      GO TO 280
  290 NFA=NFA-1
  900 FORMAT(8E10.0)
      READ(ICDRD,8750)  (ASELT(I),I=1,15)
      READ(ICDRD,1011)  CHANGE,READ,RETURN,CONTRL
      READ(ICDRD,8750)  (OPTION(J),J=1,15)
C    THIS ROUTINE SETS UP TRACK NAME ARRAY
      ITRA=0
  130 CALL UNFORM(ICDRD,1)
      IF(IWRDCT.EQ.0)  GO TO 120
      DO 110 I=1,IWRDCT
      CALL FINDNM(K,J,I,&110)
      ITRA=ITRA+1
      ITRAA(ITRA)=K
      ITRNA(ITRA)=J
      ITRIA(ITRA)=INDEXA(I)
  110 CONTINUE
      GO TO 130
  120 CONTINUE
C    THIS ROUTINE SETS UP TABLE NAME ARRAY
      DO 101 JJ=1,7
      CALL UNFORM(ICDRD,1)
      TABNUM=IWRDCT
      DO 102 LL=1,TABNUM
      TABVAR(LL,JJ)  =  NAMEA(LL)
      INDVAR(LL,JJ)  =  INDEXA(LL)
  102 CONTINUE
      WRDVNT(JJ)  =  TABNUM
  101 CONTINUE
 8750 FORMAT(1X,5A8)
 1011 FORMAT(1X,4A8)
 8101 FORMAT(A8)
 8031 FORMAT(1H0,'ERROR')
 8764 FORMAT(1H0,'THIS OPTION HAS NOT BEEN PROGRAMED YET')
      DO 1701 I=1,120
      IPOTAD(I)=100000
      IPOT(I)=100000
 1701 CONTINUE
      DO 1028 I=1,500
      READ(ICDRD,50,END=32)  NOPARM,PARVAL
   50 FORMAT  (I3,1X,G20.6)
      IF(NOPARM.EQ.304)  GO TO 2222
 1100 PARAM(NOPARM)=PARVAL
 1028 CONTINUE
 32   WRITE(ITTY,33)
   33 FORMAT('  END OF CARDS')
 2222 CONTINUE
      DO 9007 I=1,48
      CALL UNFORM(ICDRD,1)
      CALL FINDNM(K,J,1,&9007)
      NAMDAC(I)=J
      DACPLA(I)=K
      SCALDC(I)=FNUMA(1)
```

```
      IDAC(I)=INDEXA(1)
 9007 CONTINUE
      DO 1269 I=1,28
      CALL UNFORM(ICDRD,1)
      CALL FINDNM(K,J,1,&1269)
      NAMADC(I)=J
      ADCPLA(I)=K
      IADC(I)=INDEXA(1)
      SCALAC(I)=FNUMA(1)
 1269 CONTINUE
      CALL POTSET
      CALL SBPG4
 1689 CONTINUE
      DO 661 I=1,NCOM
 661  CONTINUE
C ***********************
C *                     *
C * INITIALIZATION PASS *
C *                     *
C ***********************
C         1 LOAD JDATE ARRAY
C         2 WRITE  TIME AND DATE
      CALL  IDATE(JDATE)
      CALL TIMDAT(JDATE,ITTY)
C**************************************************************************
C
C **************
C *            *
C * OPTION TEST * - ENTER A NAME FROM KEYBD (OPTEST)
C *            *
C **************
C
C         1 IF OPTEST IS AN OPTION KEYWORD PASS CONTROL TO OPTION EXECUTI
C         2 IF OPTEST IS AN OUTPUT KEYWORD PASS CONTROL TO OUTPUT ARRAY A
C         3 IF OPTEST IS IN THE ANAME ARRAY WRITE ITS PRESENT AND INITIAL
C         4 IF OPTEST IS EQUAL TO RESET  GO TO RESET ROUTINE
C         5 IF NONE OF THE ABOVE ENVOKE ERROR MONITOR
C
 8749 WRITE(ITTY,8754)
 8754 FORMAT(1H0,'OPTION')
      READ(KEYBD,1031) OPTEST
 1031 FORMAT(1A8)
 8450 CONTINUE
      LSTART=1
      LAST=80
      SELECT=OPTEST
      LVEC=1
      DO 8756 IOR=1,15
      IF(OPTION(IOR).EQ.OPTEST) GO TO 8758
 8756 CONTINUE
      IF(OPTEST.EQ.REMOVE) GO TO 8234
      IF(OPTEST.EQ.RESET) GO TO 8230
      IF(OPTEST.EQ.EXM) GO TO 8802
      DO 8765 IS=1,15
      IF(OPTEST.EQ.SELT(IS)) GO TO 720
 8765 CONTINUE
      GO TO 8768
C
C**************************************************************************
C
```

```
C ********************
C *                  *
C * OPTION EXECUTIVE * - CONTROL IS PASSED FROM OPTION TEST
C *                  *
C ********************
C     IF OPTEST IS EQUAL TO:
C        1 X - TRANSFER CONTROL TO EXECUTION REGION
C        2 IC - TRANSFER CONTROL TO EXECUTION REGION
C        3 OUTPUT - TRANSFER CONTROL TO OUTPUT ARRAY ASSEMBLER
C        4 TERM - TRANSFER CONTROL TO TERMINAL REGION
C        5 ADCA - ALTER ADC ARRAY
C        6 DACA - ALTER DAC ARRAY
C        7 F - FLOATING POINT OPERATIONS
C        8 I - INTEGER OPERATIONS
C        9 MES - SEND MESSAGE TO LINE PRINTER
C       10 TEST - EXECUTE TEST ROUTINE
C       11 RF-STR - RESTART FLIGHT PHASE SEQUENCER
C       12 IF NONE OF THE ABOVE RETURN TO OPTION TEST
 8758 CONTINUE
      IF(OPTEST.EQ.NX) GO TO 8802
      IF(OPTEST.EQ.NTERM) GO TO 8809
      IF(OPTEST.EQ.NIC) GO TO 8802
      IF(OPTEST.EQ.NRESR) GO TO 8888
C
      IF(OPTEST.NE.NADCA) GO TO 5000
C ##### --- ADC ROUTINE ---#####
      CALL ADCA(ADCNUM,NAMADC,IADC,SCALAC,ADCPLA,ITTY,KEYBD)
 5000 CONTINUE
      IF(OPTEST.NE.NII.AND.OPTEST.NE.NFF) GO TO 5010
C#####---ALTER OR READ DATA LIST ---#####
      CALL RDWRT(OPTEST)
 5010 CONTINUE
      IF(OPTEST.NE.NDACA) GO TO 5020
C #####---DAC ROURINE ---#####
      CALL DACA (DACNUM,NAMDAC,IDAC,SCALDC,DACPLA,ITTY,KEYBD)
 5020 CONTINUE
      IF(OPTEST.NE.NMES) GO TO`5035
C #####--- MESSAGE ROUTINE ---#####
      CALL MESRTN(ITTY,KEYBD,RETURN,LPTR)
 5035 CONTINUE
      IF(OPTEST.NE.NMULT) GO TO 5040
C#####--- MULTI RUN ---#####
      CALL MULTRN (ITTY,LOCAT,LOOPN,VALMR,FINLMP,ICT,IRUNS)
 5040 CONTINUE
      IF(OPTEST.NE.NTESTP) GO TO 5050
C#####--- TEST OPTION ---#####
      CALL TESTP(KEYBD,ITTY,NCOM,ORNAME,IORDER,RVALUE,RSVAL,REALT)
 5050 CONTINUE
      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')
```

```
      CALL UNFORM(5,1)
      DO 705 IOU=1,3
      IF(UNNAM(IOU).EQ.NAMEA(1)) GO TO 710
  705 CONTINUE
      WRITE(ITTY,715)
  715 FORMAT(1H ,'FOR UNIT ENTER  L (LIN PT), T (TELE), B (BOTH)')
      GO TO 720
  710 DO 725 MODE=1,4
      IF(MODENA(MODE).EQ.NAMEA(2)) GO TO 730
  725 CONTINUE
      WRITE(ITTY,735)
735   FORMAT(1H ,'FOR MODE ENTER  A (ALL), S (SING.), M (MULTI), XEQ (EX
     1ECUTION)')
      GO TO 720
  730 CONTINUE
C
 8215 CONTINUE
      IF(SELECT.NE.NLA) GO TO 2005
      CALL ARAST
 2005 CONTINUE
      IF(SELECT.NE.NTABLE) GO TO 2010
C#####--- TABLE SET UP ---#####
      CALL TABLES(ITTY,KEYBD)
 2010 CONTINUE
      IF(SELECT.NE.NTRACK) GO TO 2020
C#####--- TRACK ROUTINE ---#####
      CALL TRACKS(ITTY,KEYBD,DTIN)
 2020 CONTINUE
C#####--- SET UP OUTPUT NAME ARRAY ---#####
      IF(MODE.NE.2) GO TO 670
      OUTNAM(21)=OPTEST
      DEVICE(21)=IOU
      GO TO 8253
  670 DO 741 JJ=1,20
      IF(OUTNAM(JJ).EQ.OPTEST) GO TO 740
  741 CONTINUE
      DO 745 JJ=1,20
      IF(OUTNAM(JJ).EQ.BLANK) GO TO 740
  745 CONTINUE
  740 OUTNAM(JJ)=OPTEST
      IMODE(JJ)=MODE
      DEVICE(JJ)=IOU
      GO TO 8749
C#####--- REMOVE SINGLE VARIABLE ---#####
 8234 CONTINUE
      WRITE(ITTY,350)
  350 FORMAT(1H ,'WHAT')
      READ(KEYBD,1031) OPTEST
      DO 7350 I=1,20
      IF(OUTNAM(I).EQ.OPTEST) OUTNAM(I)=BLANK
 7350 CONTINUE
      GO TO 8749
C#####--- RESET OUTPUT NAME ARRAY ---#####
C
C     LOAD OUTPUT NAME ARRAY WITH BLANKS
 8230 DO 8231 I=1,20
      OUTNAM(I)=BLANK
 8231 CONTINUE
      GO TO 8749
C*********************************************************************
```

```
C
C *******************
C *                 *
C * EXECUTION REGION * - CONTROL IS TRANSFERED FROM OPTION EXECUTIVE
C *                 *
C *******************
 8802 CONTINUE
C        1 FILL BVALUE ARRAY WITH INITIAL CONDITIONS
C        2 SET POTS
C        3 SET DACS
C        4 EQUIVALENCE + STORE IC
C        5 IF REAL TIME IS CALLED ENTER FLAGE
C        6 WRITE TIME,DATE, AND RUN NUMBER
C        7 CHANGE AIALOG MODE
C     SAVHTP INIALIZED TO PARAM(129) AFTER ISN 10
      IF(OPTEST.EQ.NIC) GO TO 170
      LRUNS=LRUNS+1
      ITRUNS=ITRUNS+1
  170 CONTINUE
      IF(ICT.EQ.0.OR.OPTEST.NE.NXM) GO TO 165
      DO 160 I=1,ICT
      IF(LRUNS.LT.LOOPN(I)) GO TO 160
      KTEMP=LRUNS-LOOPN(I)
      BVALUE(LOCAT(I))=VALMR(I)+FLOAT(KTEMP)*FINLMR(I)
  160 CONTINUE
  165 CONTINUE
      IF(SAVHTP.EQ.PARAM(129)) GO TO 500
      CALL VHTPIC
      I=IFIX(PARAM(129))
      IF(I.EQ.0) I=7
      TABNUM = WRDVNT(I)
      DO 40  J=1,TABNUM
      NAMEA(J) = TABVAR(J,I)
      INDEXA(J) = INDVAR(J,I)
   40 CONTINUE
      DO 100 I=1,TABNUM
      CALL FINDNM(K,J,I,&100)
      ITABI(I)=INDEXA(I)
      ITNAM(I)=J
      ITABP(I)=K
  100 CONTINUE
  500 CONTINUE
      SAVHTP = PARAM(129)
      IF(REALT.GT..5) IRT=1
      RTSW=IFIX(REALT)
      IF(ICT.EQ.0.OR.OPTEST.NE.NXM) GO TO 155
      DO 150 I=1,ICT
      IF(LRUNS.LT.LOOPN(I)) GO TO 150
      KTEMP=LRUNS-LOOPN(I)
      BVALUE(LOCAT(I))=VALMR(I)+FLOAT(KTEMP)*FINLMR(I)
  150 CONTINUE
  155 CONTINUE
      CALL POTSET
      IF(REALT.LT..5) GO TO 75
      DO 1702 I=1,120
      IF(IPOT(I).EQ.IPOTAD(I)) GO TO 1702
      CALL POTCHK(I,IPOT(I),3,&8152,&8152)
      IPOTAD(I)=IPOT(I)
 1702 CONTINUE
   75 CONTINUE
```

```
      CALL SBPG4
      CALL SAMO(6,ISAMOE)
      IKEEP=ISAMP-1
      IDACK=0
      JIN=0
      IF(IOR.EQ.12) GO TO 8749
      CALL WAITEU (200)
      IF(LRUNS.GT.1) GO TO 1888
      CALL TIMDAT(JDATE,ITTY)
      CALL TIMDAT(JDATE,LPTR)
      WRITE(LPTR,9050) ITRUNS
      WRITE(ITTY,9050) ITRUNS
 9050 FORMAT(1H0,'RUN ',I3,' HAS STARTED'/1H0,
     1 'OUTPUT BELOW')
 1888 CONTINUE
      CALL CLOCK(NTIME1)
C
C
C#####--- ENTER REAL TIME PART ---#####
C     AT THIS POINT THE RTMON SUBPROGRAM IS ACTIVATED
C     RTMON INTURN EXECUTS THE MODLE
C
      IVHTP = PARAM(129) + .5
      CALL RTMON
      CALL CMPVAR
C     WHEN EXECUTION TAKES PLACE THE FOLLOWING TAKES PLACE:
C         1 REAL TIME PRECENT IS CALCULATED
C         2 CHANGE ANALOGE MODE
C         3 CALCULATE RUN MODE
C         4 EXECUTE SELECTED OUTPUTS FOR GIVEN MODE
C                 B MODE=3 FOR MULTI-RUN
C                 A MODE=1 FOR SINGLE RUN
C         5 IF MODE IS EQUAL TO TWO GO TO OPTION TEST
C         6 IF PROGRAM IS IN MULTI-RUN IRUNS IS GREATOR THAN LRUNS
C                 A INCREMENT VARIABLES SELECTED
C                 B EXECUTE NEXT RUN
C         7 END OF RUN LRUNS=0,ITRUNS=1
C         8 RETURN TO OPTION TEST
C
C
      CALL CLOCK(NTIME2)
      NRTIME=NTIME2-NTIME1
      IF(NRTIME.GT.1) RTPER= (TIME*10000.)/FLOAT(NRTIME)
      MODE=1
      IF(OPTEST.EQ.NXM) MODE=3
      DO 3210 I=1,48
      IF(I.EQ.19.OR.I.EQ.20) ITMP(I)=IOUT(I)
 3210 CONTINUE
      CALL LBDAFP(0C,47,DACO,ILBDAF)
      CALL TLDA
      EFF=0.0
      IF(ADOUT.NE.0.0) EFF=ANOUT/ADOUT
 8253 CONTINUE
      DO 8943 I=1,20
      IFP=1
      ILA=2
      IF(MODE.NE.2) GO TO 555
      CNAME=OUTNAM(21)
      IF(DEVICE(21).EQ.1) ILA=1
      IF(DEVICE(21).EQ.2) IFP=2
```

```
      I=20
      GO TO 550
  555 IF(IMODE(I).EQ.4) GO TO 560
      IF(IMODE(I).EQ.MODE) GO TO 560
      GO TO 8943
  560 CNAME=OUTNAM(I)
      IF(CNAME.EQ.BLANK) GO TO 8943
      IF(DEVICE(I).EQ.1) ILA=1
      IF(DEVICE(I).EQ.2) IFR=2
  550 CONTINUE
      DO 8946 K=IFR,ILA
      IF(K.EQ.1) MOPU=LPTR
      IF(K.EQ.2) MOPU=ITTY
      IF(CNAME.NE.NADCL) GO TO 3000
C #####--- LIST ADC ARRAY ---#####
      CALL LSTADC(ADCNUM,MOPU,NAMADC,IADC,SCALAC,ORNAME)
      GO TO 8946
 3000 CONTINUE
      IF(CNAME.NE.NDACL) GO TO 3010
C#####--- LIST DAC ARRAY ---#####
      CALL LSTDAC(DACNUM,MOPU,IDAC,SCALDC,NAMDAC,ORNAME)
      GO TO 8946
 3010 CONTINUE
      IF(CNAME.NE.NDUMP) GO TO 3020
C#####--- DUMP ---#####
      CALL DUMP (MOPU,NCOM,IORDER,ORNAME,BVALUE)
      GO TO 8946
 3020 CONTINUE
      IF(CNAME.NE.NIA) GO TO 3030
      CALL ARAWT(MOPU,BVALUE,ORNAME)
      GO TO 8946
 3030 CONTINUE
      IF(CNAME.NE.NNPC) GO TO 3040
      GO TO 8946
 3040 CONTINUE
      IF(CNAME.NE.NPLOT) GO TO 3050
      WRITE(ITTY,8764)
      GO TO 8946
 3050 CONTINUE
      IF(CNAME.NE.NSTAT) GO TO 3060
      WRITE(ITTY,8764)
      GO TO 8946
 3060 CONTINUE
      IF(CNAME.NE.NSTD) GO TO 3070
C#####--- STD OUTPUT ---#####
C#####--- STD OUTPUT ---#####
      WRITE(ITTY,2345) AXAVE,TIMDEC,CUVRAT,BETDMX,BETAMX,DELBET,
     1AYMAX,PHIMAX,RMAX,DEL,DELPSI,DSWMAX,TQFMAX,TQRMAX
 2345 FORMAT('0 AXAV=',F8.3,' DECL TIME=',F8.3,' AVCUR=',F8.3,' BTDMAX='
     1,F8.3,' BTMAX=',F8.3,' DELBT=',F8.3/
     1' AYMAX=',F8.3,' PHIMAX=',F8.3,' RMAX=',F8.3,' LANE CHNG DEL=',
     1F8.3,' DELPSI=',F8.3,' MAX STEER=',F8.3/
     1' FTRQMAX=',F8.3,' RTRQMAX=',F8.3/)
      GO TO 8946
 3070 CONTINUE
      IF(CNAME.NE.NTABLE) GO TO 3080
C#####--- TABLE OUTPUT ---#####
      CALL TABLEO(MOPU,ORNAME,LRUNS,ITRUNS,BVALUE)
      GO TO 8946
 3080 CONTINUE
```

```
      IF(CNAME.NE.NTESTO) GO TO 3085
C#####---TEST VALUE OUTPUT -----#####
      GO TO 8946
 3085 CONTINUE
      IF(CNAME.NE.NTIMD) GO TO 3090
C#####---DATE---#####
      CALL TIMDAT(JDATE,MOPU)
      GO TO 8946
 3090 CONTINUE
      IF(CNAME.NE.NT4) GO TO 3100
      CALL FRMONT(MOPU,ORNAME,NAMDAC,IDAC,PHIMAX)
      GO TO 8946
 3100 CONTINUE
      IF(CNAME.NE.NTRACK) GO TO 3110
C#####--- TRACK OUTPUT ---#####
      CALL TRACC(MOPU,ORNAME,DTIN)
      GO TO 8946
 3110 CONTINUE
 8946 CONTINUE
 8943 CONTINUE
      IF(MODE.EQ.2) GO TO 8749
      IF(OPTEST.EQ.NO) GO TO 8152
 8150 IF(IRUNS.EQ.LRUNS) GO TO 8152
      GO TO 8802
 8152 CONTINUE
      LRUNS=0
      GO TO 8749
C
C*******************************************************************************
C
C#####--- OPTION ERROR ---#####
 8768 CONTINUE
      WRITE(ITTY,8031)
      READ(KEYBD,8101) OPTEST
      IF(OPTEST.NE.QUES) GO TO 8450
      WRITE(ITTY,8762)
 8762 FORMAT(1H0,'OPTION NOT FOUND'/1H0,
     1'TO XEQ. PROGRAM          TYPE X'/1H0,
     1'TO TERMINATE PROGRAM     TYPE TERM'/1H0,
     1'FOR MULTIPLE RUNS        TYPE MULTI'/1H0,
     1'FOR TEST RUN OR ABEND    TYPE TEST'/1H0,
     1'TO ALTER DAC ARRAY       TYPE DACA'/1H0,
     1'TO ALTER ADC ARRAY       TYPE ADCA'/1H0,
     1'TO SET IC ONLY           TYPE IC'/1H0,
     1'TO SEND MESSAGE TO LP TYPE MES'/1H0,
     1'FOR TIME AND DATE                 TYPE T+D'/1H0,
     1'TO DUMP DATA LIST                 TYPE DUMP'/1H0,
     1'FOR STANDARD OUTPUT               TYPE STD'/1H0,
     1'FOR TEST VARIABLES                TYPE TESTO'/1H0,
     1'TO RESET   (NO OUTPUT)            TYPE RESET'/1H0,
     1'TO TRACK REAL TIME VARIABLES      TYPE TRACK'/1H0,
     1'FOR TABULAR OUTPUT                TYPE TABLE'/1H0,
     1'TO LIST DAC ARRAY                 TYPE DACL'/1H0,
     1'TO LIST ADC ARRAY                 TYPE ADCL'/1H0,
     1'FOR TERMINATION MONITOR           TYPE TM')
      GO TO 8749
C#####--- TERMINATE #####
 8809 OSFCB=0
      CALL TIMDAT(JDATE,ITTY)
      IF(IRT.NE.1) GO TO 5607
```

```
         CALL HPOST( DONECP,'J007' )
      CALL WAITRT(OSECB)
 5607 CONTINUE
      WRITE(ITTY,8821)
 8821 FORMAT(1H0,'PROGRAM TERMINATED')
      CALL RACN(1,IRACNE)
      CALL WRTOFF
      CALL RDOFF
      STOP
      END
```

## 2.1.2 SBPG4

PRESENTED HERE IS THE FORTRAN LISTING FOR THE INITIALIZATION SUBPROGRAM. THE FOLLOWING IS PERFORMED IN SBPG4:

1) Calculation of initial conditions using input data.

2) Initialization of digital-to-analog converters to their time = 0 values.

```
C     SUBROUTINE SBPG4
      SUBROUTINE SBPG4
C     THIS SUBROUTINE CALCULATES INITIAL CONDITIONS
      DIMENSION NAMFX(124),NAME(289)
      COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR
      COMMON/SPLTAX/SPSR3,CPSR3,SPSR4,CPSR4,SCR3,SCR4,TBCR3,TBCR4,TBSR3,
     1   TBSR4,TRSR3,TRSR4,TRCR3,TRCR4,PSR3,PSR4,IAX
      COMMON/PTBK/AP1,AP2,AP3,AP4,AP5,BTC1,BTC2
      COMMON/FEES/FEE1,FEE2,THE1,THE2
      COMMON/FRIDAY/BTVMAX,BTVTB(100)
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/EES/O1,O2,O3,E4,E5,E6
      COMMON/ALPHA/ALPH(20)
      COMMON/COMBLK/AIXP,SM,AIYP,AIXZP,GAM1,GAM2,GAM3,AIXBR,AIYBR,
     1     AIZBR,A1,A2,AIXZBR,A12,E1,E2,E3,DELTA,GV1,GV2,GP1,GP2,GR1,
     1     GR2,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,             ANGNL,ANGNLO
     1     ,TRO2,TFO2,TSO2,G,THRD,TWN7
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
     1   ANOUT,ADOUT
      COMMON/XX/IDAC(48),IADC(32)
      COMMON/INOUT/INA(32),IOUTA(48),IN(32),DACO(48),ISW1,ISW7,SFIN(32),
     1      SFOUT(48),IPRT,ITMP(48)
      COMMON/UVW/VC,UIN
      COMMON/XYZ/ NUMBR
      COMMON/OPSW/IBSW
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1     YO,ZO,THEO,PHIO,PSIO
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/MICKEY/IRUNTB(002),VTB(002),SNLTB(002),SNRTB(002),DSWTB(002
     1 ),BTTB(002),DTB(002),EFFTB(002),DYTB(002),PSITB (002),NRUN,
     1   YSPEC,PSIM,XPF
      COMMON/XBS/XB(15),NS(4,15),DELX(4),XI(4),NNN
      COMMON/NONAME/XEND,O,EXIT2
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTP,DEL,
     1               AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,
     1               TIMBMP,GETDL,TIMIN5,          TSTEP ,    IVHTP
      EQUIVALENCE
     1    (PARAM( 1),AMS)     , (PARAM( 2),AMUF)   , (PARAM( 3),AMUR)   ,
     1    (PARAM( 4),ZF)      , (PARAM( 5),ZR)     , (PARAM( 6),A)      ,
     1    (PARAM( 7),B)       , (PARAM( 8),TF)     , (PARAM( 9),TR)     ,
     1    (PARAM(10),IS)      , (PARAM(11),AIX)    , (PARAM(12),AIY)    ,
     1    (PARAM(13),AIZ)     , (PARAM(14),AIXZ)   , (PARAM(15),AIR)    ,
     1    (PARAM(16),CF)      , (PARAM(17),RF)     , (PARAM(18),CFP)    ,
     1    (PARAM(19),AKF)     , (PARAM(20),ALAMF)  , (PARAM(21),OFC)    ,
     1    (PARAM(22),OFT)     , (PARAM(23),CR)     , (PARAM(24),RR)     ,
     1    (PARAM(25),CRP)     , (PARAM(26),AKR)    , (PARAM(27),ALAMR)  ,
     1    (PARAM(28),ORC)     , (PARAM(29),ORT)    , (PARAM(30),AKRS)   ,
     1    (PARAM(31),RW)                           , (PARAM(33),OI)     ,
     1    (PARAM(34),CA0)     , (PARAM(35),CA1)    , (PARAM(36),CA2)    ,
     1    (PARAM(37),CA3)     , (PARAM(38),CA4)    , (PARAM(39),AISW)   ,
     1    (PARAM(44),AKDL)    , (PARAM(41),AKSC)   , (PARAM(42),ANG)    ,
     1    (PARAM(43),WG)      , (PARAM(40),ANL2)   , (PARAM(45),AKSL)
      EQUIVALENCE
     1    (PARAM(46),ANL1)    , (PARAM(47),AIFW)   , (PARAM(48),HDL)    ,
     1    (PARAM(49),AIWF)    , (PARAM(50),AIWR)   , (PARAM(51),AID)    ,
     1    (PARAM(52),ARBR)    , (PARAM(53),EPS1)   , (PARAM(54),EPS2)   ,
```

```
1    (PARAM(55),PTBR)      , (PARAM(56),YSA1)    , (PARAM(57),YSA2)     ,
1    (PARAM(58),YHS1)      , (PARAM(59),YHS2)    , (PARAM(60),AKD)      ,
1    (PARAM(61),TQDBR)     , (PARAM(62),AK)      , (PARAM(63),PIN)      ,
1    (PARAM(64),QIN)       , (PARAM(65),RIN)     , (PARAM(66),UIZ)      ,
1    (PARAM(67),VIN)       , (PARAM(68),WIN)     , (PARAM(69),XIN)      ,
1    (PARAM(70),YIN)       , (PARAM(71),ZIN)     , (PARAM(72),THEIN)    ,
1    (PARAM(73),PHIIN)     , (PARAM(74),PSIIN)   , (PARAM(75),DTIN)     ,
1    (PARAM(76),TEND)      , (PARAM(77),AKT1)    , (PARAM(78),AKT2)     ,
1    (PARAM(79),AKT3)      , (PARAM(80),AKT4)    , (PARAM(81),RPS1)     ,
1    (PARAM(82),RPS2)      , (PARAM(83),RPS3)    , (PARAM(84),RPS4)     ,
1    (PARAM(85),B1)        , (PARAM(86),B2)      , (PARAM(87),B3)
 EQUIVALENCE
1 (PARAM(88),B4),           (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),
1  (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN),
1    (PARAM( 94),DEL3IN), (PARAM( 95),PHIDN), (PARAM(96),PHIRN) ,
1    (PARAM( 97),DFW1IN), (PARAM( 98),DFW2IN),(PARAM( 99),U1PIN),
1    (PARAM(100),U2PIN),   (PARAM(101),U3PIN), (PARAM(102),U4PIN),
1    (PARAM(103),S1PIN),   (PARAM(104),S2PIN), (PARAM(105),S3PIN),
1    (PARAM(106),S4PIN), (PARAM(107),PPRT)
1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)
1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),
1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)
1  ,(PARAM(119),TQRBR),(PARAM(120),TQFBR)
1  ,(PARAM(121),PFL),(PARAM(122),TTD),(PARAM(123),DSW)
1    ,(PARAM(124),TSW)
 EQUIVALENCE
   (PARAM(130),AMCR),(PARAM(131),ESP),(PARAM(132),AKSL1),
1  (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),
1  (PARAM(136),CCR),(PARAM(137),CFCP),(PARAM(138),AP),
1  (PARAM(139),EP1),(PARAM(140),EP2),(PARAM(141),ERR1),
1  (PARAM(142),ERR2),
1  (PARAM(143),AML1),(PARAM(144),AML2),(PARAM(145),BRIM),
1    (PARAM(146),BWR),
1      (PARAM(196),EPSK1),(PARAM(197),EPSK2)
 EQUIVALENCE
1    (PARAM(284),HFC),(PARAM(285),HRC)
 EQUIVALENCE
1    (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),
1    (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)
 EQUIVALENCE
1(PARAM(296),DFL1DT),(PARAM(297),DEL2DT),(PARAM(298),DEL3DT),
1(PARAM(299),DEL1),(PARAM(300),DEL2),(PARAM(301),DEL3),
1(PARAM(302),PHIRD),(PARAM(303),PHIP),(PARAM(304),DELFW1),
1(PARAM(305),DELFW2),(PARAM(306),U1P),(PARAM(307),U2P),
1(PARAM(308),U3P),(PARAM(309),U4P),(PARAM(310),S1P),
1(PARAM(311),S2P),(PARAM(312),S3P),(PARAM(313),S4P),
1(PARAM(314),QUAN1),(PARAM(315),QUAN2),(PARAM(316),QUAN3),
1(PARAM(317),QUAN4),(PARAM(318),ARPS1),(PARAM(319),ARPS2),
1(PARAM(320),WSTH1),(PARAM(321),WCTH1),(PARAM(322),WSTH2),
1(PARAM(323),WCTH2),(PARAM(324),IOUT(1))
 EQUIVALENCE (NAME(172),NAMEX(1))
 EQUIVALENCE (PHIRD,DFL4DT),(PHIP,DEL4)
 DATA NAME/'  MS','  MUF',' MUR','  ZF','  ZR','   A','   B','  TF',
1    '  TR','  TS','  IX','  IY','  IZ',' IXZ','  IP','  CF','  FF',
1    'CFPR','  KF','LAMF','OMFC','OMFT','  CR','  RR','CRPR','  KR',
1    'LAMR','OMIC','OMRT',' KRS','  RW','    ',' FOT','  A0','  A1',
1    '  A2','  A3','  A4','    ','    ',' KSC','  NG','LAFC','LAFT',
1    'LARC','LART',' IFW','    ',' IHF',' IWR','  ID','  AR','    ',
1    '    ','  FT','YSA1','YSA2','PHS1','PHS2','CTSW','    ','    ',
1    'P-IN','Q-IN','R-IN','U-IN','V-IN','W-IN','X-IN','Y-IN','Z-IN',
```

```
     1    'THIN','PHIN','PSIN','  DT','  TN',' KT1',' KT2',' KT3',' KT4',
     1    'RPS1','RPS2','RPS3','RPS4','  B1','  B2','  B3','  B4','D1DT',
     1    'D2DT','D3DT','DELF','DELR','DEL3','PHDT','PHIR','DFW1','DFW2',
     1    'U1PR','U2PR','U3PR','U4PR','S1PR','S2PR','S3PR','S4PR','PPRT',
     1    '    ','    ','TQMX',' KTQ','  VC','MTSW','DSWM',' TST','DSLP',
     1    'CGAM','  CS','    ','    ',' PFL','  T1',' DSW',' TSW','ISW5',
     1    'SW15',
     1    'PQSW','VTPS','VHTP','AMCR',' ESP','KSL1','KSL2',' AA1',' AA2',
     1    ' CCR','CFCP','  AP',' EP1',' EP2','ERR1','ERR2','AML1','AML2',
     1    'RRIM','    ','    ','    ','    ','    ','    ','    ','    ',
     1    '    ','    ','    ','    ','    ','    ','    ','    ','    ',
     1    '    ','    ','    ','    ','    ','    ',' SNT','SNSO','SNS1'/
      DATA NAMEX
     1  /'SNSW','DIST',' PL ','TSCP','    ','    ','    ','    ','PAST',
     1    '    ',' SI1',' SI2',' SI3',' SI4','    ','    ','    ',
     1    '    ','    ','    ','MTQB','DRSW',' LDF','LDRF',' EK1',' EK2',
     1    'BMPL','BMPS','BMPH','  XB','APF1','APF2','APR1','APR2','MUSF',
     1    'MUSR','    ','    ','    ','    ','    ','    ','    ','    ',
     1    '    ','    ','    ','FEE1','FEE2','THE1','THE2','    ','    ',
     1    '    ','    ','    ','    ','    ','    ','  H1','  H2','    ',
     1    'AKF1','AKF2','AKF3','AKF4',' BR1',' BR2',' BR3',' BR4',
     1    ' KCF',' KCR',' KSR',' RB1',' RB2',' RB3',' RB4','AFK1','AFK2',
     1    'AFK3','ARK1','ARK2','ARK3','OFC0','OFC1','OFC2','OFC3','ORC0',
     1    'ORC1','ORC2','ORC3','CP0F','CP1F','CP2F','CP0R','CP1R','CP2R',
     1    'CR0F','CR1F','CR2F','CR0R','CR1R','CR2R','    ','    ','BMPN',
     1    'TQB0','TQB1','    ','    ','    ','    ',' HFC',' HRC','    ',
     1    'AXLE','    ','    ','ROT','RA0','RA1','RA2','RA3','RA4'/
      EQUIVALENCE (COMPVR(1),AXAVE)
      DIMENSION COMPVR(17)
      DATA RAD/0.1745329E-1/
      REAL*4 IOUT(48),IN,ITMP,SCALAC(28),SCALDC(48)
      INTEGER*2   RTSW  ,RBSW  ,LDTSW ,CPEN  ,OPDN
  960 FORMAT('1  PARAMETER VALUES - MODEL C - ',20A4,/
     1   (' ',5(I4,3X,A4,'=',G12.5,',')))
C     VHTP COMPARISON VARIABLE INITIALIZATION
      DO 21 I=1,19
      COMPVR(I) = 0.
   21 CONTINUE
      TSTEP = DTIN
      NUMBR = 0
      DO 20 I=1,4
      DELX(I) = 0.
   20 CONTINUE
      IVHTP = PARAM(129) + .5
      TQFMAX=-1.E20
      TQRMAX=-1.E20
      AP1=PARAM(055)
      AP2=PARAM(213)
      AP3=PARAM(214)
      AP4=PARAM(215)
      AP5=PARAM(216)
      BTC1=PARAM(217)
      BTVMAX=-1.E20
      BTC2=PARAM(218)
      FEE1=PARAM(219)*.01745329
      FEE2=PARAM(220)*.01745329
      PSIMAX=-1.E20
      THE1=PARAM(221)*.01745329
      THE2=PARAM(222)*.01745329
      PSIM=PSIIN*RAD
```

```
      XEND=TEND
         EXIT2  = 10.0*5280.0*12.0/3600.0
      TIME25=0.0
      TIME10=0.0
      O1=-6.0E-6
      O2=0.009
      O3=0.0001
      E4=-0.16
      E5=-0.46
      E6=10.4
      ANUMO=0.0
      ADENO=0.0
      RMAX=-1.E20
      PSI5=0.0
      DSWMAX=-1.E20
      PHIMAX=-1.E20
      ETAMAX=-1.E20
      DEL1DT=DEL1DN
      DEL2DT=DEL2DN
      DEL3DT=DEL3DN
      DEL1=0.0
      DEL2=0.0
      DEL3=DEL3IN
      PHIRD=PHIDN*RAD
      PHIR=PHIRN*RAD
      DELFW1=DFW1IN*RAD
      DELFW2=DFW2IN*RAD
      U1P=U1PIN
      U2P=U2PIN
      U3P=U3PIN
      U4P=U4PIN
      S1P=S1PIN
      S2P=S2PIN
      S3P=S3PIN
      S4P=S4PIN
      QUAN1=0.0
      QUAN2=0.0
      QUAN3=0.0
      QUAN4=0.0
      F1F1=CFP*SIGN(1.,DEL1DT)
      F1F2=CFP*SIGN(1.,DEL2DT)
      IF(DEL1.LT.OFC) GO TO 1
      IF(DEL1.GT.OFT) GO TO 2
      F2F1=AKF*DEL1
      GO TO 3
    1 F2F1=AKF*(ALAMF*DEL1-(ALAMF-1.)*OFC)
      GO TO 3
    2 F2F1=AKF*(ALAMF*DEL1-(ALAMF-1.)*OFT)
    3 IF(DEL2.LT.OFC) GO TO 4
      IF(DEL2.GT.OFT) GO TO 5
      F2F2=AKF*DEL2
      GO TO 6
    4 F2F2=AKF*(ALAMF*DEL2-(ALAMF-1.0)*OFC)
      GO TO 6
    5 F2F2=AKF*(ALAMF*DEL2-(ALAMF-1.)*OFT)
    6 S1P=-CF*DEL1DT-F1F1-F2F1+(RF*(DEL2-DEL1))/TF**2
      S2P=-CF*DEL2DT-F1F2-F2F2-(RF*(DEL2-DEL1))/TF**2
      IF( PARAM(287).EQ.2. ) GO TO 106
      ZETA3=TS*PHIR/2.+DEL3
      ZETA3D=TS*PHIRD/2.+DEL3DT
```

```
      ZETA4=-ZETA3+2.*DEL3
      ZETA4D=-ZETA3D+2.*DEL3DT
      GO TO 15
  106 ZETA3=DEL3
      ZETA4=DEL4
      ZETA3D=DEL3DT
      ZETA4D=DEL4DT
   15 CONTINUE
      IF(ZETA3.LT.OBC)GO TO 7
      IF(ZETA3.GT.OBT)GO TO 8
      F2R3=AKR*ZETA3
      GO TO 9
    7 F2R3=AKR*(ALAMR*ZETA3-(ALAMR-1.)*OBC)
      GO TO 9
    8 F2R3=AKR*(ALAMR*ZETA3-(ALAMR-1.)*OBT)
    9 IF(ZETA4.LT.OBC)GO TO 10
      IF(ZETA4.GT.OBT)GO TO 11
      F2R4=AKR*ZETA4
      GO TO 12
   10 F2R4=AKR*(ALAMR*ZETA4-(ALAMR-1.)*OBC)
      GO TO 12
   11 F2R4=AKR*(ALAMR*ZETA4-(ALAMR-1.)*OBT)
   12 F1R3=CRP*SIGN(1.,ZETA3D)
      F1R4=CRP*SIGN(1.,ZETA4D)
      IF(PARAM(287).EQ.2.) GO TO 13
      S3P=-CR*ZETA3D-F1R3-F2R3-RR*PHIR/TS
      S4P=-CR*ZETA4D-F1R4-F2R4+RR*PHIR/TS
      GO TO 14
   13 S3P=-CR*ZETA3D-F1R3-F2R3+(RR/TR**2)*(DEL4-DEL3)
      S4P=-CR*ZETA4D-F1R4-F2R4-(RR/TR**2)*(DEL4-DEL3)
   14 CONTINUE
      P=PIN*RAD
      PO=P
      Q=QIN*RAD
      QO=Q
      R=RIN*RAD
      RO=R
      U=UIN
      UO=U
      V=VIN
      VO=VIN
      W=WIN
      WO=WIN
      X=XIN
      XO=XIN
      Y=YIN
      YO=YIN
      Z=ZIN
      ZO=ZIN
      THE=THEIN*RAD
      THEO=THE
      PHI=PHIIN*RAD
      PHIO=PHI
      PSI=PSIIN*RAD
      PSIO=PSI
      IF(PPRT.NE.0.0) WRITE (LPTR,960) (ALPH(I),I=1,20),((K,NAMP(K),
     1 PARAM(K)),K=1,N1)
  940 FORMAT(10G12.5)
      TIME=0.0
      JJTIME=0
```

```
      DT=0.0                                                            SBPG3000
  998 FORMAT('0',8E15.6)                                                SBPG3010
      IHSW=0                                                            SBPG3020
      XB(1)=PARAM(201)                                                  SBPG3030
      NBMP=PARAM(277)+0.5                                               SBPG3040
      IF(NBMP.LT.2) GO TO 4321                                          SBPG3050
      DO 5432 I=2,NBMP                                                  SBPG3060
      XB(I)=XB(I-1)+PARAM(199)                                          SBPG3070
 5432 CONTINUE                                                          SBPG3080
 4321 CONTINUE                                                          SBPG3090
      CALL SBPG22                                                       SBPG3100
      CALL LBDAFP(00,47,DACO,ILPERR)                                    SBPG3110
      CALL TLDA                                                         SBPG3120
      DO 6240 I=1,48                                                    SBPG3130
      ITMP(I) = DACO(I)                                                 SBPG3140
 6240 CONTINUE                                                          SBPG3150
      CALL STCO(1,ISTCOE)                                               SBPG3160
      DT=DTIN                                                           SBPG3170
      ISW1=0                                                            SBPG3180
      ISW7=0                                                            SBPG3190
      RETURN                                                            SBPG3200
      END                                                               SBPG3210
```

### 2.1.3 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.

3) Calculation of analog-to-digital converter scale factors.

```
C     SUBROUTINE POTSET
      SUBROUTINE POTSET
C     THIS SUBROUTINE CALCULATES VALUES FOR POTENTIOMETER SETTINGS
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR
      COMMON/HHHH/H1,H2,H3,H4
      COMMON/SPLTAX/SPSR3,CPSR3,SPSR4,CPSR4,SCR3,SCR4,TBCR3,TBCR4,TBSR3,
     1   TBSR4,TRSR3,TRSR4,TRCR3,TRCR4,PSR3,PSR4,IAX
      COMMON/CLEAN/ONEOA,ONEOD
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1    YO,ZO,THEO,PHIO,PSIO
      COMMON/ZILCH/TQMAXP,AKTQP
      COMMON/INOUT/INA(32),IOUTA(48),IN(32),DACO(48),ISW1,ISW7,SFIN(32),
     1     SFOUT(48),IPRT,ITMP(48)
      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
     1   ANOUT,ADOUT
      COMMON/COMBLK/AIXP,SM,AIYP,AIXZP,GAM1,GAM2,GAM3,AIXBR,AIYBR,
     1    AIZBR,A1,A2,AIXZBR,A12,E1,E2,E3,DELTA,GV1,GV2,GP1,GP2,GR1,
     1    GR2,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,               ANGNL,ANGNLO
     1    ,TRO2,TFO2,TSO2,G,THRD,TWN7
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/UVW/VC,UIN
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      EQUIVALENCE
     1    (PARAM( 1),AMS)     , (PARAM( 2),AMUF)   , (PARAM( 3),AMUR)   ,
     1    (PARAM( 4),ZF)      , (PARAM( 5),ZR)     , (PARAM( 6),A)      ,
     1    (PARAM( 7),B)       , (PARAM( 8),TF)     , (PARAM( 9),TR)     ,
     1    (PARAM(10),TS)      , (PARAM(11),AIX)    , (PARAM(12),AIY)    ,
     1    (PARAM(13),AIZ)     , (PARAM(14),AIXZ)   , (PARAM(15),AIE)    ,
     1    (PARAM(16),CF)      , (PARAM(17),RF)     , (PARAM(18),CFP)    ,
     1    (PARAM(19),AKF)     , (PARAM(20),ALAMF)  , (PARAM(21),OFC)    ,
     1    (PARAM(22),OFT)     , (PARAM(23),CR)     , (PARAM(24),RR)     ,
     1    (PARAM(25),CRP)     , (PARAM(26),AKR)    , (PARAM(27),ALAMR)  ,
     1    (PARAM(28),ORC)     , (PARAM(29),ORT)    , (PARAM(30),AKFS)   ,
     1    (PARAM(31),RW)                           , (PARAM(33),OT)     ,
     1    (PARAM(34),CA0)     , (PARAM(35),CA1)    , (PARAM(36),CA2)    ,
     1    (PARAM(37),CA3)     , (PARAM(38),CA4)    , (PARAM(39),AISW)   ,
     1    (PARAM(44),AKDL)    , (PARAM(41),AKSC)   , (PARAM(42),ANG)    ,
     1    (PARAM(43),WG)      , (PARAM(40),ANL2)   , (PARAM(45),AKSL)
      EQUIVALENCE
     1    (PARAM(46),ANL1)    , (PARAM(47),AIFW)   , (PARAM(48),HDL)    ,
     1    (PARAM(49),AIWF)    , (PARAM(50),AIWR)   , (PARAM(51),AID)    ,
     1    (PARAM(52),ARBR)    , (PARAM(53),EPS1)   , (PARAM(54),EPS2)   ,
     1    (PARAM(55),DTRR)    , (PARAM(56),YSA1)   , (PARAM(57),YSA2)   ,
     1    (PARAM(58),YHS1)    , (PARAM(59),YHS2)   , (PARAM(60),ABD)    ,
     1    (PARAM(61),TQDBR)   , (PARAM(62),AF)     , (PARAM(63),PIN)    ,
     1    (PARAM(64),QIN)     , (PARAM(65),RIN)    , (PARAM(66),UIZ)    ,
     1    (PARAM(67),VIN)     , (PARAM(68),WIN)    , (PARAM(69),XIN)    ,
     1    (PARAM(70),YIN)     , (PARAM(71),ZIN)    , (PARAM(72),THEIN)  ,
     1    (PARAM(73),PHIIN)   , (PARAM(74),PSIIN)  , (PARAM(75),DTIN)   ,
     1    (PARAM(76),TEND)    , (PARAM(77),AKT1)   , (PARAM(78),AKT2)  ,
     1    (PARAM(79),AKT3)    , (PARAM(80),AKT4)   , (PARAM(81),RPS1)  ,
     1    (PARAM(82),RPS2)    , (PARAM(83),RPS3)   , (PARAM(84),RPS4)   ,
     1    (PARAM(85),B1)      , (PARAM(86),B2)     , (PARAM(87),B3)
      EQUIVALENCE
     1 (PARAM(88),B4),          (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),
     1  (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN),
     1    (PARAM( 94),DEL3TN), (PARAM( 95),PHIDN), (PARAM(96),PHIPN),
     1    (PARAM( 97),DFW1IN), (PARAM( 98),DFW2IN),(PARAM( 99),U1PIN),
     1    (PARAM(100),U2PIN),  (PARAM(101),U3PIN), (PARAM(102),U4PIN),
```

```
     1   (PARAM(103),S1PIN),  (PARAM(104),S2PIN), (PARAM(105),S3PIN),         POTS 600
     1   (PARAM(106),S4PIN), (PARAM(107),PPRT)                                POTS 610
     1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)                 POTS 620
     1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),                 POTS 630
     1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)                     POTS 640
     1  ,(PARAM(119),TQRBR),(PARAM(120),TQFBR)                                POTS 650
     1  ,(PARAM(121),PFL),(PARAM(122),TTD),(PARAM(123),DSW)                   POTS 660
     1    ,(PARAM(124),TSW)                                                   POTS 670
      EQUIVALENCE                                                             POTS 680
     1  (PARAM(130),AMCR),(PARAM(131),ESP),(PARAM(132),AKSL1),                POTS 690
     1  (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),                 POTS 700
     1  (PARAM(136),CCR),(PARAM(137),CFCR),(PARAM(138),AP),                   POTS 710
     1  (PARAM(139),EP1),(PARAM(140),EP2),(PARAM(141),ERR1),                  POTS 720
     1  (PARAM(142),ERR2),                                                    POTS 730
     1  (PARAM(143),AML1),(PARAM(144),AML2),(PARAM(145),RPIM),                POTS 740
     1   (PARAM(146),RWR)                                                     POTS 750
     1   ,(PARAM(196),EPSK1),(PARAM(197),EPSK2)                               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),ANL),(PARAM(234),AKF1),                 POTS 810
     1  (PARAM(235),AKF2),(PARAM(236),AKR3),(PARAM(237),AKR4)                 POTS 820
      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                                                             POTS 880
     1(PARAM(296),DEL1DT),(PARAM(297),DEL2DT),(PARAM(298),DEL3DT),            POTS 890
     1(PARAM(299),DEL1),(PARAM(300),DEL2),(PARAM(301),DEL3),                  POTS 900
     1(PARAM(302),PHIRD),(PARAM(303),PHIR),(PARAM(304),DELFW1),               POTS 910
     1(PARAM(305),DELFW2),(PARAM(306),U1P),(PARAM(307),U2P),                  POTS 920
     1(PARAM(308),U3P),(PARAM(309),U4P),(PARAM(310),S1P),                     POTS 930
     1(PARAM(311),S2P),(PARAM(312),S3P),(PARAM(313),S4P),                     POTS 940
     1(PARAM(314),QUAN1),(PARAM(315),QUAN2),(PARAM(316),QUAN3),               POTS 950
     1(PARAM(317),QUAN4),(PARAM(318),ARPS1),(PARAM(319),ARPS2),               POTS 960
     1(PARAM(320),WSTH1),(PARAM(321),WCTH1),(PARAM(322),WSTH2),               POTS 970
     1(PARAM(323),WCTH2),(PARAM(324),IOUT(1))                                 POTS 980
      REAL*4 IOUT(48)                                                         POTS 990
      DATA             T/10000.0/                                             POTS1000
C     N1 , N2 EQUATED TO THEIR VALUES IN MAIN                                 POTS1010
      IAX=PARAM(287)+0.5                                                      POTS1020
      PSR3=PARAM(288)*.0174533                                                POTS1030
      PSR4=PARAM(289)*.0174533                                                POTS1040
      SPSR3=(TAN(2.0*HFC/TF))*2.0/AMUF                                        POTS1050
      SPSR4=(TAN(2.0*HRC/TR))*2.0/AMUF                                        POTS1060
      CPSR3=COS(PSR3)                                                         POTS1070
      CPSR4=COS(PSR4)                                                         POTS1080
      SCR3=SPSR3*CPSR3                                                        POTS1090
      SCR4=SPSR4*CPSR4                                                        POTS1100
      TMP=2.0*B/TS                                                            POTS1110
      TBSR3=TMP*SPSR3                                                         POTS1120
      TBSR4=TMP*SPSR4                                                         POTS1130
      TBCR3=TMP*CPSR3                                                         POTS1140
      TBCR4=TMP*CPSR4                                                         POTS1150
      TMP=TR/TS                                                               POTS1160
      TRSR3=TMP*SPSR3                                                         POTS1170
      TRSR4=TMP*SPSR4                                                         POTS1180
      TRCR3=TMP*CPSR3                                                         POTS1190
```

```
      TRCR4=TMP*CPSR4
      SM=AMS+AMUF+AMUR
      UIN=UIZ*12.0*5280.0/3600.0
      VC=VCIN*12.0*5280.0/3600.0
      ISW7=1
      IPRT=PARAM(108)+0.5
      TWO3=2.0/3.0
      HUN=0.01
      TOU=0.001
      TTO=0.0001
      G=386.4
      THRD=1.0/3.0
      TWN7=1.0/27.0
      H1=RW-(AMUF+B*AMS/(A+B))*G/(2.*AKT1)
      H2=RW-(AMUF+B*AMS/(A+B))*G/(2.*AKT2)
      H3=RW-(AMUR+A*AMS/(A+B))*G/(2.*AKT3)
      H4=RW-(AMUR+A*AMS/(A+B))*G/(2.*AKT4)
      ZIN=(B*(H1+ZF)+A*(H3+ZR))/(A+B)*(-1.)
      THEIN=(H1-H3+ZF-ZR)/(A+B)*57.29578
      AIBR=AIWR+AID*ARBR**2*0.25
      AIBRP=AIBR-AIWR
      TOO=0.0
      RPS1=UIN/H1
      RPS2=UIN/H2
      RPS3=UIN/H3
      RPS4=UIN/H4
      TFO2=TF*0.5
      TSO2=TS/2.0
      TRO2=TR*0.5
      AIXP=AMUF*ZF*ZF+AMUR*ZR*ZR
      AIYP=AIXP
      AIZP=AMUF*(A*A+TFO2**2)+AMUR*B*B + AIR
      IF(IAX.EQ.1) GO TO 30
      AIZP=AIZP+AMUR*TRO2**2 - AIR
   30 AIXZP=AMUF*A*ZF-AMUR*B*ZR
      GAM1=AMUF*A-AMUR*B
      GAM2=AMUF*ZF+AMUR*ZR
      GAM3=GAM2
      AIXBR=AIX+AIXP
      AIYBR=AIY+AIYP
      AIZBR=AIZP +AIZ
      A1=GAM2/SM
      A2=AIYBR/GAM2
      AIXZBR=AIXZP+AIXZ
      CA23=CA2*CA3
      A12=A1-A2
      E1=AIXBR*AIZBR-AIXZBR**2
      E2=GAM1*AIXZBR-GAM3*AIZBR
      E3=GAM3*AIXZBR-GAM1*AIXBR
      DELTA=E1*SM+GAM2*E2+GAM1*E3
      GV1=GAM2*AIZBR-GAM1*AIXZBR
      GV2=GAM2*AIXZBR-GAM1*AIXBR
      GP1=SM*AIZBR-GAM1**2
      GP2=SM*AIXZBR-GAM1*GAM3
      GR1=GP2
      GR2=SM*AIXBR-GAM2*GAM3
      CIP=B*AMS*G/(AMUF*(A+B))+G
      TQMAXP=TQMAX*ARBR*0.5
      AKTQP=AKTQ*ARBR*0.5
      CIVP=A*AMS*G/(AMUR*(A+B))+G
```

```
      PZF=RW+ZF                                                         POTS1800
      RZR=RW+ZR                                                         POTS1810
      A2T= OT*CA2                                                       POTS1820
      CA20=CA0*CA2                                                      POTS1830
      ONEOA=1.0/A12                                                     POTS1840
      ONEOD=1.0/DELTA                                                   POTS1850
      IPOT(01 )=T*PARAM(175)/AMS                                        POTS1860
      IPOT(02 )=(2.0/(10.0*AMUF))*T*PARAM(175)                          POTS1870
      IPOT(04 )=(HUN*RF/(TF*TF))*T*0.1                                  POTS1880
      IPOT(03 )=IPOT(04 )                                               POTS1890
      IPOT(05)=(2.0*AKT2/(5000.0*AMUF))*T/1.0*PARAM(175)                POTS1900
      IPOT(06 )=T*PARAM(175)/AMS                                        POTS1910
      IPOT(07 )=IPOT(02 )                                               POTS1920
      IPOT(14)=RF/(TF*TF*100.0)*T*0.1                                   POTS1930
      IPOT(10 )=(AKT3/(5000.0*AMUR))*T*PARAM(175)                       POTS1940
      IPOT(11 )=(AKT4/(5000.0*AMUR))*T*PARAM(175)                       POTS1950
      IPOT(12 )=T*PARAM(175)/AMS                                        POTS1960
      IPOT(13 )=(0.1/AMUR)*T*PARAM(175)                                 POTS1970
      IPOT(09 )=IPOT(13 )                                               POTS1980
      IPOT(08)=RF/(TF*TF*100.0)*T *0.1                                  POTS1990
      IPOT(16 )=TOU*CFP*T                                               POTS2000
      IPOT(19 )=.1*TOU*2.0*CFP*T                                        POTS2010
      IPOT(21)=PARAM(175)*T                                             POTS2020
      IPOT(22 )=IPOT(16 )                                               POTS2030
      IPOT(24 )=IPOT(19 )                                               POTS2040
      IPOT(25)=PARAM(175)*T                                             POTS2050
      IPOT(27 )=TOU*CRP*T                                               POTS2060
      IPOT(28)=PARAM(175)*T                                             POTS2070
      IPOT(29 )=.1*TOU*2.0*CRP*T                                        POTS2080
      IPOT(31)=PARAM(175)*T                                             POTS2090
      IPOT(32)=(2.0*AKT1/(5000.0*AMUF))*T/1.0*PARAM(175)                POTS2100
      IPOT(33)=PARAM(175)*T                                             POTS2110
      IPOT(49 )=IPOT(27 )                                               POTS2120
      IPOT(51 )=(60.0*AKT1/(10000.0*AIWF))*T*PARAM(175)                 POTS2130
      IPOT(52 )=(4.0/AIWF)*T*PARAM(238)*PARAM(175)                      POTS2140
      IPOT(54 )=IPOT(29 )                                               POTS2150
      IPOT(60)  =(AKF/1000.)*T                                          POTS2160
      IPOT(61)  =(AKF/1000.)*T                                          POTS2170
      IPOT(62)  =(AKF/1000.)*T                                          POTS2180
      IPOT(63)  =(AKF/1000.)*T                                          POTS2190
      IPOT(83 )=(60.0*AKT4/(10000.0*AIBR))*T*PARAM(175)                 POTS2200
      IPOT(086)=0.2000*T                                                POTS2210
      IPOT(87 )=0.1333*T                                                POTS2220
      IPOT(88 )=(RW/15.0)*T                                             POTS2230
      IPOT(92)=57.3/200.*T*PARAM(175)                                   POTS2240
      IPOT(096)=0.2000*T                                                POTS2250
      IPOT(97)=IPOT(92)                                                 POTS2260
      IPOT(98 )=IPOT(88 )                                               POTS2270
      IPOT(99 )=IPOT(87 )                                               POTS2280
      IPOT(100)=2.*IPOT(92)                                             POTS2290
      IPOT(101)=HUN*RPS1*T                                              POTS2300
      IPOT(102)=(60.0*AKT2/(10000.0*AIWF))*T*PARAM(175)                 POTS2310
      IPOT(103)=(4.0/AIWF)*T*PARAM(239)*PARAM(175)                      POTS2320
      IPOT(104)=HUN*RPS2*T                                              POTS2330
      IPOT(105)=2.*IPOT(97)                                             POTS2340
      IPOT(106)=0.2*T                                                   POTS2350
      IPOT(107)=IPOT(87 )                                               POTS2360
      IPOT(108)=IPOT(88 )                                               POTS2370
      IPOT(110)=HUN*RPS3*T                                              POTS2380
      IPOT(111)=(4.0/AIBR)*T*PARAM(241)*PARAM(175)                      POTS2390
```

```
      IPOT(112)=(4.0/AIBR)*T*PARAM(240)*PARAM(175)                      POTS2400
      IPOT(113)=(60.0*AKT3/(10000.0*AIBR))*T*PARAM(175)                 POTS2410
      IPOT(114)=HUN*RPS4*T                                              POTS2420
      IPOT(116)=IPOT(106)                                               POTS2430
      IPOT(117)=IPOT(87 )                                               POTS2440
      IPOT(118)=IPOT(88 )                                               POTS2450
      IPOT(119)=AIBRP/AIBR*T*PARAM(175)                                 POTS2460
      IPOT(50 )=IPOT(119)                                               POTS2470
      CALL SSRP(08,IRLERR)                                              POTS2480
      IF(RR.GE.0) GO TO 1023                                            POTS2490
      CALL SSRM(08,IRLERR)                                              POTS2500
 1023 CONTINUE                                                          POTS2510
      IF(IAX.EQ.2)GO TO 1021                                            POTS2520
C##########################################################             POTS2530
C#####     SOLID AXLE LOGIC FOR 680      #####                          POTS2540
C##########################################################             POTS2550
             CALL SSRP(00,IRLERR)                                       POTS2560
             CALL SSRP(01,IRLERR)                                       POTS2570
             CALL SSRP(02,IRLERR)                                       POTS2580
             CALL SSRP(03,IRLERR)                                       POTS2590
             CALL SSRP(07,IRLERR)                                       POTS2600
             CALL SSRP(10,IRLERR)                                       POTS2610
             CALL RSCL( 01,IRSCLE )                                     POTS2620
      IPOT(15 )=(10.0*TS/AIR)*T*PARAM(175)                              POTS2630
      IPOT(17 )=0.40*T*PARAM(175)                                       POTS2640
      IPOT(26)=(ABS(RR)/(4000.*TS))*T*0.1                               POTS2650
      IPOT(36 )=(TSO2/40.0)*T                                           POTS2660
      IPOT(40)=0                                                        POTS2670
      IPOT(41)=0                                                        POTS2680
      IPOT(42 )=0                                                       POTS2690
      IPOT(45 )=IPOT(36 )                                               POTS2700
      IPOT(46 )=(HUN*TSO2*T)                                            POTS2710
      IPOT(35 )=IPOT(46 )                                               POTS2720
      IPOT(53 )=IPOT(26 )                                               POTS2730
      IPOT(71)  =0                                                      POTS2740
      IPOT(80 )=0                                                       POTS2750
      IPOT(81 )=0                                                       POTS2760
      IPOT(82 )=0                                                       POTS2770
      IPOT(109)=(TRO2/40.0)*T                                           POTS2780
      IPOT(115)=IPOT(109)                                               POTS2790
      GO TO 1022                                                        POTS2800
 1021 CONTINUE                                                          POTS2810
C##########################################################             POTS2820
C#####     SPLIT AXLE LOGIC FOR 680      #####                          POTS2830
C##########################################################             POTS2840
             CALL SSRM(00,IRLERR)                                       POTS2850
             CALL SSRM(01,IRLERR)                                       POTS2860
             CALL SSRM(02,IRLERR)                                       POTS2870
             CALL SSRM(03,IRLERR)                                       POTS2880
             CALL SSRM(07,IRLERR)                                       POTS2890
             CALL SSRM(10,IRLERR)                                       POTS2900
             CALL SSCL( 01,ISSCLE )                                     POTS2910
      IPOT(41)=2.0/(10.0*AMUR)*T*PARAM(175)                             POTS2920
      IPOT(40)=AKT3*2.0/(5000.0*AMUR)*T*PARAM(175)                      POTS2930
      IPOT(42 )=T*PARAM(175)/AMS                                        POTS2940
      IPOT(71)  =(RR/(100.*TR**2))*T                                    POTS2950
      IPOT(80 )=AKT4*2.0/(5000.0*AMUR)*T*PARAM(175)                     POTS2960
      IPOT(81 )=2.0/(10.0*AMUR)*T*PARAM(175)                            POTS2970
      IPOT(82 )=T*PARAM(175)/AMS                                        POTS2980
      IPOT(36 )=0                                                       POTS2990
```

```
      IPOT(46 )=0
      IPOT(109)=0
      IPOT(115)=0
      IPOT(45 )=0
      IPOT(35 )=0
      IPOT(26 )=0
      IPOT(53 )=0
      IPOT(17 )=0
      IPOT(15 )=0
 1022 CONTINUE
               CALL SSRM(11,IRLERR)
      IPOT(55)=.5000*T
      IPOT(56)=.5000*T
      IPOT(58)=.5000*T
      IPOT(72)=.5000*T
      SFIN(1)=-100.0
      SFIN(2)=SFIN(1)
      SFIN(3)=SFIN(1)
      SFIN(4)=10.0
      SFIN(5)=SFIN(4)
      SFIN(6)=SFIN(4)
      SFIN(7)=1.0
      SFIN(8)=0.25
      IF(IAX.EQ.2)SFIN(7)=SFIN(1)
      IF(IAX.EQ.2)SFIN(8)=SFIN(4)
      SFIN(9)=0.5
      SFIN(10)=SFIN(9)
      SFIN(11)=2.0
      SFIN(12)=SFIN(11)
      SFIN(13)=SFIN(11)
      SFIN(14)=SFIN(11)
      SFIN(15)=1000.0
      SFIN(16)=SFIN(15)
      SFIN(17)=SFIN(15)
      SFIN(18)=SFIN(15)
      SFIN(19)=1.0
      SFIN(20)=1.0
      SFIN(21)=1.0
      SFIN(22)=1.0
      SFIN(23)=100.
      SFIN(24)=100.
      SFIN(25)=1.0
      SFIN(26)=1.0
      SFIN(27)=1.0
      SFIN(28)=1.0
      IN(23)=RPS1+SIGN(0.5,RPS1)
      IN(24)=RPS2+SIGN(0.5,RPS2)
      IN(25)=0
      IN(26)=1
      IN(27)=0
      IN(28)=1
      DO 10 I=1,48
      SFOUT(I)=1.0
   10 CONTINUE
      SFOUT(9)=1.0/10000.
      SFOUT(10)=0.1
      SFOUT(14)=1.0/10000.
      SFOUT(25)=0.01*   AKT3/AIR
      SFOUT(27)=0.01*   AKT4/AIR
      SFOUT(28)=0.01
```

```
      SFOUT(37)=(1.0/1500.0)
      RETURN
      END
```

## 2.1.4 SBPG2

PRESENTED HERE IS THE FORTRAN LISTING FOR THE MATHEMATICAL MODEL SUBPROGRAM. THE FOLLOWING IS PERFORMED IN SBPG2:

1) Reading of the analog-to-digital converter variables.

2) Computation of simulation time.

3) Calculation of all digital model equations.

4) Data preparation for output on the digital-to-analog (D/A) converters.

5) Detection, limiting, and flagging of D/A variable overloads.

6) Collection of TRACK data for output at the end of a run.

```
C      SUBROUTINE SBPG2
       SUBROUTINE SBPG2
       COMMON/START/ ZDUMMY(4)
       COMMON/FMON/IERDAC(10),TERDAC(10),IDACK,IENDR(20),IOP
       COMMON/IO/DACPLA,ADCPLA,SCALDC,SCALAC
       COMMON/TRACK/JIN,IKEEP,ATRACK,ISAMP,ONTIM,OFFTIM,ITRA,
      1 ITRAA,ITRNA,ITRIA
       COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
      1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
      1 AKK1,AKK2,                         FXL1,FXL2,THS1,THS2,
      1AMT1,AMT2,SN,SFXU,BTVDT,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),GBT(4),FRIBR(4),
      1        RWZI(4),ZI(4),FRI(4),        UI(4),VI(4),WI(4),UGI(4),
      1        VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
      1,ALTQ(4),OTM(4),SALTQ,FOTM,ROTM
      1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
      1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4
      1,PHIDMX
       COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
       COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR
       COMMON/HHHH/H1,H2,H3,H4
       COMMON/SPLTAX/SPSR3,CPSR3,SPSR4,CPSR4,SCR3,SCR4,TBCR3,TBCR4,TBSR3,
      1   TBSR4,TRSR3,TRSR4,TRCR3,TRCR4,PSR3,PSR4,IAX
       COMMON/SOLDAX/DELPHI(20),PHIFNT(20),DELTHE(20),THEFNT(20),NCAM,
      1 NCAS,PSIFNT(7),PHIRR(7),THERR(7),PSIRR(7)
       COMMON/OUTVAR/VOUT,BTV,PSI3S,PSI4S
       COMMON/EXTRA/            UOUT,ROUT,         PSIOUT,EXTAB(002),
      1   DLYTB(002),HTAB(002)
       COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
       COMMON/FEFS/FEF1,FEF2,THE1,THE2
       COMMON/DELS/DELSWC
       COMMON/CLEAN/ONEOA,ONFOD
       COMMON/XYZ/NUMBR
       COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
      1   ANOUT,ADOUT
       COMMON/XBS/XB(15),NS(4,15),DELX(4),XI(4),NNN
       COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
      1    YO,ZO,THEO,PHIO,PSIO
       COMMON/UVW/VC,UIN
       COMMON/EES/E1,E2,E3,E4,E5,E6
       COMMON/ZILCH/TRMAXP,AKTQP
       COMMON/INOUT/ INA(32),IOUTA(48),IN(32),DACO(48),ISW1,ISW7,
      1SFIN(32),SFOUT(48),IPRT,ITMP(48)
       COMMON/COMBLK/AIXP,SM,AIYP,AIXZP,GAM1,GAM2,GAM3,AIXBR,AIYBR,
      1    AIZBR,A1,A2,AIXZBR,A12,E1,E2,E3,DELTA,GV1,GV2,GP1,GP2,GR1,
      1    GR2,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,                ANGNL,ANGNLO
      1    ,TRO2,TFO2,TSO2,G,THRD,TWN7
       COMMON/TIMBLK/JJTIMF,TIME,DT
       COMMON/OPSW/IHSW
       COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
       COMMON/NEWEP/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
       COMMON/MICKEY/IRUNTB(002),VTB(002),SNLTB(002),SNRTB(002),DSWTB(002
      1  ),RTTB(002),DTB(002),EFFTB(002),DYTB(002),PSITB (002),NRUN,
      1   YSPEC,PSIM,XPF
       COMMON/NONAME/XEND,Q,EXIT2
```

```
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,  SBPG 600
     1               AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,   SBPG 610
     1               TIMBMP,GETDL,TIMINS,        TSTEP ,   IVETP          SBPG 620
      DIMENSION CSI(4),XBM(4),SLP(4)                                    SBPG 630
      REAL*8 ZDUMMY                                                     SBPG 640
      EQUIVALENCE (EVALUE(1),ZDUMMY(1))                                 SBPG 650
      EQUIVALENCE  (APF(1),APF1),(APR(1),APR1),(MUS(1),MUSF),           SBPG 660
     1             (APF(2),APF2),(APR(2),APR2),(MUS(2),MUSR)            SBPG 670
      EQUIVALENCE                                                       SBPG 680
     1    (PARAM( 1),AMS)     , (PARAM( 2),AMUF)   , (PARAM( 3),AMUR)   ,  SBPG 690
     1    (PARAM( 4),ZF)      , (PARAM( 5),ZR)     , (PARAM( 6),A)      ,  SBPG 700
     1    (PARAM( 7),B)       , (PARAM( 8),TF)     , (PARAM( 9),TR)     ,  SBPG 710
     1    (PARAM(10),TS)      , (PARAM(11),AIX)    , (PARAM(12),AIY)    ,  SBPG 720
     1    (PARAM(13),AIZ)     , (PARAM(14),AIXZ)   , (PARAM(15),AIR)    ,  SBPG 730
     1    (PARAM(16),CF)      , (PARAM(17),RF)     , (PARAM(18),CFP)    ,  SBPG 740
     1    (PARAM(19),AKF)     , (PARAM(20),ALAMF)  , (PARAM(21),OFC)    ,  SBPG 750
     1    (PARAM(25),CRP)     , (PARAM(26),AKR)    , (PARAM(27),ALAMR)  ,  SBPG 760
     1    (PARAM(22),OFT)     , (PARAM(23),CR)     , (PARAM(24),RR)     ,  SBPG 770
     1    (PARAM(28),ORC)     , (PARAM(29),ORT)    , (PARAM(30),AKRS)   ,  SBPG 780
     1    (PARAM(31),BW)                           , (PARAM(33),OT)     ,  SBPG 790
     1    (PARAM(34),CA0)     , (PARAM(35),CA1)    , (PARAM(36),CA2)    ,  SBPG 800
     1    (PARAM(37),CA3)     , (PARAM(38),CA4)    , (PARAM(39),AISW)   ,  SBPG 810
     1    (PARAM(44),LAFT)    , (PARAM(41),AKSC)   , (PARAM(42),ANG)    ,  SBPG 820
     1    (PARAM(43),LAFC)    , (PARAM(40),ANL2)   , (PARAM(45),LARC)      SBPG 830
      EQUIVALENCE                                                       SBPG 840
     1    (PARAM(46),LART)    , (PARAM(47),AIFW)   , (PARAM(48),HDL)    ,  SBPG 850
     1    (PARAM(49),AIWF)    , (PARAM(50),AIWR)   , (PARAM(51),AID)    ,  SBPG 860
     1    (PARAM(52),ARBP)    , (PARAM(53),EPS1)   , (PARAM(54),EPS2)   ,  SBPG 870
     1    (PARAM(55),PTBR)    , (PARAM(56),YSA1)   , (PARAM(57),YSA2)   ,  SBPG 880
     1    (PARAM(58),YHS1)    , (PARAM(59),YHS2)   , (PARAM(60),AKD)    ,  SBPG 890
     1    (PARAM(61),TQDBR)   , (PARAM(62),AK)     , (PARAM(63),PIN)    ,  SBPG 900
     1    (PARAM(64),QIN)     , (PARAM(65),RIN)    , (PARAM(66),UIZ)    ,  SBPG 910
     1    (PARAM(67),VIN)     , (PARAM(68),WIN)    , (PARAM(69),XIN)    ,  SBPG 920
     1    (PARAM(70),YIN)     , (PARAM(71),ZIN)    , (PARAM(72),THEIN)  ,  SBPG 930
     1    (PARAM(73),PHIIN)   , (PARAM(74),PSIIN)  , (PARAM(75),DTIN)   ,  SBPG 940
     1    (PARAM(76),TEND)    , (PARAM(77),AKT1)   , (PARAM(78),AKT2)   ,  SBPG 950
     1    (PARAM(79),AKT3)    , (PARAM(80),AKT4)   , (PARAM(81),RPS1)   ,  SBPG 960
     1    (PARAM(82),RPS2)    , (PARAM(83),RPS3)   , (PARAM(84),RPS4)   ,  SBPG 970
     1    (PARAM(85),B1)      , (PARAM(86),B2)     , (PARAM(87),B3)        SBPG 980
      EQUIVALENCE                                                       SBPG 990
     1 (PARAM(88),B4),        (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),  SBPG1000
     1    (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN), SBPG1010
     1    (PARAM( 94),DEL3IN), (PARAM( 95),PHIDN), (PARAM(96),PHIFN),   SBPG1020
     1    (PARAM( 97),DFW1IN), (PARAM( 98),DFW2IN),(PARAM( 99),U1PIN),  SBPG1030
     1    (PARAM(100),U2PIN),  (PARAM(101),U3PIN), (PARAM(102),U4PIN),  SBPG1040
     1    (PARAM(103),S1PIN),  (PARAM(104),S2PIN), (PARAM(105),S3PIN),  SBPG1050
     1    (PARAM(106),S4PIN),  (PARAM(107),PPBT)                        SBPG1060
     1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)           SBPG1070
     1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),           SBPG1080
     1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)               SBPG1090
     1  ,(PARAM(119),TQRBF),(PARAM(120),TQRBR)                          SBPG1100
     1  ,(PARAM(121),BPL),(PARAM(122),TTD),(PARAM(123),DSW)             SBPG1110
     1  ,(PARAM(124),TSW)                                               SBPG1120
      EQUIVALENCE                                                       SBPG1130
     1  (PARAM(130),AMCR),(PARAM(131),ESP),(PARAM(132),AKSL1),          SBPG1140
     1  (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),           SBPG1150
     1  (PARAM(136),CCR),(PARAM(137),CFCR),(PARAM(138),AP),             SBPG1160
     1  (PARAM(139),EP1),(PARAM(140),EP2),(PARAM(141),ERF1),            SBPG1170
     1  (PARAM(142),ERF2),                                              SBPG1180
     1  (PARAM(143),AML1),(PARAM(144),AML2),(PARAM(145),RRIM),          SBPG1190
```

```
1   (PARAM(146),RWR),
1 (PARAM(169),SNT),(PARAM(170),SNSC),(PARAM(171),SNS1),
1    (PARAM(182),SII(1)),(PARAM(196),EPSK1),(PARAM(197),EPSK2)
 EQUIVALENCE (PARAM(202),APF(1)),(PARAM(204),APR(1)),
1    (PARAM(206),MUS(1))
 EQUIVALENCE
1    (PARAM(223),CR1C),(PARAM(224),CR1T),(PARAM(225),CR2C),
1    (PARAM(226),CR2T),(PARAM(227),CR3C),(PARAM(228),CR3T),
1    (PARAM(229),CR4C),(PARAM(230),CR4T),(PARAM(231),AH1),
1    (PARAM(232),AH2),(PARAM(233),ANL),(PARAM(234),AKF1),
1   (PARAM(235),AKF2),(PARAM(236),AKR3),(PARAM(237),AKR4),
1 (PARAM(242),AKCF),(PARAM(243),AKCR),(PARAM(244),AKSR)
 EQUIVALENCE (PARAM(245),RB(1)),(PARAM(249),TFK(1)),
1             (PARAM(252),TRK(1)),
1             (PARAM(255),OFC0),(PARAM(256),OFC1),(PARAM(257),OFC2),
1             (PARAM(258),OFC3),(PARAM(262),ORC3),
1             (PARAM(259),ORC0),(PARAM(260),ORC1),(PARAM(261),ORC2)
 EQUIVALENCE (PARAM(263),CP0F),(PARAM(264),CP1F),
1(PARAM(265),CP2F),(PARAM(266),CP0R),(PARAM(267),CP1R),
1(PARAM(268),CP2R),(PARAM(269),CR0F),(PARAM(270),CR1F),
1(PARAM(271),CR2F),(PARAM(272),CR0R),(PARAM(273),CR1R),
1(PARAM(274),CR2R)
 EQUIVALENCE (RB(1),RB1),(RB(2),RB2)
 EQUIVALENCE (RB(3),RB3),(RB(4),RB4)
 EQUIVALENCE (TFK(1),AFK1),(TRK(1),ARK1)
 EQUIVALENCE (TFK(2),AFK2),(TRK(2),ARK2)
 EQUIVALENCE (TFK(3),AFK3),(TRK(3),ARK3)
 EQUIVALENCE
1    (PARAM(284),HFC),(PARAM(285),HRC),
1    (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),
1    (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)
 EQUIVALENCE
1(PARAM(296),DEL1DT),(PARAM(297),DEL2DT),(PARAM(298),DEL3DT),
1(PARAM(299),DEL1),(PARAM(300),DEL2),(PARAM(301),DEL3),
1(PARAM(302),PHIRD),(PARAM(303),PHIR),(PARAM(304),DELFW1),
1(PARAM(305),DELFW2),(PARAM(306),U1P),(PARAM(307),U2P),
1(PARAM(308),U3P),(PARAM(309),U4P),(PARAM(310),S1P),
1(PARAM(311),S2P),(PARAM(312),S3P),(PARAM(313),S4P),
1(PARAM(314),QUAN1),(PARAM(315),QUAN2),(PARAM(316),QUAN3),
1(PARAM(317),QUAN4),(PARAM(318),ARPS1),(PARAM(319),ARPS2),
1(PARAM(320),WSTH1),(PARAM(321),WCTH1),(PARAM(322),WSTH2),
1(PARAM(323),WCTH2),(PARAM(324),IOUT(1))
 EQUIVALENCE  (PHIRD,DEL4DT),(PHIR,DEL4)
 EQUIVALENCE (RWZI(1),RWZ1),(ZI(1),Z1),(FRI(1),FR1),(AKTI(1),AKT1),
1             (RWZI(2),RWZ2),(ZI(2),Z2),(FRI(2),FR2),(AKTI(2),AKT2),
1             (RWZI(3),RWZ3),(ZI(3),Z3),(FRI(3),FR3),(AKTI(3),AKT3),
1             (RWZI(4),RWZ4),(ZI(4),Z4),(FRI(4),FR4),(AKTI(4),AKT4),
1(UI(1),U1),(VI(1),V1),(WI(1),W1),(UGI(1),UG1),(VGI(1),VG1),
1(UI(2),U2),(VI(2),V2),(WI(2),W2),(UGI(2),UG2),(VGI(2),VG2),
1(UI(3),U3),(VI(3),V3),(WI(3),W3),(UGI(3),UG3),(VGI(3),VG3),
1(UI(4),U4),(VI(4),V4),(WI(4),W4),(UGI(4),UG4),(VGI(4),VG4),
1(SINPSI(1),SINPS1),(PSII(1),PSI1),(COSPSI(1),COSPS1),(UGIP(1),UG1P
1),(PHICGI(1),PHICG1),(CVI(1),CV1),(ABI(1),AB1),(BETAI(1),BETA1),
1(SINPSI(2),SINPS2),(PSII(2),PSI2),(COSPSI(2),COSPS2),(UGIP(2),UG2P
1),(PHICGI(2),PHICG2),(CVI(2),CV2),(ABI(2),AB2),(BETAI(2),BETA2),
1(SINPSI(3),SINPS3),(PSII(3),PSI3),(COSPSI(3),COSPS3),(UGIP(3),UG3P
1),(PHICGI(3),PHICG3),(CVI(3),CV3),(ABI(3),AB3),(BETAI(3),BETA3),
1(SINPSI(4),SINPS4),(PSII(4),PSI4),(COSPSI(4),COSPS4),(UGIP(4),UG4P
1),(PHICGI(4),PHICG4),(CVI(4),CV4),(ABI(4),AB4),(BETAI(4),BETA4)
 EQUIVALENCE (AMUI(1),AMU1),(SNI(1),SN1),(RMI(1),RM1),(GBI(1),GB1),
```

```
     1              (AMUI(2),AMU2),(SNI(2),SN2),(RMI(2),RM2),(GBI(2),GB2),
     1              (AMUI(3),AMU3),(SNI(3),SN3),(RMI(3),RM3),(GBI(3),GB3),
     1              (AMUI(4),AMU4),(SNI(4),SN4),(RMI(4),RM4),(GBI(4),GB4),
     1(FRIBR(1),FR1BR),(ALFI(1),ALF1),(BETIP(1),BET1P),(BETIBR(1),BET1BR
     1),(SLIPI(1),SLIP1),(AM1I(1),AM11),(AM2I(1),AM21),(U0I(1),U01),
     1(FRIBR(2),FR2BR),(ALFI(2),ALF2),(BETIP(2),BET2P),(BETIBR(2),BET2BR
     1),(SLIPI(2),SLIP2),(AM1I(2),AM12),(AM2I(2),AM22),(U0I(2),U02),
     1(FRIBR(3),FR3BR),(ALFI(3),ALF3),(BETIP(3),BET3P),(BETIBR(3),BET3BR
     1),(SLIPI(3),SLIP3),(AM1I(3),AM13),(AM2I(3),AM23),(U0I(3),U03),
     1(FRIBR(4),FR4BR),(ALFI(4),ALF4),(BETIP(4),BET4P),(BETIBR(4),BET4BR
     1),(SLIPI(4),SLIP4),(AM1I(4),AM14),(AM2I(4),AM24),(U0I(4),U04),
     1(U1I(1),U11),(BAMI(1),BAM1),(SII(1),SI1),(SAMI(1),SAM1),(FI(1),F1)
     1,
     1(U1I(2),U12),(BAMI(2),BAM2),(SII(2),SI2),(SAMI(2),SAM2),(FI(2),F2)
     1,
     1(U1I(3),U13),(BAMI(3),BAM3),(SII(3),SI3),(SAMI(3),SAM3),(FI(3),F3)
     1,
     1(U1I(4),U14),(BAMI(4),BAM4),(SII(4),SI4),(SAMT(4),SAM4),(FI(4),F4)
      EQUIVALENCE (FXUI(1),FXU1),(FYUI(1),FYU1),(GI(1),G1),(FCI(1),FC1),
     1              (FXUI(2),FXU2),(FYUI(2),FYU2),(GI(2),G2),(FCI(2),FC2),
     1              (FXUI(3),FXU3),(FYUI(3),FYU3),(GI(3),G3),(FCI(3),FC3),
     1              (FXUI(4),FXU4),(FYUI(4),FYU4),(GI(4),G4),(FCI(4),FC4),
     1(FCIMAX(1),FC1MAX),(FSI(1),FS1),
     1(FCIMAX(2),FC2MAX),(FSI(2),FS2),
     1(FCIMAX(3),FC3MAX),(FSI(3),FS3),
     1(FCIMAX(4),FC4MAX),(FSI(4),FS4)
      EQUIVALENCE (ZIP(1),Z1P),(PHII(1),PHI1),
     1              (ZIP(2),Z2P),(PHII(2),PHI2),
     1              (ZIP(3),Z3P),(PHII(3),PHI3),
     1              (ZIP(4),Z4P),(PHII(4),PHI4)
      EQUIVALENCE (DL1S,DLIS(1)),(DL2S,DLIS(2)),(DL3S,DLIS(3))
     1             ,(DL4S,DLIS(4))
      REAL*4 MUP   ,MUS(2),PB(4),TFK(3),TRK(3),SII(4),APF(2),APR(2)
      REAL*4 LAFC,LAFT,LARC,LART
      REAL*4 AKTI(4)
      REAL*4 ATRACK(2000)
      REAL*4 BVALUE(2)
      REAL*4 IOUT(48),IN,ITMP,SCALAC(28),SCALDC(48)
      INTEGER*2 DACPLA(48),ADCPLA(28),ITRAA(50),ITRNA(50),ITRIA(50)
      INTEGER*2  RTSW  ,RBSW  ,LDTSW ,OPEN
C     USE A/D READ VALUES
      DO 7413 I=1,28
      BVALUE(ADCPLA(I))=IN(I)*SCALAC(I)
 7413 CONTINUE
      DELFW1=-DELFW1
      DELFW2=-DELFW2
      IHSW=1
      TIME=FLOAT(JJTIME)*DT
      JJTIME=JJTIME+1
      ENTRY SBPG22
      ISW=1
      IF(TIME.GT.0.) GO TO 6
      DO 5 K=1,4
      FSI(K) = 0.
      ALTO(K) = 0.
      ZIMX(K) = 100.
    5 CONTINUE
      PHIDMX = 0.
    6 CONTINUE
C FUNCTION:  PSIFNT-COEFFICIENTS TO A POLYNOMIAL FIT OF FRONT WHEEL
```

```
C          TOE-IN IS A FUNCTION OF SUSPENSION DEFLECTION (DELI)
C
C INPUTS:     PSIFNT-(DEGREES/INCH)
C             DELI-(INCHES)
C     *********************************************************************
C     INCREASING THE SPRUNG MASS OVER THAT FOR WHICH THE STATIC WHEEL
C     DEFLECTION IS MEASURED, YIELDS A DELFIN AND A DELRIN WHICH
C     IS A NEGATIVE NUMBER
C     *********************************************************************
C     DELFIN AND DELRIN REPRESENT A CHANGE IN STATIC DISPLACEMENT
C     OF THE FRONT AND REAR WHEELS DUE TO LOAD CONFIGURATIONS
C OUTPUTS:    POLY-(DEGREES)
C
C     DLIS (I=1,2,3,4) IS THE SUSPENSION DEFLECTION RELATIVE
C           TO THE UNLOADED POSITION FOR WHEEL I
      DL1S = DEL1 + DELFIN
      DL2S = DEL2 + DELFIN
      DL3S = DEL3 + DELRIN
      DL4S = DEL4 + DELRIN
      IF(IAX.EQ.1) DL3S = DL3S    + TSO2*PHIR
      IF(IAX.EQ.1) DL4S = DL3S - TSO2*PHIR
      PSI1=DELFW1+(POLY(DL1S,PSIFNT)+EPSK1)*.01745329
      PSI2=DELFW2-(POLY(DL2S,PSIFNT)+EPSK2)*.01745329
      PSI3S = AKRS*PHIR
      PSI4S = AKRS*PHIR
C
C FUNCTION:   PHIFNT-COEFFICIENTS TO A POLYNOMIAL FIT OF FRONT WHEEL
C             CAMBER AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)
C
C INPUTS:     PHIFNT-(DEGREES/INCH)
C             DELI-(INCHES)
C
C OUTPUTS:    POLY-(DEGREES)
C
      PHI1=(POLY(DL1S,PHIFNT)+SIGN(FEE1,FS1))*.01745329
      PHI2=(-POLY(DL2S,PHIFNT)+SIGN(FEE2,FS2))*.01745329
      PHI3=PHIR
      PHI4=PHIR
C
C FUNCTION:   THEFNT-CASTER AS A FUNCTION OF SUSPENSION
C             DEFLECTION (DELI)
C
C INPUTS:     THEFNT (DEGREES/INCH)
C             DELI-(INCHES)
C
C OUTPUT:     POLY-(DEGREES)
C
      THS1=(POLY(DL1S,THEFNT)+THE1)*.01745329
      THS2=(POLY(DL2S,THEFNT)+THE2)*.01745329
      PHS1=YHS1+PHI1
      PHS2=YHS2+PHI2
      IF(IAX.EQ.1)GO TO 7843
C
C FUNCTION:   PSIRR-COEFFICIENTS TO A POLYNOMIAL FIT OF REAR WHEEL
C             TOE-IN AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)
C
C INPUTS:     PSIRR-(DEGREES/INCH)
C             DELI-(INCHES)
C
C OUTPUTS:    POLY-(DEGREES)
```

```
C
      PSI3S = POLY(DL3S,PSIRR) * .01745329
      PSI4S = -POLY(DL4S,PSIRR) * .01745329
C
C FUNCTION:  PHIRR-COEFFICIENTS TO A POLYNOMIAL FIT OF REAR WHEEL
C            CAMBER AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)
C
C INPUTS:    PHIRR-(DEGREES/INCH)
C            DELI-(INCHES)
C
C OUTPUTS:   POLY-(DEGREES)
C
      PHI3 =POLY(DL3S,PHIRR)*.01745329
      PHI4=-POLY(DL4S,PHIRR)*.01745329
 7843 CONTINUE
C     CALCULATION OF FRONT BUMP STOP FORCES
      IF(DL1S.LT.OFC) GO TO 21
      IF(DL1S.GT.OFT) GO TO 22
      FBS1 = 0.
      GO TO 23
   21 FBS1 = AKF*(LAFC - 1.)*(DL1S - OFC)
      GO TO 23
   22 FBS1 = AKF*(LAFT - 1.)*(DL1S - OFT)
   23 CONTINUE
      IF(DL2S.LT.OFC) GO TO 24
      IF(DL2S.GT.OFT) GO TO 25
      FBS2 = 0.
      GO TO 26
   24 FBS2 = AKF*(LAFC - 1.)*(DL2S - OFC)
      GO TO 26
   25 FBS2 = AKF*(LAFT - 1.)*(DL2S - OFT)
   26 CONTINUE
C     CALCULATION OF REAR BUMP STOP FORCES
      IF(DL3S.LT.ORC) GO TO 31
      IF(DL3S.GT.ORT) GO TO 32
      FBS3 = 0.
      GO TO 33
   31 FBS3 = AKR*(LARC - 1.)*(DL3S - ORC)
      GO TO 33
   32 FBS3 = AKR*(LART - 1.)*(DL3S - ORT)
   33 CONTINUE
      IF(DL4S.LT.ORC) GO TO 34
      IF(DL4S.GT.ORT) GO TO 35
      FBS4 =0.
      GO TO 36
   34 FBS4 = AKR*(LARC - 1.)*(DL4S - ORC)
      GO TO 36
   35 FBS4 = AKR*(LART - 1.)*(DL4S - ORT)
   36 CONTINUE
  100 TM1=Z-A*THE
      TM2=TRO2*PHI
      Z1PP=TM1+TM2
      Z1P=Z1PP+ZF
      Z1=Z1P+DEL1
      Z2PP=TM1-TM2
      Z2P=Z2PP+ZF
      Z2=Z2P+DEL2
      TM1=Z+B*THE
      TM2=TRO2*PHI
      Z3PP=TM1+TM2
```

```
      Z3P=Z3PP+ZR
      Z3=Z3P+DEL3
      IF(IAX.EQ.1)Z3=Z3+TRO2*PHIR+DEL3-DEL3
      Z4PP=TM1-TM2
      Z4P=Z4PP+ZR
      Z4=Z4P+DEL4
      IF(IAX.EQ.1)Z4=Z4-TRO2*PHIR+DEL3-DEL4
      DO 20 K=1,4
      RWZI(K) = RW + ZI(K)
      IF(RWZI(K).LT.ZIMX(K)) ZIMX(K) = RWZI(K)
      FRI(K) = 0.
      IF(RWZI(K).GT.0.) FRI(K) = AKTI(K) * RWZI(K)
   20 CONTINUE
      TM1=U+ZF*Q
      TM2=TFO2*R
      U1=TM1-TM2
      U2=TM1+TM2
      TM1=U+ZR*Q
      TM2=TRO2*R
      U3=TM1-TM2
      U4=TM1+TM2
      VARZFP=V+A*R-ZF*P
      VBRZRP=V-B*R-ZR*P
      PPHIR=P
      IF(IAX.EQ.1)PPHIR=P+PHIRD
      V1=VARZFP+Z1*P
      V2=VARZFP+Z2*P
      V3=VBRZRP+Z3*PPHIR
      V4=VBRZRP+Z4*PPHIR
      WAQ=W-A*Q
      WBQD3=W+B*Q+DEL3DT
      TF2P=TFO2*P
      TR2P=TRO2*P
      W1=WAQ+TF2P+DEL1DT
      W2=WAQ-TF2P+DEL2DT
      IF(IAX.EQ.2)GO TO 9738
      W3=WBQD3+TRO2*PPHIR
      W4=WBQD3-TRO2*PPHIR
      GO TO 9739
 9738 WBQD4=W+B*Q+DEL4DT
      W3=WBQD3+TR2P
      W4=WBQD4-TR2P
 9739 CONTINUE
      PSI3 = PSI3S+ ALTO(3)*AKSR
      PSI4 = PSI4S+ ALTO(4)*AKSR
      DO 30 K=1,4
      UGI(K) = UI(K) + THP*WI(K)
      VGI(K) = VI(K) - PHI*WI(K)
      SINPSI(K) = SIN(PSII(K))
      COSPSI(K) = COS(PSII(K))
      UGIP(K) = UGI(K) * COSPSI(K) + VGI(K) * SINPSI(K)
   30 CONTINUE
      CONVRT = 3600./(12.*5280.)
      CZ=COS(PSI)
      SN=SIN(PSI)
      DO 40 K=1,4
      CVI(K) = SQRT(UI(K)*UI(K) + VI(K)*VI(K))*CONVRT
      ABI(K) = ABS(UGI(K))
      BETAI(K) = ATAN(VGI(K)/ABI(K)) - PSII(K)*UGI(K)/ABI(K)
      SNI(K) = SNS0 / SNT
```

```
   40 CONTINUE                                                              SBPG4200
C     INTFUN IS USED FOR ROAD PATCH WITH VARING COEFFICENT OF FRICTION     SBPG4210
      INTFUN=PARAM(172)+0.5                                                 SBPG4220
      IF(INTFUN.EQ.0)GO TO 3497                                             SBPG4230
      IF(INTFUN.NE.1) GO TO 3498                                            SBPG4240
      X1=A*CZ-TFO2*SN  +X                                                   SBPG4250
      X2=A*CZ+TFO2*SN  +X                                                   SBPG4260
      X3=-B*CZ-TRO2*SN +X                                                   SBPG4270
      X4=-B*CZ+TRO2*SN+X                                                    SBPG4280
      TEMP=PARAM(173)+PARAM(174)                                            SBPG4290
      TEMP=TEMP*12.0                                                        SBPG4300
      PPPP=PARAM(173)*12.0                                                  SBPG4310
      IF(X1.GT.PPPP       .AND.X1.LE.TEMP)SN1=SNS1/SNT                      SBPG4320
      IF(X2.GT.PPPP       .AND.X2.LE.TEMP)SN2=SNS1/SNT                      SBPG4330
      IF(X3.GT.PPPP       .AND.X3.LE.TEMP)SN3=SNS1/SNT                      SBPG4340
      IF(X4.GT.PPPP       .AND.X4.LE.TEMP)SN4=SNS1/SNT                      SBPG4350
      GO TO 3498                                                            SBPG4360
 3497 CONTINUE                                                              SBPG4370
      YY1=A*SN+TFO2*CZ  +Y                                                  SBPG4380
      Y2=A*SN-TFO2*CZ   +Y                                                  SBPG4390
      Y3=-B*SN+TRO2*CZ +Y                                                   SBPG4400
      Y4=-B*SN-TRO2*CZ+Y                                                    SBPG4410
      IF(YY1.LT.0.0) SN1=SNS1/SNT                                           SBPG4420
      IF(Y2.LT.0.0) SN2=SNS1/SNT                                            SBPG4430
      IF(Y3.LT.0.0) SN3=SNS1/SNT                                            SBPG4440
      IF(Y4.LT.0.0) SN4=SNS1/SNT                                            SBPG4450
 3498 CONTINUE                                                              SBPG4460
      RA23=RA2*RA3                                                          SBPG4470
      R2T=ROT*RA2                                                           SBPG4480
      RA20=RA0*RA2                                                          SBPG4490
C     CALCULATION OF SIDE FORCE FRICTION COEFF                              SBPG4500
C                                                                          CSBPG4510
C FUNCTION:  AMUI-MAXIMUM LATERAL FRICTION COEFFICIENT                     CSBPG4520
C                                                                          CSBPG4530
C INPUTS:    B1-(PARAM(85)),LOAD TERM COEFFICIENT OF LATERAL FRICTION      CSBPG4540
C            COEFFICIENT (1/LB)                                            CSBPG4550
C            B2-(PARAM(86)),VELOCITY TERM COEFFICIENT OF LATERAL           CSBPG4560
C            FRICTION COEFFICIENT (1/MPH)                                  CSBPG4570
C            B3-(PARAM(87)),CONSTANT TERM (UNITY)                           SBPG4580
C            B4-(PARAM(88)),QUADRATIC LOAD TERM(1/LB**2)                    SBPG4590
C            FRI-RADIAL TIRE FORCE (POUNDS)                                CSBPG4600
C            CVI-VELOCITY OF VEHICLE (MPH)                                 CSBPG4610
C                                                                          CSBPG4620
C OUTPUT:    AMUI-MAXIMUM LATERAL FRICTION COEFFICIENT (UNITY)             CSBPG4630
C                                                                          CSBPG4640
      DO 60 K=1,2                                                           SBPG4650
      KK = K + 2                                                            SBPG4660
      AMUI(K)=(B1*FRI(K)+B2*CVI(K)+B3+B4*FRI(K)*FRI(K))*SNT(K)              SBPG4670
      RMI(K) = FRI(K) * AMUI(K)                                             SBPG4680
      FRIBR(K) = AMIN(FRI(K),A2T)                                           SBPG4690
C     ALFI IS THE DENOMINATOR FOR THE BETA BAR CALCULATION                  SBPG4700
      ALFI(K) = CA1*FRIBR(K)*(FRIBR(K) - CA2) - CA20                        SBPG4710
      IF(ALFI(K)/CA2.GE.0.) ALFI(K) =-1.0E-10                               SBPG4720
      PHICGI(K) = THE*SINPSI(K) + PHI*COSPSI(K) + PHIT(K)                   SBPG4730
     1 + AKCF*FSI(K)                                                        SBPG4740
      BETIP(K) = CA23*(CA4-FRIBR(K))*FRIBR(K)*PHICGI(K)/(CA4*ALFI(K))       SBPG4750
      IF(RMI(K).EQ.0.) GO TO 610                                            SBPG4760
      BETIBR(K) = ALFI(K)*(BETAI(K) + BETIP(K))/(CA2*RMI(K))                SBPG4770
      GO TO 710                                                             SBPG4780
  610 BETIBR(K) = 0.                                                        SBPG4790
```

```
  710 CONTINUE
      AMUI(KK) = (RB3 + RB1*FRI(KK) + RB2*CVI(KK) + RB4*FRI(KK)*FRI(KK))
     1 *SNI(KK)
      RMI(KK) = FRI(KK) * AMUI(KK)
      FRIBR(KK) = AMIN(FRI(KK),R2T)
      ALFI(KK) = RA1*FRIBR(KK)*(FRIBR(KK) - RA2) - RA20
      IF(ALFI(KK)/RA2.GE.0.) ALFI(KK) = 1.0E-10
      PHICGI(KK) = THE*SINPSI(KK) + PHI*COSPSI(KK) + PHII(KK)
     1 + AKCR*PSI(KK)
      IF(IAX.EQ.1) PHICGI(KK)=0.
      BETIP(KK)=RA23*(RA4-FRIBR(KK))*FRIBR(KK)*PHICGI(KK)/(RA4*ALFI(KK))
      IF(RMI(KK).EQ.0.) GO TO 630
      BETIBR(KK) = ALFI(KK)*(BETAI(KK) + BETIP(KK)) / (RA2*RMI(KK))
      GO TO 730
  630 BETIBR(KK) = 0.
  730 CONTINUE
   60 CONTINUE
      DO 11 K=1,4
      ABI(K) = ABS(BETIBR(K))
      IF(ABI(K).GE.3.) GO TO 10
      GBI(K) = BETIBR(K)*(1.-THRD*ABI(K)+TWN7*BETIBR(K)**2)
      GO TO 80
   10 GBI(K) = BETIBR(K)/ABI(K)
   80 CONTINUE
C     PARAM(314 -317) ARE EQUIVALENCED TO QUAN1 - 4
      SLIPI(K) = PARAM(K + 313)
      IF(SLIPI(K).LT.(-1.).OR.SLIPI(K).GT.1.) SLIPI(K)=SIGN(1.,SLIPI(K))
      SAMI(K) = (BETAI(K) + BETIP(K)) * 57.29578
   11 CONTINUE
C     CIRCUMFERENTIAL FRICTION COEFF CALCULATION
C
C            MUP- PEAK BRAKING COEF. OF FRICTION
C            MUS- SLIDING COEF. OF FRICTION
C            SII- SLIP RATIO AT WHICH PEAK BRAKING
C                 COEF. OF FRICTION OCCURS
C
C            SNI- RATIO OF SIM. VEHICLE SKID NUMBER SURFACE
C                   TO TIRE DATA SKID NUMBER SURFACE
C
C FUNCTION:   AM1I-RISE SLOPE OF UXI VS. WHEEL SLIP
C
C            SAMI- SIDE-SLIP ANGLE (DEGREES)
C            SI1-(PARAM(182),UNITY)
C            SI2-(PARAM(183),UNITY)
C            SI3-(PARAM (184),UNITY)
C            SI4-(PARAM(185),UNITY)
C
C            OUTPUT:   AM1I - UNITY
      DO 13 K=1,2
      KK=K+2
      MUP(K) = APF1 + APF2*FRI(K)
      MUP(KK) = APR1 + APR2 * FRI(KK)
      AM1I(K) = (MUP(K)/SII(K))*(1. - .03*ABS(SAMI(K)))
C **  MUS(1) EQUALS MUSF,MUS(2) EQUALS MUSR **
      IF(AM1I(K).LT.MUS(1)) AM1I(K) = MUS(1)
      AM1I(K) = AM1I(K) * SNI(K)
      AM1I(KK) = (MUP(KK)/SII(KK))*(1. - 0.03*ABS(SAMI(KK)))
      IF(AM1I(KK).LT.MUS(2))  AM1I(KK) = MUS(2)
      AM1I(KK) = AM1I(KK) * SNI(KK)
      AM2I(K) = ((MUS(1) - MUP(K))/(1. - SII(K)))*(1.-.06*ABS(SAMI(K)))
```

```
      IF(AM2I(K).GE.MUS(1)) AM2I(K) = MUS(1)
      AM2I(K) = AM2I(K) * SNI(K)
      AM2I(KK)=((MUS(2) -MUP(KK))/(1.-SII(KK)))*(1.-.06*ABS(SAMI(KK)))
      IF(AM2I(KK).GE.MUS(2))  AM2I(KK) = MUS(2)
      AM2I(KK) = AM2I(KK) * SNI(KK)
C OUTPUT:      U1I-VALUE OF UXI AT BRAKE SLIP = 1. (UNITY)
      U1I(K) = MUS(1) * SNI(K)
      U1I(KK) = MUS(2)  * SNI(KK)
C OUTPUT:      U0I-INTERCEPT OF UXI AT BRAKE SLIP = 0  (UNITY)
      U0I(K) = U1I(K) - AM2I(K)
      U0I(KK) = U1I(KK) - AM2I(KK)
   13 CONTINUE
      DO 12 K=1,4
      BAMI(K) = BETAI(K) + BETIP(K)
      XBM(K) = BAMI(K)
      SLP(K) = SLIPI(K)
C
C FUNCTION:  FCSI-SIDE FORCE SHAPING AS A FUNCTION OF SLIP
C
C INPUTS:    SAMI- SIDE-SLIP ANGLE (DEGREES)
C            SLP-SLIP (UNITY)
C            GAMF-SIDE FORCE SHAPING FUNCTION AS A FUNCTION OF
C            SLIP (UNITY)
C            AFA-BRAKING SLIP (UNITY)
C            NFA-NUMBER OF DATA POINTS
C
C OUTPUTS:   FCSI-LINEARLY ITERPOLATED SIDE FORCE SHAPING FUNCTION
C
      CSI(K) = FCSI(SAMI(K),SLP(K))
      FI(K) = CSI(K)
C            PARAM(306) TO (309) CIRCUM. FRICTION COEF.
      FXUI(K)= FRI(K)*(THE-PARAM(K+305)*COSPSI(K) - FI(K)*AMUI(K)
     1*SINPSI(K)*GBI(K))
      GI(K) = -PHI-PARAM(K+305)*SINPSI(K)+FI(K)*AMUI(K)*COSPSI(K)*GBI(K)
      FYUI(K) = FRI(K)*GI(K)
      FCI(K) = FRI(K)*PARAM(K+305)
      FCIMAX(K) = FRI(K)*AM1I(K)*SII(K)
      FSI(K) = FRI(K)*FI(K)*AMUI(K)*GBI(K)
   12 CONTINUE
C      ALIGNING TORQUE CALCULATIONS
C     OVER-TURNING MOMENT CALCULATIONS
      DO 4280 K=1,2
      KK= K+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
      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(K)=FRI(K)*(OFC1*FSI(K)+OFC2*FSI(K)*PHICGI(K)+OFC3*PHICGI(K))
      OTM(KK)=FRI(KK)*(ORC1*FSI(KK)+ORC2*FST(KK)*PHICGI(KK)+ORC3
     1  *PHICGI(KK))
 4280 CONTINUE
      SALTQ=ALTQ(1)+ALTQ(2)+ALTQ(3)+ALTQ(4)
      FOTM=OTM(1)+OTM(2)
      ROTM=OTM(3)+OTM(4)
      SFXU=FXU1+FXU2+FXU3+FXU4
      SFYU=FYU1+FYU2+FYU3+FYU4
      SNPSIU=A*(FYU1+FYU2)-B*(FYU3+FYU4)+TFO2*(FXU2-FXU1)
     1    +TRO2*(FXU4-FXU3) + SALTQ
      IF(IAX.EQ.2)GO TO 4287
```

```
      SNTHEU=A*(S1P+S2P)-B*(S3P+S4P)-FXU1*Z1PP-FXU2*Z2PP
     1       -FXU3*Z3PP-FXU4*Z4PP
      SNPHIU=TFO2*(S2P-S1P)+TSO2*(S4P-S3P)+FYU1*(Z1PP+HFC)
     1       +FYU2*(Z2PP+HFC)
     1                                 -(FYU3+FYU4)*(DEL3+HRC+ZR)
     1 + FOTM
      GO TO 4288
 4287 SNTHEU=A*(S1P+S2P)-B*(S3P+S4P)-FXU1*Z1PP-FXU2*Z2PP
     1       -FXU3*Z3PP-FXU4*Z4PP
      SNPHIU=TFO2*(S2P-S1P)+TRO2*(S4P-S3P)+FYU1*(Z1PP+HFC)
     1       +FYU2*(Z2PP+HFC)+FYU3*(Z3PP+HRC)+FYU4*(Z4PP+HRC)
     1 + FOTM+ROTM
 4288 CONTINUE
C     KINEMATIC CALCULATIONS
      GO TO (1000,1000,3000),ISW
 1000 CONTINUE
      QDT=(SFXU/SM-SNTHEU/GAM2)*ONEOA
      UDT=V*R-W*Q-G*THE-(A2*SFXU/SM-A1*SNTHEU/GAM2)*ONEOA
      WDT=U*Q-V*P-(S1P+S2P+S3P+S4P)/AMS
      TMP=W*P-U*R+G*PHI
      D1=SM*TMP+SFYU
      D2=-GAM3*TMP+SNPHIU
        D3=GAM1*TMP+SNPSIU
         VDT=(D1*F1+D2*GV1+D3*GV2)*ONEOD
      PDT=(-D1*E2+D2*GP1+D3*GP2)*ONEOD
      RDT=(D1*E3+D2*GR1+D3*GR2)*ONEOD
      PHIDT=P+R*THE
      THEDT=Q-R*PHI
  101 PSIDT=R + Q*PHI
      XDT=U*CZ-V*SN
      YDT=U*SN+V*CZ
      ZDT=W-U*THE+V*PHI
      ANUMDT=(FC1+FC2+FC3+FC4)
      ADENDT=(FC1MAX+FC2MAX+FC3MAX+FC4MAX)
      ISWPQ=PARAM(127)+0.5
      ISWPQ=ISWPQ+1
      GO TO (7001,7002,7003,7004),ISWPQ
      GO TO 7001
 7002 PDT=0.0
      GO TO 7001
 7003 QDT=0.0
      GO TO 7001
 7004 PDT=0.0
      QDT=0.0
 7001 CONTINUE
      GO TO (1100,1200),ISW
 1100 CONTINUE
      IF(PARAM(180).EQ.1)
     1GO TO 99100
      U = UO+UDT*DT
      V=VO+VDT*DT
      W=WO+WDT*DT
      P=PO+PDT*DT
      Q=QO+QDT*DT
      R=RO+RDT*DT
      X=XO+XDT*DT
      Y=YO+YDT*DT
      Z=ZO+ZDT*DT
      PHI=PHIO+PHIDT*DT
      THE=THEO+THEDT*DT
```

```
      PSI=PSIO+PSIDT*DT                                                 SBPG6600
      ANUM=ANUMO+ANUMDT*DT                                              SBPG6610
      ADEN=ADENO+ADENDT*DT                                              SBPG6620
99100 CONTINUE                                                          SBPG6630
      UDTO=UDT                                                          SBPG6640
      VDTO=VDT                                                          SBPG6650
      WDTO=WDT                                                          SBPG6660
      PDTO=PDT                                                          SBPG6670
      QDTO=QDT                                                          SBPG6680
      RDTO=RDT                                                          SBPG6690
      PHIDTO=PHIDT                                                      SBPG6700
      THEDTO=THEDT                                                      SBPG6710
      PSIDTO=PSIDT                                                      SBPG6720
      XDTO=XDT                                                          SBPG6730
      YDTO=YDT                                                          SBPG6740
      ZDTO=ZDT                                                          SBPG6750
      ANUMDO=ANUMDT                                                     SBPG6760
      ADENDO=ADENDT                                                     SBPG6770
      IF(PARAM(180).EQ.1.)                                              SBPG6780
     1GO TO 1200                                                        SBPG6790
      ISW=2                                                             SBPG6800
      GO TO 100                                                         SBPG6810
 1200 TLT=0.5*DT                                                        SBPG6820
      V=VO+TLT*(VDT+VDTO)                                               SBPG6830
      W=WO+TLT*(WDT+WDTO)                                               SBPG6840
      P=PO+TLT*(PDT+PDTO)                                               SBPG6850
      Q=QO+TLT*(QDT+QDTO)                                               SBPG6860
      R=RO+TLT*(RDT+RDTO)                                               SBPG6870
      X=XO+TLT*(XDT+XDTO)                                               SBPG6880
      Y=YO+TLT*(YDT+YDTO)                                               SBPG6890
      Z=ZO+TLT*(ZDT+ZDTO)                                               SBPG6900
      PHI=PHIO+TLT*(PHIDT+PHIDTO)                                       SBPG6910
      THE=THEO+TLT*(THEDT+THEDTO)                                       SBPG6920
      PSI=PSIO+TLT*(PSIDT+PSIDTO)                                       SBPG6930
      U=UO+TLT*(UDT+UDTO)                                               SBPG6940
      ANUM=ANUMO+TLT*(ANUMDT+ANUMDO)                                    SBPG6950
      ADEN=ADENO+TLT*(ADENDT+ADENDO)                                    SBPG6960
      PHIOUT=PHI+TLT*PHIDT                                              SBPG6970
      THEOUT=THE+TLT*THEDT                                              SBPG6980
      POUT=P+PDT*TLT                                                    SBPG6990
      QOUT=Q+QDT*TLT                                                    SBPG7000
      ROUT=R+RDT*TLT                                                    SBPG7010
      UOUT=U+UDT*TLT                                                    SBPG7020
      VOUT=V+VDT*TLT                                                    SBPG7030
      WOUT=W+WDT*TLT                                                    SBPG7040
      ZOUT=Z+ZDT*TLT                                                    SBPG7050
      XOUT=X+XDT*TLT                                                    SBPG7060
      YOUT=Y+YDT*TLT                                                    SBPG7070
      PDTOUT=0.5*(3.0*PDT-PDTO)                                         SBPG7080
      QDTOUT=0.5*(3.0*QDT-QDTO)                                         SBPG7090
      RDTOUT=0.5*(3.0*RDT-RDTO)                                         SBPG7100
      PSIOUT=PSI+TLT*PSIDT                                              SBPG7110
      UDTOUT=0.5*(3.0*UDT-UDTO)                                         SBPG7120
      VDTOUT=.5*(3.*VDT-VDTO)                                           SBPG7130
      WDTOUT=0.5*(3.0*WDT-WDTO)                                         SBPG7140
      ANOUT=ANUM+TLT*ANUMDT                                             SBPG7150
      ADOUT=ADEN+TLT*ADENDT                                             SBPG7160
      PO=P                                                              SBPG7170
      QO=Q                                                              SBPG7180
      DDO=DD                                                            SBPG7190
```

```
      RO=R
      UO=U
      VO=V
      WO=W
      XO=X
      YO=Y
      ZO=Z
      PHIO=PHI
      THEO=THE
      PSIO=PSI
      ANUMO=ANUM
      ADENO=ADEN
      IF(PARAM(180).EQ.1.)
     1GO TO 99120
      P=POUT
      Q=QOUT
      R=ROUT
      U=UOUT
      V=VOUT
      W=WOUT
      X=XOUT
      Y=YOUT
      Z=ZOUT
      PHI=PHIOUT
      THE=THEOUT
      PSI=PSIOUT
      ANUM=ANOUT
      ADEN=ADOUT
      IF(PARAM(180).EQ.2.)
     1GO TO 3000
      ISW=3
      GO TO 100
 3000 P=PO
      Q=QO
      R=RO
      U=UO
      V=VO
      W=WO
      X=XO
      Y=YO
      Z=ZO
      PHI=PHIO
      THE=THEO
      PS =PSIO
99120 CONTINUE
C     STEERING AND BRAKING COMMANDS CALCULATED
      DSLM=PARAM(114)/PARAM(116)
      XTMP=PARAM(121)/PARAM(192)
      IF(PARAM(126).NE.0.0)GO TO 4321
      IF(TIME.GT.TST) GO TO 6000
      DELSWC=0.0
      GO TO 7000
 6000 DELSWC=(TIME-TST)*DSLM
      IF(ABS(DELSWC).GT.DSWCM) DELSWC=DSWCM*SIGN(1.0,DELSWC)
      IF(PARAM(128).EQ.3.0)GO TO 7000
      IF( TIME.GT.4.5 )DELSWC=DSWCM*(5.5-TIME)*SIGN(1.0,DELSWC)
 7000 DELSWC=DELSWC*.01745329
      PF=0.0
      IF(TIME.LT.TTI)GO TO 4444
      PF=(TIME-CGAM)*XTMP
```

```
      IF(PARAM(128).EQ.1.0)GO TO 2223
      IF(PARAM(128).EQ.3.0)GO TO 2223
 2222 IF(PF.GT.PFL) PF=PFL
      IF(TIME.LT.CGAM) PF=0.0
      PFR=(TIME-CS)*XTMP
      IF( TIME.GT.CS )PF=PF*(CS-TIME)/10.
      IF(TIME.LT.CS) PFR=0.0
      IF(PFR.GT.PFL) PFR=PFL
      IF( TIME.GT.CS )PFR=PFR*(CS-TIME)/10.
C
C FUNCTION:  FF-FRONT WHEEL BRAKE TORQUE AS A FUNCTION OF FRONT
C            BRAKE LINE PRESSURE
C
C INPUTS:    PFR-FRONT WHEEL BRAKE LINE PRESSURE (PSI)
C            PBF-BRAKE LINE PRESSURE(PSI), ABSISSA USED IN LINEAR
C            INTERPOLATION SUBROUTINE
C            TQBF-FRONT WHEEL BRAKE TORQUE (INCH-POUNDS),ORDINATE USED
C            IN LINEAR INTERPOLATION SUBROUTINE
C
C OUTPUTS:   FF-INTERPOLATED FRONT WHEEL BRAKE TORQUE AS A FUNCTION
C            OF FRONT BRAKE LINE PRESSURE
C
      TQFBR=-FF(PF)
C
C FUNCTION:  FR-REAR WHEEL BRAKE TORQUE AS A FUNCITON OF REAR BRAKE
C            LINE PRESSURE
C
C INPUTS:    PFR-BRAKE LINE PRESSURE(PSI)
C            PBR-BRAKE LINE PRESSURE (PSI),ABSISSA
C            TQBR-REAR WHEEL BRAKE TORQUE (INCH-POUNDS),ORDINATE
C
C OUTPUT:    FR-INTERPOLATED REAR WHEEL BRAKE TORQUE AS A FUNCTION
C            OF REAR BRAKE LINE PRESSURE
C
      TQRBR=-FR(PFR)
      GO TO 2345
 2223 PF=(TIME-CGAM)*XTMP
      IF(PF.GT.PFL) PF=PFL
      PFR=(TIME-CGAM)*XTMP
      IF(PFR.GT.PFL) PFR=PFL
      TQFBR=-FF(PF)
      TQRBR=-FF(PFR)
      IF(TIME.LE.CGAM)TQFBR=0.
      IF(TIME.LE.CGAM) TQRBR=0.
      GO TO 2345
 4444 TQFBR=0.0
      TQRBR=AKTQP*(VC-UOUT)
      IF(TQRBR.GT.TQMAXP) TQRBR=TQMAXP
      GO TO 2345
 4321 CONTINUE
      DELSWC=SIN(3.141593*TIME)          *DSW*.01745329
      IF(TIME.GT.TSW) DELSWC=0.0
      PF=0.0
      TQRBR=0.0
      TQFBR=0.0
      IF(PARAM(125).EQ.0.0)GO TO 2345
      IF(TIME.LE.PARAM(278).OR.TIME.GT.PARAM(279))GO TO 2345
      PF=(TIME-PARAM(278))*26000.0
      IF(PF.GT.PFL) PF=PFL
      TQRBR=-FR(PF)
```

```
      TQFBR=-FF(PF)                                                     SBPG8400
 2345 CONTINUE                                                          SBPG8410
      IF(PARAM(193).NE.0.0)DELSWC=0.01745329*(PARAM(194)*YOUT+PARAM(195)SBPG8420
     1     *YDT)                                                        SBPG8430
      PTB1=PTBR                                                         SBPG8440
      PTB2=PTBR                                                         SBPG8450
      AKK1=1.0                                                          SBPG8460
      AKK2=1.0                                                          SBPG8470
      IF(PARAM(60).EQ.1.0)GO TO 4334                                    SBPG8480
      CALL PTBAK(BETA1,FR1,AKK1,PTB1)                                   SBPG8490
      CALL PTBAK(BETA2,FR2,AKK2,PTB2)                                   SBPG8500
 4334 CONTINUE                                                          SBPG8510
      AMT1=FXU1*(PTB1*SINPS1-YSA1*COSPS1-Z1*(PHI1*COSPS1-PHS1))         SBPG8520
     1   +FYU1*(-PTB1*AKK1*COSPS1-YSA1*SINPS1-Z1*(PHI1*SINPS1-THS1))    SBPG8530
     1     -FR1*(-PTB1*(PHS1*COSPS1+THS1*SINPS1)+YSA1*(THS1*COSPS1-     SBPG8540
     1       PHS1*SINPS1)-Z1*(PHS1*PHI1*SINPS1-THS1*PHI1*COSPS1))       SBPG8550
      AMT2=FXU2*(PTB2*SINPS2-YSA2*COSPS2-Z2*(PHI2*COSPS2-PHS2))         SBPG8560
     1   +FYU2*(-PTB2*AKK2*COSPS2-YSA2*SINPS2-Z2*(PHI2*SINPS2-THS2))    SBPG8570
     1     -FR2*(-PTB2*(PHS2*COSPS2+THS2*SINPS2)+YSA2*(THS2*COSPS2-     SBPG8580
     1       PHS2*SINPS2)-Z2*(PHS2*PHI2*SINPS2-THS2*PHI2*COSPS2))       SBPG8590
      AMT1 = SWMT*AMT1                                                  SBPG8600
      AMT2 = SWMT*AMT2                                                  SBPG8610
      NNN=PARAM(198)/(PARAM(75)*UOUT)+0.5                               SBPG8620
      XI(1)=XOUT+A*CZ-TFO2*SN                                           SBPG8630
      XI(2)=XOUT+A*CZ+TFO2*SN                                           SBPG8640
      XI(3)=XOUT-B*CZ-TRO2*SN                                           SBPG8650
      XI(4)=XOUT-B*CZ+TRO2*SN                                           SBPG8660
      NBMP=PARAM(277)+0.5                                               SBPG8670
      IF(NBMP.EQ.0) GO TO 8499                                          SBPG8680
      DO 8498 I=1,4                                                     SBPG8690
      DELX(I)=GETDEL(XI,I,PARAM(200),NBMP)                              SBPG8700
      GETDL = GETDL + DELX(I)                                           SBPG8710
 8498 CONTINUE                                                          SBPG8720
 8499 CONTINUE                                                          SBPG8730
C     CALCULATION OF ANTI PITCH AND ROLL FORCES                         SBPG8740
C     FOR SOLID AXLE DEL3 IS REAR AXLE VERTICAL ROLL CENTER             SBPG8750
C     DL3S AND DL4S ARE REAR WHEEL SUSPENSION DEFLECTIONS               SBPG8760
      AP1 = (CP0F + CP1F*DL1S + CP2F*DL1S*DL1S) * FXUT(1)               SBPG8770
      AP2 = (CP0F + CP1F*DL2S + CP2F*DL2S*DL2S) * FXUT(2)               SBPG8780
      AP3 = (CP0R + CP1R*DL3S + CP2R*DL3S*DL3S) * FXUT(3)               SBPG8790
      AP4 = (CP0R + CP1R*DL4S + CP2R*DL4S*DL4S) * FXUT(4)               SBPG8800
      AR1 = -(CR0F + CR1F*DL1S + CR2F*DL1S*DL1S) * FYUT(1)              SBPG8810
      AR2 =  (CR0F + CR1F*DL2S + CR2F*DL2S*DL2S) * FYUT(2)              SBPG8820
      AR3 = -(CR0R + CR1R*DL3S + CR2R*DL3S*DL3S) * FYUT(3)              SBPG8830
      AR4 =  (CR0R + CR1R*DL4S + CR2R*DL4S*DL4S) * FYUT(4)              SBPG8840
      ANTI1 = AP1 + AR1 - FBS1                                          SBPG8850
      ANTI2 = AP2 + AR2 - FBS2                                          SBPG8860
      ANTI3 = AP3 + AR3 - FBS3                                          SBPG8870
      ANTI4 = AP4 + AR4 - FBS4                                          SBPG8880
C     LONGITUDINAL AND LATERAL ACCELERATION CALCULATION                 SBPG8890
      ETAX=(UDTOUT-VOUT*ROUT+WOUT*QOUT)/386.4                           SBPG8900
      ETAL=(VDTOUT+ROUT*UOUT-WOUT*POUT)/386.4                           SBPG8910
      BTV=VOUT/UOUT                                                     SBPG8920
      BTVDT=(UOUT*VDTOUT-VOUT*UDTOUT)/(UOUT*UOUT)                       SBPG8930
      ONER=(ROUT+BTVDT)/SQRT(UOUT**2+VOUT**2)                           SBPG8940
C     COMPARISON VARIABLE DATA COLLECTION                               SBPG8950
      IF(IVHTP.GT.2) GO TO 402                                          SBPG8960
C     COMPARISON VARIABLES FOR VHTP # 1                                 SBPG8970
C     AXAVE = AVERAGE LONGITUDINAL DECELERATION                         SBPG8980
      IF(U.GT.(UIN-88.)) GO TO 400                                      SBPG8990
```

```
      AXI = AXI + ETAX                                                  SBPG9000
      GO TO 401                                                         SBPG9010
 400  TIMIN5 = TIME                                                     SBPG9020
 401  CONTINUE                                                          SBPG9030
      TIMDEC  = TIME - TIMIN5                                           SBPG9040
  402 CONTINUE                                                          SBPG9050
      IF(IVHTP.NE.2) GO TO 412                                          SBPG9060
C     VHTP #2 COMPARISON VARIABLES                                      SBPG9070
C     AVERAGE PATH CURVATURE RATIO , CUVRAT                             SBPG9080
C     AVERAGE LONGITUDINAL DECELERATION, AXAVE                          SBPG9090
C     PEAK BODY SIDESLIP RATE, BETDMX                                   SBPG9100
      IF (TIME.LT.CGAM) GO TO 410                                       SBPG9110
      IF( TIME.GT.(CGAM + 1.)) GO TO 411                                SBPG9120
      CURVAV = CURVAV + ONER                                            SBPG9130
      ABBTV = ABS(BTV)                                                  SBPG9140
      ABTVDT = ABS(BTVDT)                                               SBPG9150
      IF(ABBTV.GT.BETAMX) BETAMX = ABBTV                                SBPG9160
      IF(ABTVDT.GT.BETDMX) BETDMX = ABTVDT                              SBPG9170
      GO TO 411                                                         SBPG9180
 410  CURTBP = ONER                                                     SBPG9190
 411  CONTINUE                                                          SBPG9200
  412 CONTINUE                                                          SBPG9210
      IF(IVHTP.NE.3) GO TO 422                                          SBPG9220
C     VHTP #3                                                           SBPG9230
      IF((GETDL.LE.0.).AND.(JUMP.EQ.0)) GO TO 420                       SBPG9240
      IF(TIME.GT.(TIMBMP + 1))  GO TO 421                               SBPG9250
      JUMP =1                                                           SBPG9260
      CURVAV = CURVAV + ONER                                            SBPG9270
      ABTVDT = ABS(BTVDT)                                               SBPG9280
      ABBTV  = ABS(BTV)                                                 SBPG9290
      IF(ABTVDT.GT.BETDMX) BETDMX = ABTVDT                              SBPG9300
      IF(ABBTV.GT.BETAMX) BETAMX = ABBTV                                SBPG9310
      GO TO 421                                                         SBPG9320
  420 CURTBP = ONER                                                     SBPG9330
      TIMBMP =  TIME                                                    SBPG9340
  421 CONTINUE                                                          SBPG9350
  422 CONTINUE                                                          SBPG9360
      IF(IVHTP.NE.4) GO TO 432                                          SBPG9370
C     VHTP #4  COMPARISON VARIABLES                                     SBPG9380
      IF(TIME.LT.TST) GO TO 430                                         SBPG9390
      IF(TIME.GT.(TST + 2.)) GO TO 431                                  SBPG9400
      CURVAV = CURVAV + ONER                                            SBPG9410
      ABTVDT = ABS(BTVDT)                                               SBPG9420
      ABBTV  = ABS(BTV)                                                 SBPG9430
      IF(ABTVDT.GT.BETDMX) BETDMX = ABTVDT                              SBPG9440
      IF(ABBTV.GT.BETAMX) BETAMX = ABBTV                                SBPG9450
      DELBET = BETAMX - BETA                                            SBPG9460
      GO TO 431                                                         SBPG9470
 430  BETA = BTV                                                        SBPG9480
 431  CONTINUE                                                          SBPG9490
  432 CONTINUE                                                          SBPG9500
      IF(IVHTP.NE.5) GO TO 442                                          SBPG9510
C     VHTP #5  COMPARISON VARIABLES                                     SBPG9520
      IF(TIME.GT.3.4) GO TO 450                                         SBPG9530
      IF(DSW.GT.0) GO TO 460                                            SBPG9540
      DELSTR= DELSTR + ABS(Y + 144.)                                    SBPG9550
      GO TO 461                                                         SBPG9560
  460 CONTINUE                                                          SBPG9570
      DELSTR=DELSTR + ABS(Y - 144.)                                     SBPG9580
  461 CONTINUE                                                          SBPG9590
```

```
      ABBTV = ABS(BTV)
      IF(ABBTV.GT.BETAMX) BETAMX = ABBTV
      DELPSI = PSI
  450 CONTINUE
  442 CONTINUE
C     VHTP #6 COMPARISON VARIABLE
      IF(ABS(PHI).GT.PHIMAX) PHIMAX = ABS(PHI)
      IF(ABS(PHIDT).GT.PHIDMX) PHIDMX = ABS(PHIDT)
      IF(ABS(ETAL).GT.AYMAX) AYMAX= ABS(ETAL)
      IF(ABS(R).GT.RMAX) RMAX = ABS(R)
      FXL1=AML1*RRIM*ARPS1*ARPS1*WCTH1
      FXL2=AML2*RRIM*ARPS2*ARPS2*WCTH2
      FZL1=AML1*RRIM*ARPS1*ARPS1*WSTH1
      FZL2=AML2*RRIM*ARPS2*ARPS2*WSTH2
C     PREPARATION OF VARIABLES TO BE OUTPUT ON D/A CONVERTERS
      TEMP = (AMT1 + ALTQ(1)) / AIFW - RDTOUT
      TEMP=TEMP+(-FXL1*(YSA1+RWR/2.0))/AIFW
      IOUT(01)=- TEMP*SFOUT(9)*PARAM(175)
      TEMP=RZF+ZOUT-A*THEOUT+TFO2*PHIOUT
      TEMP=TEMP-DELX(1)
      IOUT(02)=TEMP*SFOUT(10)
      TEMP = (AMT2 + ALTQ(2))/ AIFW - RDTOUT
      TEMP=TEMP+(-FXL2*(YSA2+RWR/2.0))/AIFW
      IOUT(03)=- TEMP*SFOUT(9)*PARAM(175)
      TEMP=RZF+ZOUT-A*THEOUT-TFO2*PHIOUT
      TEMP=TEMP-DELX(2)
      IOUT(04)=TEMP*SFOUT(10)
      TEMP= (AM21-AM11)*0.05
      IOUT(05)=TEMP
      TM1=TFO2*PDTOUT
      TM2=A*QDTOUT
      TM3=CIP
      TEMP=-TM1+TM2+TM3-FYU1*SPSR3
      IOUT(06)=TEMP*SFOUT(14)*PARAM(175)
      TEMP= (AM22-AM12)*0.05
      IOUT(07)=TEMP
      TEMP= TM1+TM2+TM3+FYU2*SPSR3
      IOUT(08)=TEMP*SFOUT(14)*PARAM(175)
      IOUT(09)=-TQFBR*0.25*SFOUT(14)
      IOUT(10)=-TQRBR*0.25*SFOUT(14)
      IOUT(11)=DELSEC/10.0
      IOUT(12) = 0
      TEMP=(-TRO2-Z3*PHIR)
      IOUT(13)=TEMP*SFOUT(25)*PARAM(175)
      TEMP=CIVP-B*QDTOUT
      IOUT(14) =      TEMP*SFOUT(14)*PARAM(175)
      TEMP=(TRO2-Z4*PHIR)
      IOUT(15)=TEMP*SFOUT(27)*PARAM(175)
      TEMP=-PDTOUT-(FYU3*(TRO2*PHIR-Z3)+FYU4*(-TRO2*PHIR-Z4))/AIR
      TEMP = TEMP - ((FYU3+FYU4)*HRC - FOTM)/AIR
      IOUT(16)=TEMP*SFOUT(28)*PARAM(175)
      TEMP= (AM23-AM13)*0.05
      IOUT(17)=TEMP
      TEMP=(RZR+ZOUT+B*THEOUT+PHIOUT*TRO2)
      TEMP=TEMP-DELX(3)
      IOUT(18)=TEMP*SFOUT(10)
      TEMP= (AM24-AM14)*0.05
      IOUT(19)=TEMP
      TEMP=(RZR+ZOUT+B*THEOUT-PHIOUT*TRO2)
      TEMP=TEMP-DELX(4)
```

```
      IOUT(20)=TEMP*SPOUT(10)
      IOUT(21)  = U01*0.05
      IOUT(22)  = U02*0.05
      IOUT(23)  = AM11*.05
      IOUT(29)  = AM12*.05
      IOUT(25)=UG1P*SPOUT(37)
      IOUT(26)=UG2P*SPOUT(37)
      IOUT(27)=UG3P*SPOUT(37)
      IOUT(24)=UG4P*SPOUT(37)
      IOUT(28)  = U03*.05
      IOUT(30)  = U04*.05
      IOUT(31)  = AM13*.05
      IOUT(32)  = AM14*.05
      IOUT(33)  = -SI1
      IOUT(34)  = -SI2
      IOUT(35)  = -SI3
      IOUT(36)  = -SI4
      IOUT(37)=0
      IF(IAX.EQ.1)GO TO 7719
      TEMP    =G*(1.+A*AMS/(AMUR*(A+B)))-B*QDTOUT-TRO2*PDTOUT
     1         -FYU3*SPSR4
      IOUT(12)=TEMP*SPOUT(14)*PARAM(175)
      TEMP    =G*(1.+A*AMS/(AMUR*(A+B)))-B*QDTOUT+TRO2*PDTOUT
     1         +FYU4*SPSR4
      IOUT(37)=TEMP*SPOUT(14)*PARAM(175)
      IOUT(13)=C
      IOUT(16)=0
 7719 CONTINUE
      IF(UOUT.GE.25.0*5280.*12.0/3600.0)TIME25=TIME
      IF(UOUT.GE.10.0*5280.*12.0/3600.0)TIME10=TIME
      TEMPE=ABS(ROUT*57.29578)
      IF(TEMPE.GT.RMAX)RMAX=TEMPE
      TEMPE=ABS(ETAL)
      IF(TEMPE.GT.ETAMAX)ETAMAX=TEMPE
      TEMPE=ABS(PHIOUT*57.29578)
      IF(TEMPE.GT.PHIMAX)PHIMAX=TEMPE
      TEMPE=ABS(DELSWC*57.29578)
      IF(TEMPE.GT.DSWMAX)DSWMAX=TEMPE
      IF(TIME.LE.5.0)PSI5=PSIOUT*57.29578
      DO 3147 I=1,48
      DACO(I)=BVALUE(DACPLA(I))/SCALEC(I)
      SDACO=DACO(I)
      DACO(I)=AMAX1(-.9995,(AMIN1(.9995,DACO(I))))
      IF(SDACO.EQ.DACO(I)) GO TO 8317
      IDACK=IDACK+1
      IF(IDACK.GT.10) IDACK=10
      IFRDAC(IDACK)  = I
      TFRDAC(IDACK)=TIME
 8317 CONTINUE
 3147 CONTINUE
      IF(ABS(PSIOUT).GT.ABS(PSIM))PSIM=PSIOUT
      TEMPE=ABS(TORBR)
      IF(TEMPE.GT.TORMAX)TORMAX=TEMPE
      TEMPE=ABS(TOFBR)
      IF(TEMPE.GT.TOFMAX)TOFMAX=TEMPE
      TEMPE=ABS(PSIOUT)
      IF(TEMPE.GT.PSIMAX)PSIMAX=TEMPE
      NUMBR = NUMBR + 1
C     DATA COLLECTION FOR TRACK OPTION
      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.3999) JIN=3999
      ATRACK(JIN)=BVALUE(J)
 8199 CONTINUE
 8185 CONTINUE
      RETURN
      END
```

## 2.1.5 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
      SUBROUTINE VHTPIC
C     THIS SUBROUTINE INITIALIZES FOR A VHTP MANEUVER
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      REAL*4 VHTPAR(27,7)
      INTEGER*4 PARMNO(27),SAVE/1/,NUMPRM/27/
      INTEGER*4 IONE/0/
      IF(IONE.GE.1) GO TO 40
      ICDRD = 1
      READ(ICDRD,100) (PARMNO(J),(VHTPAR(J,I),I=1,7),J=1,NUMPRM)
  100 FORMAT(I3,1X,7F10.3)
      IONE = IONE + 1
   40 CONTINUE
      I = IFIX(PARAM(129)) + 1
      IF(I.EQ.1) GO TO 10
      IF((I.GE.2).AND.(SAVE.NE.1)) GO TO 10
C     IF I = 1 ORIGINAL DATA MUST BE RESTORED
C     IF IIS NOT = 1 MUST DECIDE TO STORE DATA
C     IF I NE 1 AND OLD I NE 1 DO NOT STORE
      DO 20 J=1,NUMPRM
      VHTPAR(J,1) = PARAM(PARMNO(J))
   20 CONTINUE
   10 CONTINUE
      DO 30 J=1,NUMPRM
      PARAM(PARMNO(J)) = VHTPAR(J,I)
   30 CONTINUE
      SAVE = PARAM(129)
      IF(PARAM(129).EQ.4) PARAM(114)=PARAM(42)*((PARAM(6)+PARAM(7)))/60.
      IF(PARAM(129).EQ.5) PARAM(123)=66.*(PARAM(6)+PARAM(7))*PARAM(42)
     1 / (PARAM(66)*88.)
      IF(PARAM(129).EQ.6) PARAM(123)=PARAM(42)*(PARAM(6)+PARAM(7))
     1 / 7.5
      RETURN
      END
```

## 2.1.6 CMPVAR

PRESENTED HERE IS THE FORTRAN LISTING FOR THE COMPARISON VARIABLE (CV) CALCULATION SUBPROGRAM. THE CALCULATION AND OUTPUT OF THE CV'S ARE PERFORMED IN CMPVAR FOLLOWING EACH SIMULATION RUN.

```
C     SUBROUTINE CMPVAR
      SUBROUTINE CMPVAR
C     THIS SUBROUTINE CALCULATES THE COMPARISON VARIABLES
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,
     1               AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBFT,DELPSI,BETAMX,
     1               TIMBMP,GETDL,TIMIN5,        DT,        IVHTP
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      DATA CURV1G/.00078/
      DATA LPTR/2/
C     CALCULATION OF COMPARISON VARIABLES
      IF(TIMDEC.EQ.0.) TIMDEC=.00000001
      IF(CURTBP.EQ.0. ) CURTBP=.00000001
      GO TO(1,2,3,4,5,6), IVHTP
      AXAVE = AXI*DT/TIMDEC
      GO TO 10
    1 CONTINUE
      AXAVE = AXI*DT/TIMDEC
      GO TO 10
    2 CONTINUE
      AXAVE = AXI*DT/TIMDEC
      CUVRAT =  CURVAV * DT/CURTBP
      GO TO 10
    3 CONTINUE
      CUVRAT =  CURVAV * DT/CURTBP
      GO TO 10
    4 CONTINUE
      CUVRAT =  CURVAV*.5*DT/CURV1G
      GO TO 10
    5 CONTINUE
      DEL= (DELSTR*DT/3.4)/12.
    6 CONTINUE
   10 CONTINUE
      RMAX = RMAX/57.3
      WRITE(LPTR,2345) AXAVE,TIMDEC,CUVRAT,BETDMX,BETAMX,DELBFT,
     1AYMAX,PHIMAX,RMAX,DEL,DELPSI,DSWMAX,TQFMAX,TQRMAX
 2345 FORMAT('0 AXAV=',F8.3,' DECL TIME=',F8.3,' AVCUR=',F8.3,' BTDMAX='
     1,F8.3,' BTMAX=',F8.3,' DELBT=',F8.3/
     1'0AYMAX=',F8.3,' PHIMAX=',F8.3,' RMAX=',F8.3,' LANE CHNG DEL=',
     1F8.3,' DELPSI=',F8.3,' MAX STEER=',F8.3/
     1'0FTRQMAX=',F9.3,' RTRQMAX=',F9.3/)
      RETURN
      END
```

### 2.1.7 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
       SUBROUTINE RTMON
C      THIS SUBROUTINE INITIALIZES FOR REAL TIME OPERATION
       COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
       COMMON /RBBLK/ AD2RB ,AD1RB ,CLSRB ,CLRRB ,ICRB  ,OPRB ,PILRB
       COMMON /RBBLK/ TCNBUF,TIMBUF,LDARB ,TDARB ,PILRB1
       COMMON/RBBLK/SLRB05,RLRB05
       COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAECB,TDAECB
       COMMON /ECBBLK/AD2ECB,AD1ECB,CLSECB,CLRECB,ICECB ,OPECB
       COMMON /ECBBLK/OSECB ,DONECB
       COMMON/ECBBLK/SLECB5,RLECB5
       COMMON/INOUT/INA(32),IOUTA(48),IN(32),IOUT(48),ISW1,ISW7,SFIN(32),
     1     SFOUT(48),IPRT,ITMP(48)
C
       REAL*8                 PILRB(3)    ,LDARB(23)   ,TCNBUF(8)
       REAL*8      TIMBUF(8)
       REAL*8      SAVE2(16)   ,PILRB1(3)   ,AD2RB(6)    ,AD1RB(6)
       REAL*8      CLRRB(6)    ,OPRB(6)     ,TDARB(6)
       REAL*8      SAVE0(16)   ,SAVE1(16)   ,CLSRB(6)    ,ICRB(6)
       REAL*8  SLRB05(6),RLRB05(6)
C
       REAL*4      IOUT   ,IN     ,ITMP
       REAL*4      ADC2(04)    ,ADC1(24)
C
       INTEGER*4              TCNECB      ,TIMECB
       INTEGER*4   CONSL/01/  ,PILECB     ,ADAECB      ,TDAECB
       INTEGER*4   RCL0/00/   ,CLRECB     ,IMODOP/34/  ,OPECB
       INTEGER*4   F2/20/     ,L2/23/     ,FIRST/00/   ,LAST/47/
       INTEGER*4              NONE/00/    ,AD2ECB      ,AD1ECB
       INTEGER*4   SCL0/00/   ,CLSECB     ,IMODIC/06/  ,ICECB
       INTEGER*4     MONE/-1/   ,F1/00/     ,L1/23/
       INTEGER*4   TDAECB
       INTEGER*4   OSECB      ,DONECB
       INTEGER*4  SCL05/5/,RCL05/5/,SLECB5,RLECB5
C
       INTEGER*2              NUMEVT/03/ ,ZERO/00/
       INTEGER*2   UNIT/19/
       INTEGER*2 TWO/02/
       INTEGER*2   RTSW  ,RBSW  ,LDTSW ,OPEN  ,OPDN
C
       EQUIVALENCE (ADC1(24),IN(24))       ,(ADC2(1),IN(25))
C
       EXTERNAL         INIT,CART ,ENDRUN,HYBINT
C
       IF( RBSW.EQ.1 ) GO TO 200
          CALL BLJCB( 'J007',OSECB,NUMEVT,NONE )
          CALL DEFEP( INIT,SAVE0,ZERO,'NONE','NO' )
          CALL DEFEP( ENDRUN,SAVE1,ZERO,'NONE','NO' )
          CALL DEFEP( CART,SAVE2,ZERO,'NONE','NO' )
          CALL CRBCRB( F1,L1,ADC1,AD1RB,AD1ECB,CONSL )
          CALL CRBCRB( F2,L2,ADC2,AD2RB,AD2ECB,CONSL )
          CALL TLDARB( TDARB,TDAECB,CONSL )
          CALL SSCLRB( SCL0,CLSRB,CLSECB,CONSL )
          CALL SSCLRB(SCL05,SLRB05,SLECB5,CONSL)
          CALL RSCLRB( RCL0,CLRRB,CLRECB,CONSL )
          CALL RSCLRB(RCL05,RLRB05,RLECB5,CONSL)
          CALL SAMORB( IMODIC,ICRB,ICECB,CONSL )
          CALL SAMORB( IMODOP,OPRB,OPECB,CONSL )
          OPDN   = 0
```

```
      RBSW   = 1
200 CONTINUE
    IF( RTSW.EQ.0 ) GO TO 210
    IF( OPDN.EQ.1 ) GO TO 205
      OPDN   = 1
      CALL RTOPN
      CALL RTACT( ZERO,'J007' )
205 CONTINUE
      CALL DEFPR( UNIT,HYBINT,'J007' )
      LDTSW  = 0
      OSECB  = 0
      CALL RTACT( TWO ,'J007' )
      CALL WAITRT( OSECB )
      CALL WAITBU( 200 )
      CALL DEFPR( UNIT,MONE,'J007' )
    GO TO 215
210 CONTINUE
      CALL LBDAFP( FIRST,LAST,IOUT,IERR )
      CALL TLDA
      CALL RSCL( SCLO,ICLERR )
      CALL CRBCFP( F2,L2,ADC2,ICRBCE )
      CALL SSCL( RCLO,ICLERR )
      CALL CRBCFP( F1,L1,ADC1,ICRBCE )
      CALL SBPG2
215 CONTINUE
    RETURN
    END
```

## 2.1.8 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) Initiation 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
      SUBROUTINE RTIME
C     THIS SUBROUTINE PROVIDES THE REAL TIME SEQUENCING
      COMMON/APL/ OPEN   ,RTSW   ,LDTSW  ,RBSW
      COMMON /RBBLK/ AD2RB ,AD1RB ,CLSRB ,CLRRB ,ICRB   ,OPRB ,PILRB
      COMMON /RBBLK/ TCNBUF,TIMBUF,LDARB ,TDARB  ,PILRB1
      COMMON/RBBLK/SLRB05,RLRB05
      COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAECB,TDAECB
      COMMON /ECBBLK/AD2ECB,AD1ECB,CLSECB,CLRECB,ICECB ,OPECB
      COMMON /ECBBLK/OSECB  ,DONECB
      COMMON/ECBBLK/SLECB5,RLECB5
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1    YO,ZO,THEO,PHIO,PSIO
      COMMON/INOUT/INA(32),IOUTA(48),IN(32),IOUT(48),ISW1,ISW7,SFIN(32),
     1      SFOUT(48),IPRT,ITMP(48)
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/NONAME/XEND,O,EXIT2
      DIMENSION CSI(4),XBM(4),SLP(4)
      REAL*8         BUFF(8)      ,PILRB(3)     ,LDARB(23)    ,TCNBUF(8)
      REAL*8         TIMBUF(8)
      REAL*8                                     CLSRB(6)     ,ICRB(6)
      REAL*8                       PILRB1(3)    ,AD2RB(6)     ,AD1RB(6)
      REAL*8         CLRRB(6)     ,OPRB(6)      ,TDARB(6)
      REAL*8       BUFF1(8)
      REAL*8   SLRB05(6),RLRB05(6)
C
      REAL*4         IOUT   ,IN     ,ITMP
      REAL*4         ADC2(04)     ,ADC1(24)
C
      INTEGER*4    TIMCAN       ,TCNECB       ,TIMECB
      INTEGER*4    CONSL/01/    ,PILECB       ,ADAECB       ,TDAECB
      INTEGER*4                  EVTRET/02/  ,TIMINT/120000/
      INTEGER*4 SLECB5,RLECB5 ,              FIRST/00/   ,LAST/47/
      INTEGER*4 CLRECB,OPECB,AD2ECB,AD1ECB,CLSECB,ICECB
      INTEGER*4    TDAECB       ,STATUS
      INTEGER*4    OSECB        ,DONECB
      INTEGER*4   PILCB1
C
      INTEGER*2    PILIST(2)/1,0/,EVTLST/1/
      INTEGER*2    TWO  /02/ ,ONE/01/
      INTEGER*2    RTSW   ,RBSW   ,LDTSW  ,OPEN
C
      EQUIVALENCE (ADC1(24),IN(24))        ,(ADC2(1),IN(25))
C
C     EVENT 0
C
      ENTRY INIT
         CALL PGET( PILIST, 0   ,'J007',PILRB1 )
         PILECB = 0
         CALL PCAN( PILIST,BUFF,PILECB )
         CALL HIOCHK( PILECB )
         CALL PEVT( PILIST,EVTLST,'J007',PILRB )
         DONECB = 0
         CALL HWAIT( DONECB )
         CALL PREL( PILIST,'J007',PILRB1 )
         CALL HDONE( 'DN' )
      CALL HEXIT
```

```
C
C     EVENT 1
C
      ENTRY ENDRUN
      TCNECB = 0
         CALL RDTIMR( TIMCAN,TCNECB,'CANC',TCNBUF )
         CALL HIOCHK( TCNECB )
         PILECB = 0
         CALL PDAC( PILIST,BUFF,PILECB )
         CALL HIOCHK( PILECB )
         PILECB = 0
         CALL PCAN( PILIST,BUFF,PILECB )
         CALL HIOCHK( PILECB )
      ICECB  = 0
         CALL HIOREQ( ICRB )
         CALL HIOCHK( ICECB )
         CALL RTCAN( TWO   ,STATUS )
         CALL HCSPST( 'FN' )
      CALL HEXIT
C
C     EVENT 2
C
      ENTRY CART
      IF( LDTSW.EQ.1 ) GO TO 230
      PILCB1 = 0
         CALL PACT( PILIST,BUFF1,PILCB1 )
         CALL HIOCHK ( PILCB1 )
      TIMECB = 0
      TIMINT = 1.E06*DT/PARAM(175)
         CALL LDTIME( TIMINT,TIMECB,EVTRET,TIMBUF )
      OPECB  = 0
         CALL HIOREQ( OPRB )
         CALL HIOCHK( OPECB )
         LDTSW  = 1
  230 CONTINUE
      SLECB5=0
      CLRECB = 0
      TDAECB = 0
      AD2ECB = 0
      CLSECB = 0
      AD1ECB = 0
         CALL HIOREQ(SLRB05)
         CALL HIOREQ( CLRRB )
         CALL HIOREQ( TDARB )
         CALL HIOREQ( AD2RB )
         CALL HIOREQ( CLSRB )
         CALL HIOREQ( AD1RB )
         CALL HIOCHK(SLECB5)
         CALL HIOCHK( CLRECB )
         CALL HIOCHK( TDAECB )
         CALL HIOCHK( AD2ECB )
         CALL HIOCHK( CLSECB )
         CALL HIOCHK( AD1ECB )
         CALL SPPG2
      ADAECB = 0
      RLECB5=0
         CALL LBDART( FIRST,LAST,IOUT,LDARB ,ADAECB,CONSL )
         CALL HIOREQ(RLRB05)
         CALL HIOCHK( ADAECB )
         CALL HIOCHK(RLECB5)
```

```
C     APL WILL TERMINATE REAL-TIME RUN IF EITHER
C     CONDITION SHOWN BELOW IS SATISFIED
      O=SQRT(U*U+V*V)
      IF(U.LE.0.1)CALL RTACT(ONE,'J007')
      IF(PHIMAX.GT.18.) CALL RTACT(ONE,'J007')
      IF(( ISW1.EQ.1 ).OR.( ISW7.EQ.1 )) CALL RTACT( ONE    ,'J007' )
      IF( TIME.LE.XEND.AND.O.GE.EXIT2 ) GO TO 250
      CALL RTACT( ONE,'J007' )
  250 CONTINUE
      CALL HEXIT
      RETURN
      END
```

## 2.1.9 ERMONT

PRESENTED HERE IS THE FORTRAN LISTING FOR THE ABNORMAL SIMULATION OPERATION SUBPROGRAM. THE CONDITIONS OF VEHICLE ROLL-OVER AND DIGITAL-TO-ANALOG CONVERTER OVERLOAD ARE DETECTED BY ERMONT WHEN SINGLE RUN EXECUTION IS PERFORMED.

```
C     SUBROUTINE ERMONT(MOPU,ORNAME,NAMDAC,IDAC,PHIMAX)
      SUBROUTINE ERMONT(MOPU,ORNAME,NAMDAC,IDAC,PHIMAX)
C     THIS SUBROUTINE CHECKS FOR ERROR CONDITIONS AT RUN TERMINATION
      COMMON/EMON/IERDAC(10),TERDAC(10),IDACK,IENDR(20),IOR
      INTEGER*2         IDAC(48),NAMDAC(48)
      REAL*8 ORNAME(400)
      IF(PHIMAX.LT.19.) GO TO 200
      WRITE(MOPU,205) PHIMAX
  205 FORMAT(' VEHICLE ROLL OVER PHIMAX=',F8.2)
  200 CONTINUE
      IF(IDACK.LT.1) GO TO 100
      WRITE(MOPU,105)
      WRITE(MOPU,106)
      WRITE(MOPU,107) (TERDAC(J),ORNAME(NAMDAC(IERDAC(J))),
     1 IDAC(IERDAC(J)),J=1,IDACK)
  105 FORMAT(' DAC OVERLOAD')
  106 FORMAT('  TIME       VAR')
  107 FORMAT(F8.2,2X,A6,'(',I4,')')
  100 CONTINUE
      RETURN
      END
```

2.1.10 POTCHK

PRESENTED HERE IS THE FORTRAN LISTING FOR THE POTENTIOMETER SETTING CHECK SUBPROGRAM. CORRECT SETTING OF EACH POTENTIOMETER IS VERIFIED IN POTCHK. IF A SETTING ERROR IS DETECTED, APPROPRIATE OPTIONS OF CONTINUE, RETRY, OR RETURN TO THE OPTION COMMAND ARE PRESENTED TO THE USER.

```
C     SUBROUTINE POTCHK(IPOT,IVAL,ITOL,*,*)
      SUBROUTINE POTCHK(IPOT,IVAL,ITOL,*,*)
C     THIS SUBROUTINE CHECKS FOR INCORRECT POTENTIOMETER SETTINGS
C       IPOT IS THE POTENTIOMETER ADDRESS
C       IVAL IS THE POTENTIOMETER VALUE
C       ITOL IS THE POTENTIOMETER SETTING TOLERANCE
C       THE ASTERISKS(*) IN THE ARGUMENT LIST ARE DUMMY STATEMENT LABLES
C       CORRESPONDING TO THE AMPERSANDS(&) LABLE STATEMENTS IN CALLING
C       PROGRAM
C
      KEYBD = 5
      ITTY  = 6
      ITOL = 3
  100 CALL SPOT(IPOT,IVAL,ITOL,ISPOTE)
C       CHECK FOR POT FAILURE    ***
      IF(ISPOTE.EQ.0) GO TO 200
C
C       WRITES OUT NUMBER AND VALUE OF POT THAT FAILED  ***
      WRITE(ITTY,6000) IPOT,IVAL
 6000 FORMAT(1X,' POT',I3,T11,'DID NOT SET TO ',I5)
C
C       WRITES OUT PROGRAM OPTIONS FOR POT FAILURE  ***
      WRITE(ITTY,6010)
 6010 FORMAT(1X,' TYPE 1 (RETRY),2 (CONTINUE),3 (RESTART),4 (STOP)')
C
C       READS IN PROGRAM RETURN OPTIONS IN I1 FORMAT   ***
      READ(KEYBD,6020) I
 6020 FORMAT(I1)
C
C       GO TO STATEMENTS FOR PROGRAM RETURN OPTIONS   ***
      GO TO (100,200,300,400),I
C
C       PROGRAM RETURN STATEMENTS   ***
  200 RETURN
  300 RETURN 1
  400 RETURN 2
C       RETURN  -    RETURN TO NEXT STATEMENT IN CALLING PROGRAM
C       RETURN 1&2 RETURNS TO THE 1ST&2ND (&) LABLE STATEMENTS IN THE
C       CALLING PROGRAM
C       FOR REFERENCE SEE IBM FORTRAN IV LANGUAGE MANUAL PAGES 96-98
      END
```

## 2.2 FUNCTIONS

PRESENTED HERE IS THE FORTRAN LISTING FOR THE FUNCTION SUBPROGRAMS CALLED BY THE MODEL SUBPROGRAM. THE FOLLOWING LIST DETAILS THE FUNCTION NAMES AND THEIR USE:

| FUNCTION | USE |
|---|---|
| FF | Calculation of Front Wheel Brake Torque |
| FR | Calculation of Rear Wheel Brake Torque |
| FCSI | Calculation of the Wheel Slip Side Force Shaping Function |
| PTBAK | Calculation of a Caster Trail Function |
| GETDEL | Calculation of Bumps for VHTP #3 |
| XINT | Linear Interpolation of Function Values between 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)
      FUNCTION FF(P)
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      FF=XINT(P,PBF,TQBF,NTF)
      RETURN
      END
```

```
C     FUNCTION FR(P)
      FUNCTION FR(P)
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      FR=XINT(P,PBR,TQBR,NTR)
      RETURN
      END
```

```
C     FUNCTION FCSI(GAMI,SIPI)                                          CFUN
      FUNCTION FCSI(GAMI,SLPI)                                          CFUN
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),                  CFUN
     1AFA(20),GAMF(20),NTF,NTR,NFA                                      CFUN
      TMP=ABS(SLPI)                                                     CFUN
      FCSI = XINT(TMP,GAMF,AFA,NFA)                                     CFUN
      RETURN                                                            CFUN
      END                                                               CFUN
```

```
C     SUBROUTINE PTBAK(BET,FRI,AKKI,PTBI)
      SUBROUTINE PTBAK(BET,FRI,AKKI,PTBI)
      COMMON/PTBK/AP1,AP2,AP3,AP4,AP5,BTC1,BTC2
      AP5=600.
      AKKI=AP4+FRI/AP5
      TEMP=ABS(BET*57.29578)
      PTBI=AP1
      IF(TEMP.LE.BTC1) RETURN
      PTBI=AP3
      IF(TEMP.GT.BTC2) RETURN
      PTBI=AP1*(1.0-(TEMP-BTC1)*AP2)
      RETURN
      END
```

```
C     FUNCTION GETDEL(X,I,R5,NBMP)
      FUNCTION GETDEL(X,I,R5,NBMP)
C     THIS SUBROUTINE PRODUCES THE BUMPS FOR VHTP #3
      COMMON/XBS/XB(15),NS(4,15),DELX(4),XT(4),NNN
      COMMON/XYZ/NUMBR
      DIMENSION X(4)
      GETDEL=0.0
      DO 10 K=1,NBMP
      L=NBMP-K+1
      IF(X(I).LE.XB(L))NS(I,L)=NUMBR+NNN
      IF(X(I).GE.XB(L).AND.NUMBR.LE.NS(I,L))GO TO 20
   10 CONTINUE
      RETURN
   20 GETDEL=R5
      RETURN
      END
```

```
C     FUNCTION XINT(ARG,ARGTB,FUN,NP)
      FUNCTION XINT(ARG,ARGTB,FUN,NP)
C     THIS SUBROUTINE PERFORMS A LINEAR INTERPOLATION OF A FUNCTION
      DIMENSION ARGTB(NP),FUN(NP)
      DO 10 I=1,NP
      IF(ARG-ARGTB(I))30,20,10
   10 CONTINUE
      I=NP
   30 IF(I.EQ.1)I=2
      TEMP=(ARG-ARGTB(I-1))/(ARGTB(I)-ARGTB(I-1))
      XINT=FUN(I-1)+(FUN(I)-FUN(I-1))*TEMP
      RETURN
   20 XINT=FUN(I)
      RETURN
      END
```

```
C       FUNCTION  AMIN(X,Y)
        FUNCTION  AMIN(X,Y)
        IF(X-Y)1,1,2
      1 AMIN=X
        RETURN
      2 AMIN=Y
        RETURN
        END
```

```
C     FUNCTION POLY(DL,TBL)
      FUNCTION POLY(DL,TBL)
C     THIS SUBROUTINE PERFORMS A POLYNOMIAL APPROXIMATION TO A FUNCTION
      DIMENSION TBL(7)
      TMP=TBL(7)
      DO 10 I=1,6
      TMP=TMP*DL+TBL(7-I)
   10 CONTINUE
      POLY=TMP
      RETURN
      END
```

3. PRESENTED HERE ARE THE ANALOG COMPUTER DIAGRAMS

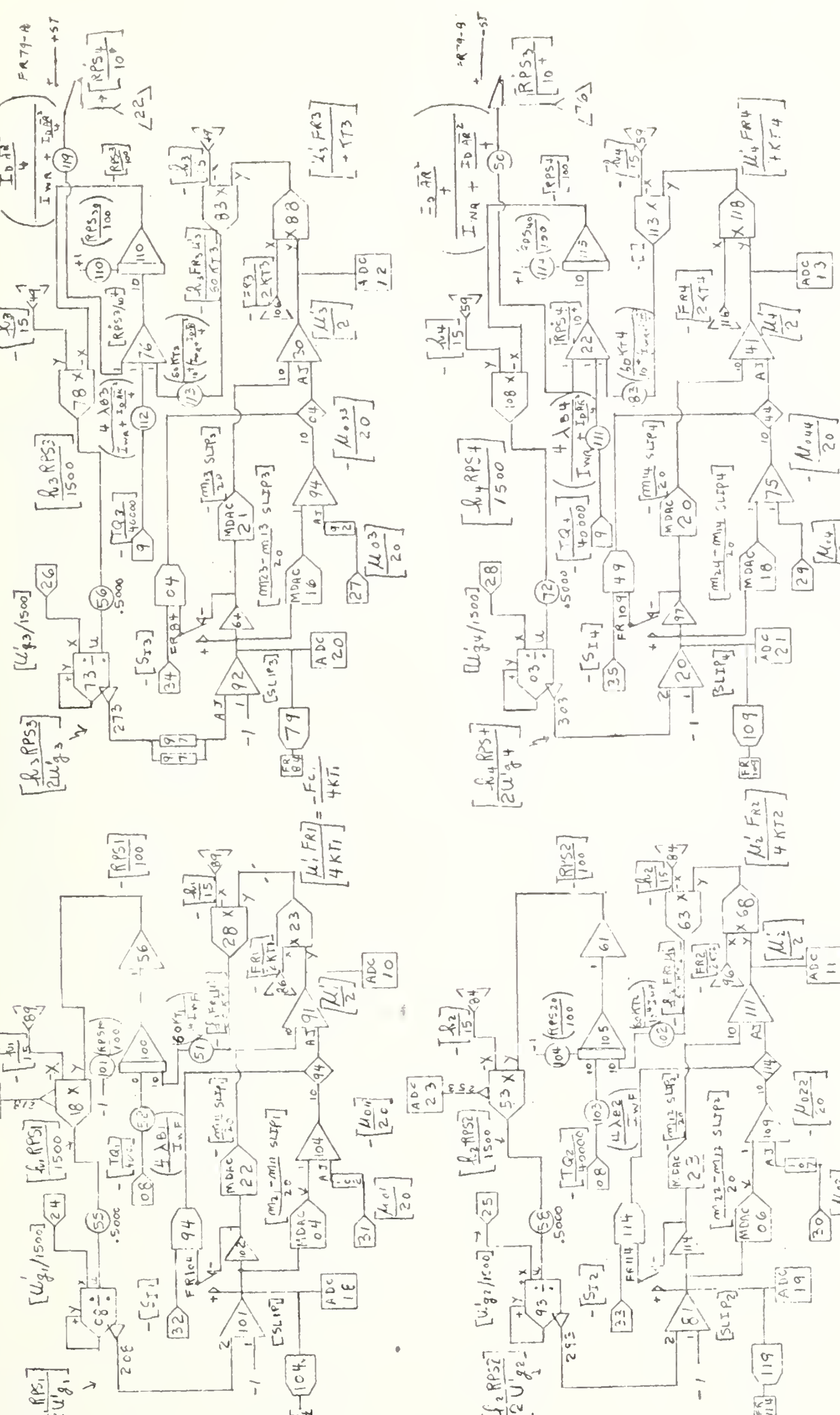


Fig. B-1 ANALOG COMPUTER DIAGRAM – ROTATIONAL WHEEL DYNAMICS

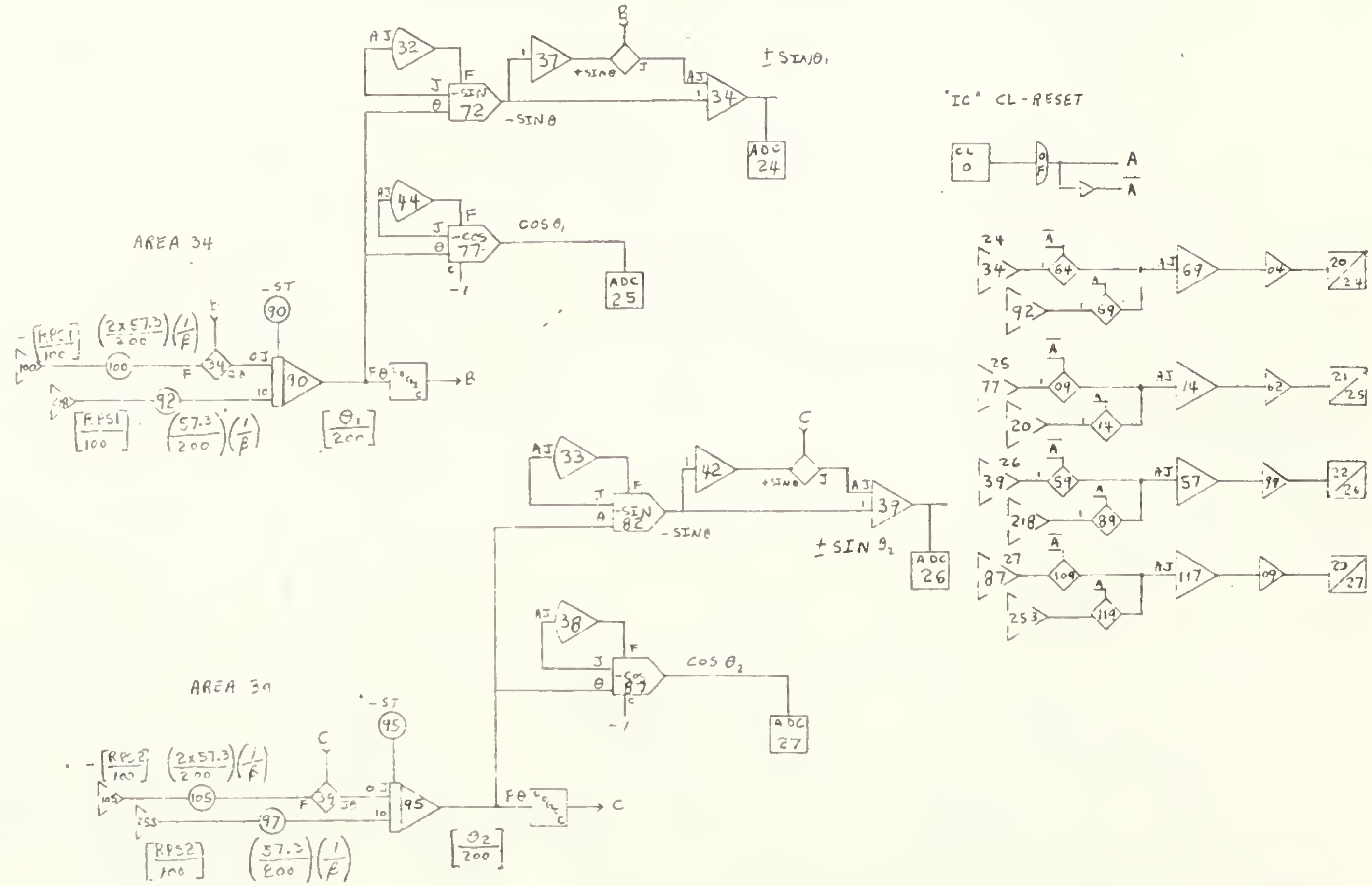



Fig. B-2 ANALOG COMPUTER DIAGRAM – CONTINUOUS RESOLUTION OF WHEEL RATES

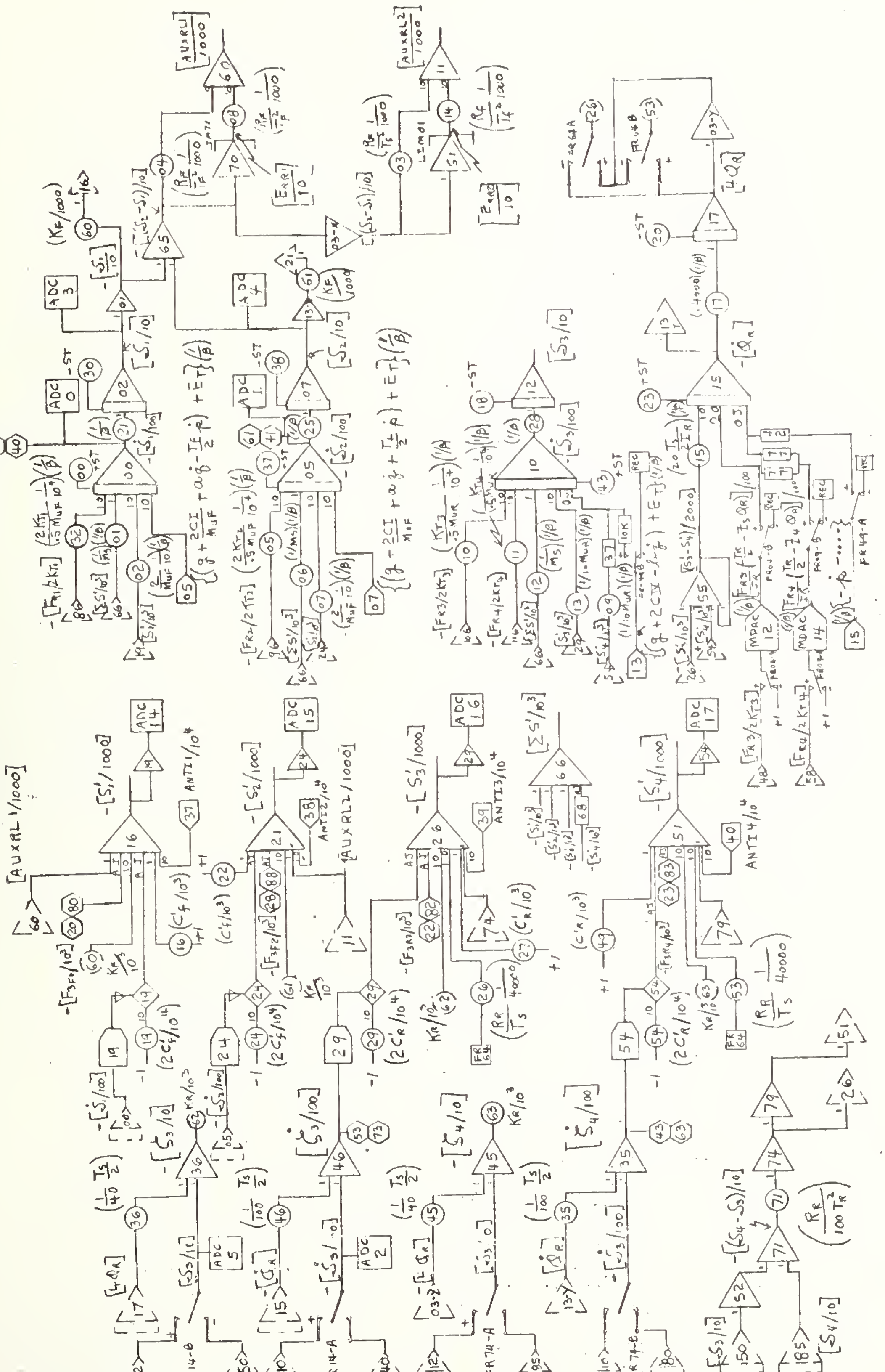
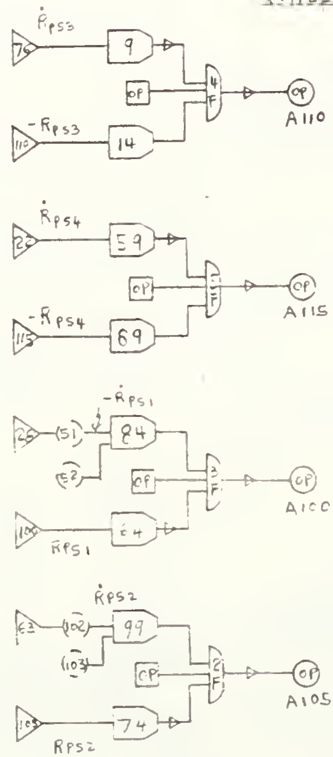


Fig. B-3 ANALOG COMPUTER DIAGRAM – SUSPENSION FORCES AND DEFLECTIONS

WHEEL-SLIP LOCKUP LOGIC




| IC-INPUT | OP-INPUT | RESULTING MODE |
|---|---|---|
| 1 | ANY | IC |
| 0 | 1 | OP |
| 0 | 0 | HOLD |

LOGIC TABLE

SOLID-SPLIT AXLE INTEGRATOR LOGIC

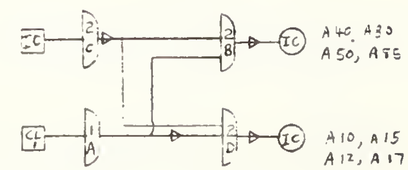



Fig. B-4 WHEEL LOCK-UP AND SPLIT/SOLID AXLE LOGIC

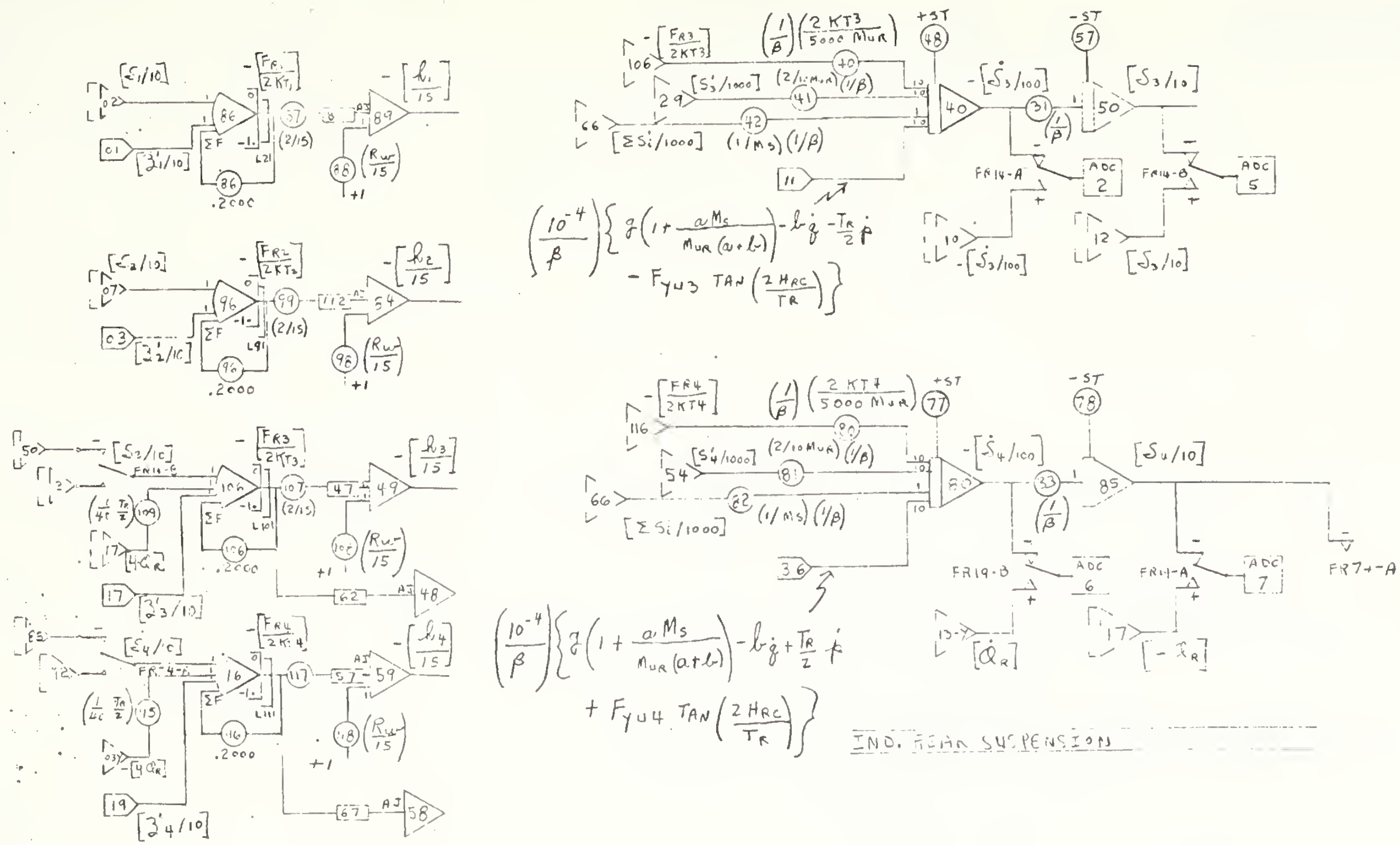



Fig. B-5 ANALOG COMPUTER DIAGRAM – RADIAL FORCES AND INDEPENDENT REAR SUSPENSION

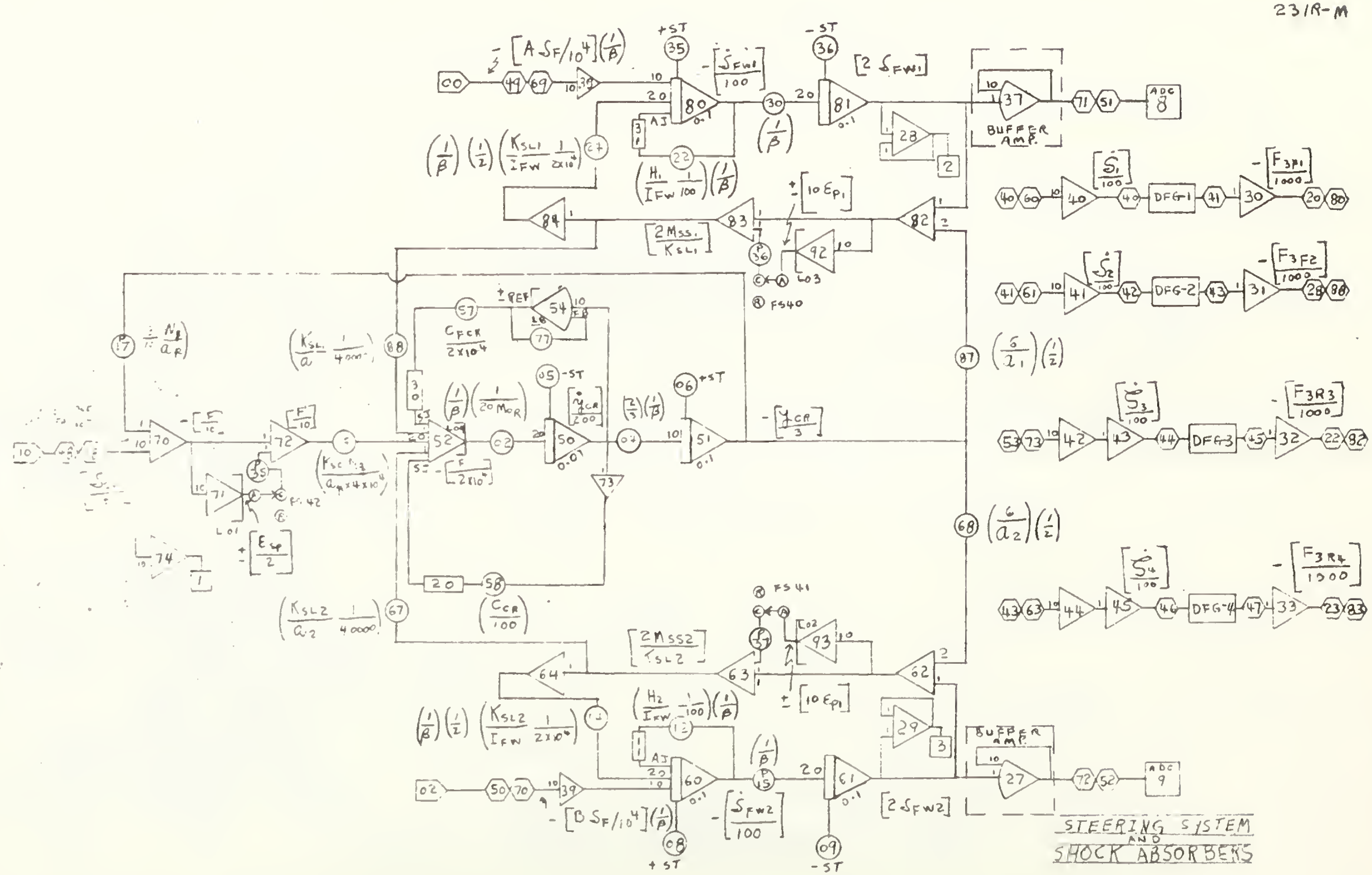



Fig. B-6 ANALOG COMPUTER DIAGRAM – STEERING SYSTEM AND SHOCK ABSORBERS

4. PRESENTED HERE ARE THE SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS. THE ORDER OF THE PARAMETERS CORRESPONDS TO THE INPUT DATA CARDS.

## SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 001 | MS | $M_S$ | Total sprung mass (lb/in/sec$^2$) |
| 002 | MUF | $M_{UF}$ | Total front unsprung mass (lb/in/sec$^2$) |
| 003 | MUR | $M_{UR}$ | Total rear unsprung mass (lb/in/sec$^2$) |
| 004 | ZF | $Z_F$ | Static distance between 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 | TS | $T_S$ | Distance between rear axle spring mounts in y-direction (in) |
| 011 | IX | $I_X$ | Roll moment of inertia of sprung mass (lb-in-sec$^2$) |
| 012 | IY | $I_Y$ | Pitch moment of inertia of sprung mass (lb-in-sec$^2$) |
| 013 | IZ | $I_Z$ | Yaw moment of inertia of sprung mass (lb-in-sec$^2$) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 014 | IXZ | $I_{XZ}$ | Product of inertia of sprung mass (lb-in-sec$^2$) |
| 015 | IR | $I_R$ | Roll moment of inertia of rear unsprung mass, exclude zero for computational purposes (lb-in-sec$^2$) |
| 016 | CF | | Viscous damping coefficient for a single front wheel (lb-in-sec) (initialization) |
| 017 | RF | $R_F$ | Auxiliary roll stiffness in front suspension (in-lb/radian) |
| 018 | CFPR | $C'_F$ | Coulomb damping at each front wheel (lb) |
| 019 | KF | $K_F$ | Front suspension spring rate (lb/in) |
| 020 | LAMF | $\lambda_F$ | Front spring rate proportionality factor (initialization) |
| 021 | OMFC | $\Omega_{FC}$ | Suspension deflection for initial front wheel contact with compression bump stop (in) |
| 022 | OMFT | $\Omega_{FT}$ | Suspension deflection for initial front wheel contact with rebound bump stop (in) |
| 023 | CR | | Viscous damping coefficient for a single rear wheel (lb-in-sec) (initialization) |
| 024 | RR | $R_R$ | Auxiliary roll stiffness in rear suspension (in-lb/radian) |
| 025 | CRPR | $C'_R$ | Coulomb damping at each rear wheel (lb) |
| 026 | KR | $K_R$ | Rear suspension spring rate (lb/in) |
| 027 | LAMR | $\lambda_R$ | Rear spring rate proportionality factor (initialization) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 028 | OMRC | $\Omega_{RC}$ | Suspension deflection for initial rear wheel contact with compression bump stop (in) |
| 029 | OMRT | $\Omega_{RT}$ | Suspension deflection for initial rear wheel contact with rebound bump stop (in) |
| 030 | KRS | $K_{RS}$ | Rear roll steer gain (rad/rad), (solid axle) |
| 031 | RW | $R_W$ | Undeflected tire radius (in) |
| 032 | | | Unassigned |
| 033 | AOMT | $A\Omega_T$ | Multiple of tire stiffness where cornering stiffness is constant, front wheels |
| 034 | A0 | $A_0$ | Constant coefficient in cornering stiffness function, front wheels |
| 035 | A1 | $A_1$ | Linear coefficient in tire cornering stiffness function, front wheels |
| 036 | A2 | $A_2$ | Quadratic coefficient in tire cornering stiffness function, front wheels |
| 037 | A3 | $A_3$ | Linear coefficient in tire camber stiffness function, front wheels |
| 038 | A4 | $A_4$ | Quadratic coefficient in tire camber stiffness function, front wheels |
| 039 - 040 | | | Unassigned |
| 041 | KSC | $K_{SC}$ | Steering column-gear flexibility (in-lb/radian) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 042 | NG | $N_G$ | Gear ratio of steering gear box |
| 043 | LAFC | $\lambda_{FC}$ | Front spring rate proportionality factor at compression bump stop |
| 044 | LAFT | $\lambda_{FT}$ | Front spring rate proportionality factor at rebound bump stop |
| 045 | LARC | $\lambda_{RC}$ | Rear spring rate proportionality factor at compression bump stop |
| 046 | LART | $\lambda_{RT}$ | Rear spring rate proportionality factor at rebound bump stop |
| 047 | IFW | $I_{FW}$ | Moment of inertia of front wheel about the king pin axis (in-lb-sec$^2$) |
| 048 | | | Unassigned |
| 049 | IWF | $I_{WF}$ | Moment of inertia of front wheel about its spin axis (in-lb-sec$^2$) |
| 050 | IWR | $I_{WR}$ | Moment of inertia of rear wheel about its spin axis (in-lb-sec$^2$) |
| 051 | ID | $I_D$ | Moment of inertia of drive line about its spin axis (in-lb-sec$^2$) |
| 052 | AR | $\overline{AR}$ | Drive axle ratio |
| 053 - 054 | | | Unassigned |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 055 | PT | $\overline{PT}$ | Front wheel caster trail (in) |
| 056 | YSA1 | $y_{SA1}$ | Distance between kingpin axis and wheel center line, measured along wheel spin axis, right front (in) |
| 057 | YSA2 | $y_{SA2}$ | Distance between kingpin axis and wheel center line, measured along wheel spin axis, left front (in) |
| 058 | PHS1 | $\phi_{SA1}$ | Kingpin inclination angle, right front (radian) |
| 059 | PHS2 | $\phi_{SA2}$ | Kingpin inclination angle, left front (radian) |
| 060 | CTSW | | Caster trail switch: 060 = 1, constant; = 0, function |
| 061 - 062 | | | Unassigned |
| 063 - 074 | | | Initial conditions: $p,q,r,u,v,w,x,y,z,\theta,\phi,\psi$. Note that $z_0$ and $\theta_0$ are computed values at t=0 and need not be specified. |
| 075 | DT | | Integration step size (sec) |
| 076 | TN | | Maximum run time (sec) |
| 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 | $RPS_i$ | Initial wheel rotation rates computed at t=0 (rad/sec) |
| 085 | B1 | $B_1$ | Load term coefficient of lateral friction coefficient, front tire (1/lb) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 086 | B2 | $B_2$ | Velocity term coefficient of lateral friction coefficient, front tire (1/mph) |
| 087 | B3 | $B_3$ | Constant term of lateral friction coefficient, front tire (dimensionless) |
| 088 | B4 | $B_4$ | Quadratic load term coefficient of lateral friction coefficient, front tire ($1/lb^2$) |
| 089 - 091 | | | Initial conditions: $\dot{\delta}_i, \delta_i, \dot{\phi}_R, \delta_{FWi}, \mu_{Xi}, S_i'$ |
| 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 | | | Initial conditions: $\dot{\delta}_i, \delta_i, \dot{\phi}_R, \delta_{FWi}, \mu_{Xi}, S_i'$ |
| 107 | PPRT | | Parameter table, print control: 107 = 1, print; = 0, no print |
| 108 - 109 | | | Unassigned |
| 110 | TQMX | | Maximum available drive torque (in-lb) |
| 111 | KTQ | $K_{TQ}$ | Drive torque gain factor (in-lb)/(in/sec) |
| 112 | VC | $V_C$ | Commanded velocity (mph) |
| 113 | MTSW | | Multiplier on front wheel aligning torque, $M_{Ti}$ |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 114 | DSWM | $\delta_{SW}$ | Maximum steering wheel angle (degrees), (except sinusoidal steer) |
| 115 | TST | | Initial time of steer (sec), (except sinusoidal steer) |
| 116 | DSLP | | Time to achieve maximum steer angle, equivalent to steer rate, exclude zero (sec), (except sinusoidal steer) |
| 117 | CGAM | | Initial time of brake application (sec), (except drastic brake and steer) |
| 118 | CS | | Initial time of brake application (sec), (except drastic brake and steer) |
| 119 | TQR | $\overline{TQ}_{Bi}$ | Rear wheel brake torque (in-lb) |
| 120 | TQF | $\overline{TQ}_{Bi}$ | Front wheel brake torque (in-lb) |
| 121 | PFL | | Applied brake pressure (psi) |
| 122 | T1 | | Drive torque control (sec) |
| 123 | DSW | | Sinusoidal steer amplitude (degrees) |
| 124 | TSW | | Duration of sinusoidal steer (sec) |
| 125 | ISW5 | | VHTP sinusoidal steer enable code: 125 = 1, enable; = 0, disable |
| 126 | SW15 | | VHTP roll over enable code: 126 = 1, enable; = 0, disable |
| 127 | PQSW | | Equation suppress option, 127 = 0, none; 1, $\dot{p} = 0$, 2, $\dot{q} = 0$; 3, $\dot{p} = \dot{q} = 0$ |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 128 | VTPS | | VHTP switch |
| 129 | VHTP | | VHTP index |
| 130 | AMCR | $M_{CR}$ | Mass of steering system connecting rod (lb-sec$^2$/in) |
| 131 | ESP | $\varepsilon_{SP}$ | Free play in steering gear box (rad) |
| 132 | KSL1 | $K_{SL1}$ | Steering linkage flexibility, right front wheel (in-lbs/radian) |
| 133 | KSL2 | $K_{SL2}$ | Steering linkage flexibility, left front wheel (in-lb/radian) |
| 134 - 135 | AAI | $a_{Li}$ | Length of steering linkage arms (in) |
| 136 | CCR | $C_{CR}$ | Viscous damping coefficient of steering system connecting rod (lb/in/sec) |
| 137 | CFCR | $C_{FCR}$ | Coulomb damping of steering system connecting rod (lb) |
| 138 | AP | $a_P$ | Length of Pitman arm (in) |
| 139 - 140 | EPI | $\varepsilon_{Pi}$ | Free play in steer of front wheel (rad) |
| 141 - 142 | ERRI | | Auxiliary roll stiffness play |
| 143 - 144 | AMLI | $M_{1i}$ | Unbalanced wheel mass (lb-sec$^2$/in) |
| 145 | RRIM | $R_{RIM}$ | Wheel rim radius (in) |
| 146 | RWR | $R_{WR}$ | Wheel rim width (in) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 147 - 168 | | | Unassigned |
| 169 | SNT | | Tire data surface skid number |
| 170 | SNS0 | | Simulated vehicle surface skid number |
| 171 | SNS1 | | Simulated vehicle surface skid number |
| 172 | SNSW | | Skid patch switch: 172 = 2, disable; 1, front approach; 0, side approach |
| 173 | DIST | | Initial distance between car and skid patch (in) |
| 174 | PL | | Skid patch length (in) |
| 175 | TSCP | | Computer time scale factor |
| 176 - 179 | | | Unassigned |
| 180 | PASS | | Number of passes through integration routine |
| 181 | | | Unassigned |
| 182 - 185 | SII | $SI_i$ | Wheel slip ratio at which peak braking coefficient of friction occurs |
| 186 - 191 | | | Unassigned |
| 192 | MTQB | | Brake force rate, exclude zero for computational purposes (psi/sec) |
| 193 | DRSW | | Driver control switch: 193 = 0, disable; 1, enable |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 194 | LDF | | Lateral displacement feedback gain (deg/in), 193 = 1 |
| 195 | LDRF | | Lateral displacement rate feedback gain (deg/in/sec), 193 = 1 |
| 196 - 197 | EKI | $\varepsilon_{Ki}$ | Static front wheel toe bias angles (degrees) |
| 198 | BMPL | | Length of single road bump (in) |
| 199 | BMPS | | Distance between 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 (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 (1/lb) |
| 206 | MUSF | $\mu_{SF}$ | Front tire sliding coefficient of friction |
| 207 | MUSR | $\mu_{SR}$ | Rear tire sliding coefficient of friction |
| 208 - 218 | | | Unassigned |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 219 - 220 | FEEI | $\Delta\phi_i$ | Front wheel camber bias angles (degrees) |
| 221 - 222 | THEI | $\Delta\theta_i$ | Front wheel caster bias angles (degrees) |
| 223 - 230 | | | Unassigned |
| 231 - 232 | HI | $H_i$ | Viscous damping derivative in front wheel (lb/in/sec) |
| 233 | | | Unassigned |
| 234 - 235 | AKFI | $K_{Fi}$ | Front suspension spring rates (lb/in) |
| 236 - 237 | AKFJ | $K_{Ri}$ | Rear suspension spring rates (lb/in) |
| 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/in-lb) |
| 245 | RB1 | $RB_1$ | Load term coefficient of lateral friction coefficient, rear tire (1/lb) |
| 246 | RB2 | $RB_2$ | Velocity term coefficient of lateral friction coefficient, rear tire (1/mph) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 247 | RB3 | $RB_3$ | Constant term of lateral friction coefficient, rear tire (dimensionless) |
| 248 | RB4 | $RB_4$ | Quadratic load term coefficient of lateral friction coefficient, rear tire ($1/lb^2$) |
| 249 | AFK1 | $A_{F1}$ | Aligning torque coefficient, front tire ($in\text{-}lb/lb^2$) |
| 250 | AFK2 | $A_{F2}$ | Aligning torque coefficient, front tire ($in\text{-}lb/lb^2$) |
| 251 | AFK3 | $A_{F3}$ | Aligning torque coefficient, front tire (in-lb/lb sq root (rad)) |
| 252 | ARK1 | $A_{R1}$ | Aligning torque coefficient, rear tire ($in\text{-}lb/lb^2$) |
| 253 | ARK2 | $A_{R2}$ | Aligning torque coefficient, rear tire ($in\text{-}lb/lb^2$) |
| 254 | ARK3 | $A_{R3}$ | Aligning torque coefficient, rear tire (in-lb/lb sq root (rad)) |
| 255 | OFC0 | $OF_0$ | Overturning moment coefficient, front tire (in-lb) |
| 256 | OFC1 | $OF_1$ | Overturning moment coefficient, front tire ($in\text{-}lb/lb^2$) |
| 257 | OFC2 | $OF_2$ | Overturning moment coefficient, front tire ($in\text{-}lb/lb^2\text{-}rad$) |
| 258 | OFC3 | $OF_3$ | Overturning moment coefficient, front tire (in-lb/lb-rad) |
| 259 | ORC0 | $OR_0$ | Overturning moment coefficient, rear tire (in-lb) |
| 260 | ORC1 | $OR_1$ | Overturning moment coefficient, rear tire ($in\text{-}lb/lb^2$) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 261 | ORC2 | $OR_2$ | Overturning moment coefficient, rear tire (in-lb/lb$^2$-rad) |
| 262 | ORC3 | $OR_3$ | Overturning moment coefficient, rear tire (in-lb/lb-rad) |
| 263 | CP0F | $P_{F0}$ | Anti-pitch coefficient, front suspension (dimensionless) |
| 264 | CP1F | $P_{F1}$ | Anti-pitch coefficient, front suspension, (1/in) |
| 265 | CP2F | $P_{F2}$ | Anti-pitch coefficient, front suspension, (1/in$^2$) |
| 266 | CP0R | $P_{R0}$ | Anti-pitch coefficient, rear suspension (dimensionless) |
| 267 | CP1R | $P_{R1}$ | Anti-pitch coefficient, rear suspension (1/in) |
| 268 | CP2R | $P_{R2}$ | Anti-pitch coefficient, rear suspension (1/in$^2$) |
| 269 | CR0F | $R_{F0}$ | Anti-roll coefficient, front suspension (dimensionless) |
| 270 | CR1F | $R_{F1}$ | Anti-roll coefficient, front suspension (1/in) |
| 271 | CR2F | $R_{F2}$ | Anti-roll coefficient, front suspension (1/in$^2$) |
| 272 | CR0R | $R_{R0}$ | Anti-roll coefficient, rear suspension (dimensionless) |
| 273 | CR1R | $R_{R1}$ | Anti-roll coefficient, rear suspension (1/in) |
| 274 | CR2R | $R_{R2}$ | Anti-roll coefficient, rear suspension (1/in$^2$) |
| 275 - 276 | | | Unassigned |
| 277 | BMPN | | Number of bumps in bump grid |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 278 | TQB0 | | Time of brake application in combined drastic brake and steer VHTP |
| 279 | TQB1 | | Time of brake release in combined drastic brake and steer VHTP |
| 280 - 283 | | | Unassigned |
| 284 | HFC | $h_{FC}$ | Distance between ground and the roll center of the front suspension (in) |
| 285 | HRC | $h_{RC}$ | Distance between center of rear axle and the roll center of the rear suspension (in) |
| 286 | | | Unassigned |
| 287 | AXLE | | Solid rear axle/split rear axle option code, solid=1, split=2 |
| 288 - 289 | | | Unassigned |
| 290 | ROMT | $R\Omega_T$ | Multiple of maximum tire load where cornering stiffness is constant, rear wheels |
| 291 | RA0 | $RA_0$ | Constant coefficient in tire cornering stiffness, rear wheels |
| 292 | RA1 | $RA_1$ | Linear coefficient in tire cornering stiffness function, rear wheels |
| 293 | RA2 | $RA_2$ | Quadratic coefficient in tire cornering stiffness function, rear wheels |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 294 | RA3 | $RA_3$ | Linear coefficient in tire camber stiffness function, rear wheels |
| 295 | RA4 | $RA_4$ | Quadratic coefficient in tire camber stiffness function, rear wheels |

5. PRESENTED HERE ARE THE SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS WHICH ARE VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS.

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 001 | MS | $M_S$ | Total sprung mass (lb/in/sec$^2$) |
| 002 | MUF | $M_{UF}$ | Total front unsprung mass (lb/in/sec$^2$) |
| 003 | MUR | $M_{UR}$ | Total rear unsprung mass (lb/in/sec$^2$) |
| 004 | ZF | $Z_F$ | Static distance between 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 | TS | $T_S$ | Distance between rear axle spring mounts in y-direction (in) |
| 011 | IX | $I_X$ | Roll moment of inertia of sprung mass (lb-in-sec$^2$) |
| 012 | IY | $I_Y$ | Pitch moment of inertia of sprung mass (lb-in-sec$^2$) |
| 013 | IZ | $I_Z$ | Yaw moment of inertia of sprung mass (lb-in-sec$^2$) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 014 | IXZ | $I_{XZ}$ | Product of inertia of sprung mass ($lb\text{-}in\text{-}sec^2$) |
| 015 | IR | $I_R$ | Roll moment of inertia of rear unsprung mass, exclude zero for computational purposes ($lb\text{-}in\text{-}sec^2$) |
| 017 | RF | $R_F$ | Auxiliary roll stiffness in front suspension (in-lb/radian) |
| 018 | CFPR | $C_F'$ | Coulomb damping at each front wheel (lb) |
| 019 | KF | $K_F$ | Front suspension spring rate (lb/in) |
| 020 | LAMF | $\lambda_F$ | Front spring rate proportionality factor (initialization) |
| 021 | OMFC | $\Omega_{FC}$ | Suspension deflection for initial front wheel contact with compression bump stop (in) |
| 022 | OMFT | $\Omega_{FT}$ | Suspension deflection for initial front wheel contact with rebound bump stop (in) |
| 024 | RR | $R_R$ | Auxiliary roll stiffness in rear suspension (in-lb/radian) |
| 025 | CRPR | $C_R'$ | Coulomb damping at each rear wheel (lb) |
| 026 | KR | $K_R$ | Rear suspension spring rate (lb/in) |
| 028 | OMRC | $\Omega_{RC}$ | Suspension deflection for initial rear wheel contact with compression bump stop (in) |
| 029 | OMRT | $\Omega_{RT}$ | Suspension deflection for initial rear wheel contact with rebound bump stop (in) |
| 030 | KRS | $K_{RS}$ | Rear roll steer gain (rad/rad), (solid axle) |
| 031 | RW | $R_W$ | Undeflected tire radius (in) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 033 | AOMT | $A\Omega_T$ | Multiple of tire stiffness where cornering stiffness is constant, front wheels |
| 034 | A0 | $A_0$ | Constant coefficient in cornering stiffness function, front wheels |
| 035 | A1 | $A_1$ | Linear coefficient in tire cornering stiffness function, front wheels |
| 036 | A2 | $A_2$ | Quadratic coefficient in tire cornering stiffness function, front wheels |
| 037 | A3 | $A_3$ | Linear coefficient in tire camber stiffness function, front wheels |
| 038 | A4 | $A_4$ | Quadratic coefficient in tire camber stiffness function, front wheels |
| 041 | KSC | $K_{SC}$ | Steering column-gear flexibility (in-lb/radian) |
| 042 | NG | $N_G$ | Gear ratio of steering gear box |
| 043 | LAFC | $\lambda_{FC}$ | Front spring rate proportionality factor at compression bump stop |
| 044 | LAFT | $\lambda_{FT}$ | Front spring rate proportionality factor at rebound bump stop |
| 045 | LARC | $\lambda_{RC}$ | Rear spring rate proportionality factor at compression bump stop |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 046 | LART | $\lambda_{RT}$ | Rear spring rate proportionality factor at rebound bump stop |
| 047 | IFW | $I_{FW}$ | Moment of inertia of front wheel about the king pin axis ($in\text{-}lb\text{-}sec^2$) |
| 049 | IWF | $I_{WF}$ | Moment of inertia of front wheel about its spin axis ($in\text{-}lb\text{-}sec^2$) |
| 050 | IWR | $I_{WR}$ | Moment of inertia of rear wheel about its spin axis ($in\text{-}lb\text{-}sec^2$) |
| 051 | ID | $I_D$ | Moment of inertia of drive line about its spin axis ($in\text{-}lb\text{-}sec^2$) |
| 052 | AR | $\overline{AR}$ | Drive axle ratio |
| 055 | PT | $\overline{PT}$ | Front wheel caster trail (in) |
| 056 | YSA1 | $Y_{SA1}$ | Distance between kingpin axis and wheel center line, measured along wheel spin axis, right front (in) |
| 057 | YSA2 | $Y_{SA2}$ | Distance between kingpin axis and wheel center line, measured along wheel spin axis, left front (in) |
| 058 | PHS1 | $\phi_{SA1}$ | Kingpin inclination angle, right front (radian) |
| 059 | PHS2 | $\phi_{SA2}$ | Kingpin inclination angle, left front (radian) |
| 077 - 078 | KTI | $K_{Ti}$ | Tire spring rate, front wheels (lb/in) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 079 - 080 | KTI | $K_{Ti}$ | Tire spring rate, rear wheels (lb/in) |
| 085 | B1 | $B_1$ | Load term coefficient of lateral friction coefficient front tire (1/lb) |
| 086 | B2 | $B_2$ | Velocity term coefficient of lateral friction coefficient, front tire (1/mph) |
| 087 | B3 | $B_3$ | Constant term of lateral friction coefficient, front tire (dimensionless) |
| 088 | B4 | $B_4$ | Quadratic load term coefficient of lateral friction coefficient, front tire ($1/lb^2$) |
| 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) |
| 130 | AMCR | $M_{CR}$ | Mass of steering system connecting rod ($lb\text{-}sec^2/in$) |
| 131 | ESP | $\epsilon_{SP}$ | Free play in steering gear box (rad) |
| 132 | KSL1 | $K_{SL1}$ | Steering linkage flexibility, right front wheel (in-lbs/radian) |
| 133 | KSL2 | $K_{SL2}$ | Steering linkage flexibility, left front wheel (in-lb/radian) |
| 134 - 135 | AAI | $a_{Li}$ | Length of steering linkage arms (in) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 136 | CCR | $C_{CR}$ | Viscous damping coefficient of steering system connecting rod (lb/in/sec) |
| 137 | CFCR | $C_{FCR}$ | Coulomb damping of steering system connecting rod (lb) |
| 138 | AP | $a_P$ | Length of Pitman arm (in) |
| 139 - 140 | EPI | $\varepsilon_{Pi}$ | Free play in steer of front wheel (rad) |
| 143 - 144 | AMLI | $M_{1i}$ | Unbalanced wheel mass (lb-sec$^2$/in) |
| 145 | RRIM | $R_{RIM}$ | Wheel rim radius (in) |
| 146 | RWR | $R_{WR}$ | Wheel rim width (in) |
| 169 | SNT | | Tire data surface skid number |
| 170 | SNS0 | | Simulated vehicle surface skid number |
| 171 | SNS1 | | Simulated vehicle surface skid number |
| 182 - 185 | SII | $SI_i$ | Wheel slip ratio at which peak braking coefficient of friction occurs |
| 196 - 197 | EKI | $\varepsilon_{Ki}$ | Static front wheel toe bias angles (degrees) |
| 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 (1/lb) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 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 (1/lb) |
| 206 | MUSF | $\mu_{SF}$ | Front tire sliding coefficient of friction |
| 207 | MUSR | $\mu_{SR}$ | Rear tire sliding coefficient of friction |
| 219 - 220 | FEEI | $\Delta\phi_i$ | Front wheel camber bias angles (degrees) |
| 221 - 222 | THEI | $\Delta\theta_i$ | Front wheel caster bias angles (degrees) |
| 231 - 232 | HI | $H_i$ | Viscous damping derivative in front wheel (lb/in/sec) |
| 234 - 235 | AKFI | $K_{Fi}$ | Front suspension spring rates (lb/in) |
| 236 - 237 | AKFJ | $K_{Ri}$ | Rear suspension spring rates (lb/in) |
| 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/in-lb) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 245 | RB1 | $RB_1$ | Load term coefficient of lateral friction coefficient, rear tire (1/lb) |
| 246 | RB2 | $RB_2$ | Velocity term coefficient of lateral friction coefficient, rear tire (1/mph) |
| 247 | RB3 | $RB_3$ | Constant term of lateral friction coefficient, rear tire (dimensionless) |
| 248 | RB4 | $RB_4$ | Quadratic load term coefficient of lateral friction coefficient, rear tire ($1/lb^2$) |
| 249 | AFK1 | $A_{F1}$ | Aligning torque coefficient, front tire ($in\text{-}lb/lb^2$) |
| 250 | AFK2 | $A_{F2}$ | Aligning torque coefficient, front tire ($in\text{-}lb/lb^2$) |
| 251 | AFK3 | $A_{F3}$ | Aligning torque coefficient, front tire (in-lb/lb sq root (rad)) |
| 252 | ARK1 | $A_{R1}$ | Aligning torque coefficient, rear tire ($in\text{-}lb/lb^2$) |
| 253 | ARK2 | $A_{R2}$ | Aligning torque coefficient, rear tire ($in\text{-}lb/lb^2$) |
| 254 | ARK3 | $A_{R3}$ | Aligning torque coefficient, rear tire (in-lb/lb sq root (rad)) |
| 255 | OFC0 | $O_{F0}$ | Overturning moment coefficient, front tire (in-lb) |
| 256 | OFC1 | $O_{F1}$ | Overturning moment coefficient, front tire ($in\text{-}lb/lb^2$) |
| 257 | OFC2 | $O_{F2}$ | Overturning moment coefficient, front tire ($in\text{-}lb/lb^2\text{-}rad$) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol: Table | Symbol: Equation | Definition or Function (Units) |
|---|---|---|---|
| 258 | OFC3 | $O_{F3}$ | Overturning moment coefficient, front tire (in-lb/lb-rad) |
| 259 | ORC0 | $O_{R0}$ | Overturning moment coefficient, rear tire (in-lb) |
| 260 | ORC1 | $O_{R1}$ | Overturning moment coefficient, rear tire (in-lb/lb$^2$) |
| 261 | ORC2 | $O_{R2}$ | Overturning moment coefficient, rear tire (in-lb/lb$^2$-rad) |
| 262 | ORC3 | $O_{R3}$ | Overturning moment coefficient, rear tire (in-lb/lb-rad) |
| 263 | CP0F | $P_{F0}$ | Anti-pitch coefficient, front suspension (dimensionless) |
| 264 | CP1F | $P_{F1}$ | Anti-pitch coefficient, front suspension, (1/in) |
| 265 | CP2F | $P_{F2}$ | Anti-pitch coefficient, front suspension, (1/in$^2$) |
| 266 | CP0R | $P_{R0}$ | Anti-pitch coefficient, rear suspension (dimensionless) |
| 267 | CP1R | $P_{R1}$ | Anti-pitch coefficient, rear suspension (1/in) |
| 268 | CP2R | $P_{R2}$ | Anti-pitch coefficient, rear suspension (1/in$^2$) |
| 269 | CR0F | $R_{F0}$ | Anti-roll coefficient, front suspension (dimensionless) |
| 270 | CR1F | $R_{F1}$ | Anti-roll coefficient, front suspension (1/in) |
| 271 | CR2F | $R_{F2}$ | Anti-roll coefficient, front suspension (1/in$^2$) |
| 272 | CR0R | $R_{R0}$ | Anti-roll coefficient, rear suspension (dimensionless) |
| 273 | CR1R | $R_{R1}$ | Anti-roll coefficient, rear suspension (1/in) |
| 274 | CR2R | $R_{R2}$ | Anti-roll coefficient, rear suspension (1/in$^2$) |

Symbols and Definitions of the Program Parameters (cont'd.)

| Parameter Number | Symbol | | Definition or Function (Units) |
|---|---|---|---|
| | Table | Equation | |
| 284 | HFC | $h_{FC}$ | Distance between ground and the roll center of the front suspension (in) |
| 285 | HRC | $h_{RC}$ | Distance between center of rear axle and the roll center of the rear suspension (in) |
| 290 | ROMT | $R\Omega_T$ | Multiple of maximum tire load where cornering stiffness is constant, rear wheels |
| 291 | RA0 | $RA_0$ | Constant coefficient in tire cornering stiffness, rear wheels |
| 292 | RA1 | $RA_1$ | Linear coefficient in tire cornering stiffness function, rear wheels |
| 293 | RA2 | $RA_2$ | Quadratic coefficient in tire cornering stiffness function, rear wheels |
| 294 | RA3 | $RA_3$ | Linear coefficient in tire camber stiffness function, rear wheels |
| 295 | RA4 | $RA_4$ | Quadratic coefficient in tire camber stiffness function, rear wheels |

# APPENDIX C

# DESCRIPTION OF HYBRID COMPUTER SIMULATION LABORATORY

## 1. HYBRID COMPUTER

The APL hybrid computer is unique in that the analog computer is a terminal to a large digital computer, with communication between them occurring over a 1000-foot data path. A block diagram of the system is presented in Figure C-1. The analog computer is an EAI Model 680 and the digital computer is an IBM System 360 Model 91. The data channel that provides the high-speed transmission required for hybrid processing is the parallel data adapter (PDA) of the IBM 2909 asynchronous data channel. The 2909, which is capable of transmitting at a 2M-byte per second rate, is working at about 40% of this rate (200K 16-bit words per second) through the PDA while servicing the hybrid. Besides the PDA, the 2909 has two additional subchannels used for hybrid processing: one for priority interrupts and the other for precision internal timing.

The priority interrupt subchannel provides up to 64 priority interrupt levels (PILS) for a System 360 which, with the exception of the 360/44, does not have a priority interrupt structure. Thus, this subchannel was necessary in order to provide the hybrid system with PILS. This subchannel currently is expanded to 16 PILS. The other subchannel provides a precision interval timer (1 μs resolution) to the hybrid user. This timer can be loaded via software and causes an interrupt when decremented to zero, which in turn initiates an event in a hybrid program.

The 360/91, one of the largest and fastest computers built by IBM, has the following characteristics:

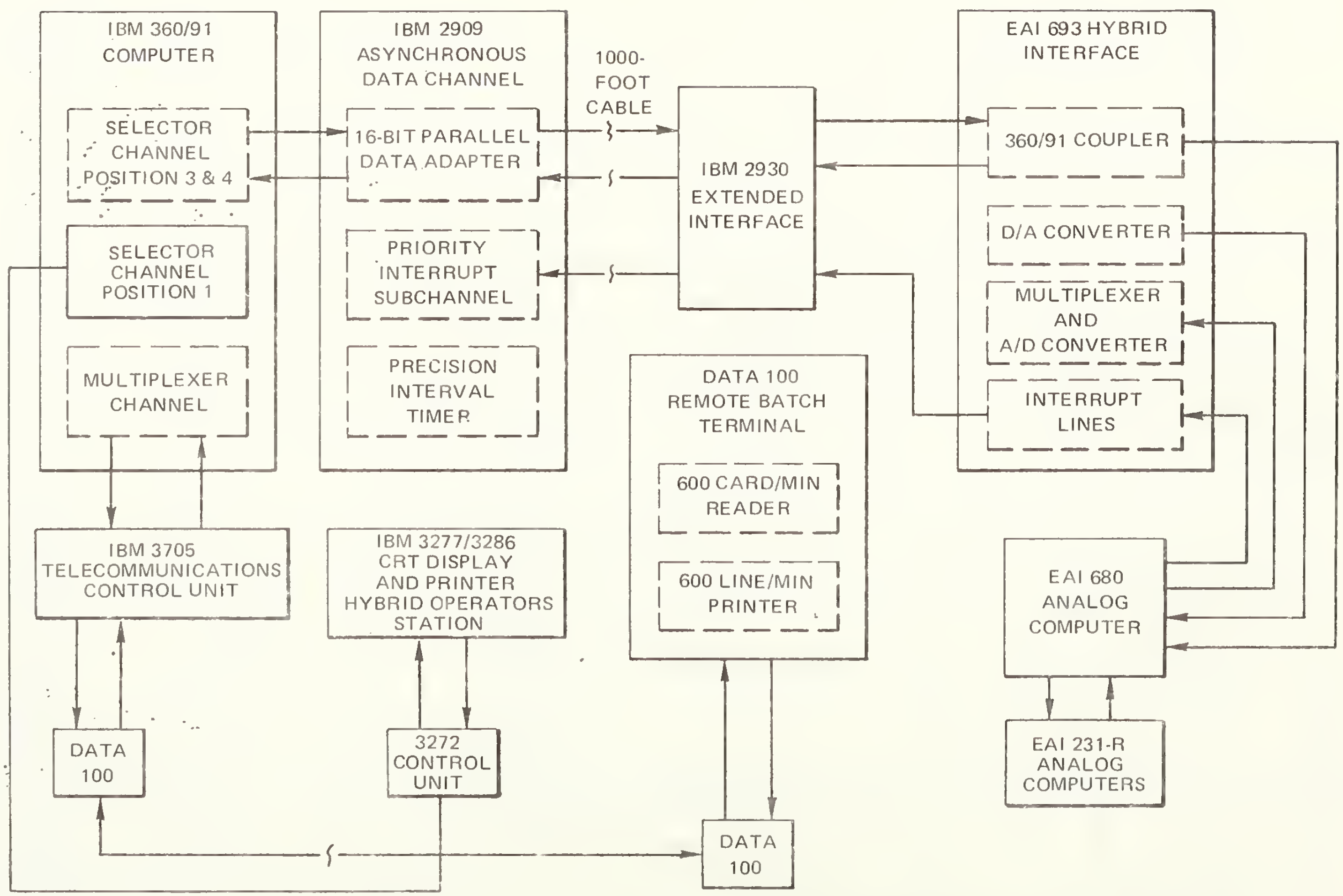



Fig. C-1 HYBRID SYSTEM BLOCK DIAGRAM

Third-generation hardware

4 million bytes of main core storage

1 trillion bytes of direct access storage

Minimum execution time of 60 ns per instruction

Use of the Operating System OS/MVT (Multiprogramming with a Variable Number of Tasks)

Two advantages are immediately obvious to a 360/91 interactive user. First, since he is only charged in proportion to his use of the central processing unit (CPU) and main core storage in the multi-programming environment, the machine is inexpensive to use. Second, since the 360/91 is a third-generation computer with nearly unlimited resources, it is extremely fast and efficient while computing. In summary, this computer gives the interactive terminal user unlimited digital resources at a cost comparable to that of a much smaller computer.

The Interactive Simulation Laboratory (ISL) is located 800 feet from the 360/91 digital computer. The 2909 PDA, which has specially designed line drivers and receivers (now standard from IBM), can easily drive the 1000-foot cable to the ISL. However, matching drivers and receivers are required in the ISL. These are housed in the IBM 2930. Individual lines are required for each bit of the data word, each control line, and for each PIL. The 2930 then cables into a 360/91 coupler (standard EAI product) housed within the EAI 693. From the coupler on, the 693 hybrid interface and 680 analog computer are standard EAI equipment.

In addition to the hybrid hardware of Figure C-1, the ISL contains three pieces of equipment that support the hybrid operations. These are a Data 100 remote batch terminal and an IBM 3270 Display System (3286 printer and a 3277 CRT with a keyboard). The Data 100 consists of a 600 card/minute reader and a 600 line/minute printer which allow the submission of jobs to the 360/91 and the return of results from the 360/91 at the ISL hybrid work station. The Data 100 operates over a dedicated communications line into a control unit connected to the 360/91 multiplexer channel. Its support package is the IBM remote job processing (RJP) portion of the ASP job scheduler.

The IBM 3270 Display System has evolved as the hybrid operator's station. Via APL-written software, all hybrid jobs can be interfaced to the Display System and problem execution directed from the CRT and input keyboard. In addition, the operator's station contains a 3286 (66 character per second) printer. All CRT activities, input and output, are recorded on this printer. The printer also serves as an addressable output device.

These hardware items comprise the APL hybrid computer system. In addition to this system, the ISL contains three 231-R analog computers, each interfaced to an EAI DES-30 logic unit and an EAI quarter-square multiplier rack. These machines are interfaced to the hybrid system via buffering amplifiers for large simulations.

## 2. HYBRID SOFTWARE

Included with the original EAI hardware purchase were three hybrid software packages operable under Operating System 360 (OS/360). The first, the HYIOS (Hybrid Input/Output Subroutines) package, was a collection of Fortran IV callable subroutines that allowed operation from the 360 of all hybrid functions in the 680 and 693 originally designed for control from the EAI PACER 100 digital computer (Ref. 8). These routines number 47 and permit complete control and readout of the data interface, logic components, and analog components. Also, these routines do extensive error checking and each has an error argument returned, which can be checked by the programmer to determine successful completion of a hybrid operation.

The second software package delivered by EAI was HYSAT (Hybrid Static Analog Test). HYSAT is an interpretive language written in Fortran using HYIOS, which automates the performance of analog computer setup and static checks. Simple commands allow changing the analog mode, setting potentiometers and control lines; reading the outputs of amplifiers, integrator derivatives, and track-store inputs; and reading the state of sense lines, comparators and relays. In the verify mode, the outputs of the analog and logic components can be compared against predetermined values, with all errors documented on the CRT. This program is interactive from the CRT/keyboard and input from a prepared data set can be selected. The capabilities of HYSAT have been combined with ease of programming of a simulation language (DSL/91) to produce a completely automated static check procedure for hybrid programs (Ref. 7). A specially wired board and specially prepared HYSAT data deck are used to verify that all 680 analog components are operational.

Whereas HYSAT permits checking the 680 analog console statically, the third software package delivered by EAI permits checking the 693 hybrid interface. HIORT (hybrid Interface Operational Readiness Test) is again an interpretive language that is interactive at the CRT and is used to perform A/D converter absolute error tests and A/D - D/A converter relative error tests. With this program, information is obtained to demonstrate the functioning, within specification, of the hybrid interface.

Thus, with these three software packages, complete hybrid programming is obtained. HYIOS provides the Fortran callable routines for application programs; HYSAT provides a a convenient interactive method for performing initial setup and static checks; and HIORT provides an interactive method of insuring the accuracy of the hybrid interface. These programs are fully documented in Ref. 8.

3. REAL-TIME HYBRID

The multiprogramming 360/91 is a great asset for the hybrid user in that it provides nearly unlimited digital resources and inexpensive operation. However, when real-time hybrid is considered, multiprogramming becomes a liability. Since many users are timesharing the facilities of the large central processor, service within a fixed time frame cannot be guaranteed. From the beginning, it was obvious that a hypervisor was required for real-time jobs.

This need has been met by IBM's real time monitor (RTM). RTM was developed at the IBM Palo Alto DACS Development Center and was first reported in a seminar at the DACS Center in September 1968 (Ref. 9). As first reported, RTM guarantees CPU service to jobs designated as real-time jobs, with RTM co-resident with the OS/360 monitor. The real-time job can use all the facilities of OS and can force all non-real time jobs into the "wait state" when it needs the CPU. IBM augmented their basic RTM with the code required, to have RTM support the PDA, precision interval timer, and priority interrupt subchannels of the IBM 2909. These packages provide Fortran callable subroutines as well as assembly language MACRO'S for accessing and controlling the three subchannels. RTM is a "free" IBM software package installable on IBM System 360 and 370 computers; it was released in December 1970. Reference 10 is an introduction to RTM and Reference 11 is the RTM Operations and Programmer's Guide.

Many applications programs have been written using the real time monitor in which two basic types of operation are employed: (a) initialization of real-time events via the priority interrupts and (b) the initialization of real-time events via decrementing of the interval timer. Besides the conventional closed-loop hybrid technique of executing a digital program involving A/D conversion, digital calculation and D/A conversion; an interrupt-based, multiplying D/A converter, hybrid function generation scheme (Ref. 12) has also been implemented. In order to complete support of these real-time hybrid jobs, the HYIOS subroutines were rewritten to run under RTM as well as OS/360. These routines are referred to as RTAM (Real Time Access Method). During this effort, much of the error checking in these routines was omitted, greatly decreasing the execution time of each routine.

As an aid for preparing real-time simulations, APL has written an interactive program which generates all RTM and RTAM subroutine calls. The input to this program is the hybrid resources required for the simulation, such as number of D/A and A/D converters and their addresses, control lines to be set or reset, etc. The output of the program is a compilable Fortran IV source program that serves as the base for the digital portion of the hybrid simulation (Ref. 13).

4. HYBRID OPERATION

Two modes of hybrid operation are currently employed: closed-loop real-time hybrid and data acquisition. In both cases the hybrid jobs are submitted to the 360/91 via the Data 100. If it is a real-time job, the hybrid applications engineer must have RTM started prior to the release of his application program. Both real-time and data acquisition jobs are run interactively at the CRT and jobs are available within minutes of submission.

Hybrid data acquisition programs are those that use the digital computer to vary parameters interactively between runs, collect data at the end of a run, and then post-process the data to determine a cost function in an all-analog simulation. No real-time constraint exists in this type of running. Stochastic variation (white noise) is usually an input and many runs are required to statistically define a data point. The digital computer response is gotten by forcing the 360/91 program into the "wait state" for the analog solution time which immediately follows the change of the analog mode to operate. Following the "wait," data is collected and simulation control is returned to the user at CRT. This mode has been quite reliable and control is immediately returned following the "wait." Non-real time jobs operate under OS/360 at an execution priority of 11 out of 13, using the HYIOS routines supplied by EAI. As previously mentioned, all real-time jobs operate under RTM in the manner discussed.

All simulations, either data acquisition or hybrid, employ a set of APL written interactive subroutines for simulation control. These routines allow readout and alteration of digital constants and variables, reassignment of D/A and A/D channels, performance of parameter variation runs, and printout of digital data (Ref. 14).

# APPENDIX D
# INTERACTIVE SUBROUTINES

## 1. INTRODUCTION

A set of generalized user communication subroutines has been added to the HVHP to enhance its operation by engineers. A subset of these routines directly aimed at the engineering user expedite 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, 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 HVHP to perform the vehicle handling test procedures (VHTP) and to calculate the vehicle comparison variables (CV).

## 2. SUBROUTINE USE

All simulation control occurs at the hybrid 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 I lists the names of the currently available interactive subroutines.

TABLE I
INTERACTIVE SUBROUTINE LIST

X (Execute Single Simulation Run)

XM (Execute Multi-run Series)

IC (Initialize Simulation)

F (Read or Alter Real Variables)

I (Read or Alter Integer Variables)

DACA (Alter DAC Array)

ADCA (Alter ADC Array)

MULTI (Setup Multiple Runs)

TEST (Test Runs)

MES (Send Message to Line Printer)

TABLE (Setup End-of-Run Output)

TRACK (Setup during Run Data Collection)

LA (List Array Values)

REMOVE (Suspend Output)

T+D (Output Timed and Date)

STD (Standard Output)

DUMP (Output All Variables)

DACL (List DAC Array)

ADCL (List ADC Array)

TERM (Terminate Program)

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 operators 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 II.

Table II
Data Output Selections

| Unit | Mode |
|---|---|
| T = CRT | S = Single Runs Only |
| L = System Line Printer | M = Multi-runs 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 which are associated with wheel computation (side force, FSI; normal force, FRI; ground patch velocity, CVI; etc.) are addressable as arrays and use only one interactive variable allocation. Currently, 300 interactive names have been used which permit the interrogation or alteration of more than 900 Fortran variables.

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

## 4. SUBROUTINE DESCRIPTIONS

### X (Execute Single Run)

Purpose - 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=    0.085 LANE CHNG DEL=    0.0   DELPSI=   0.0    MAX STEER=  27.927
FTRQMAX=    0.0    RTRQMAX=    0.0

OPTION
```

XM (Execute Multi-run Series)

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

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
```

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
```

F (Alter or Read 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, allows 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
****
```

I (Alter or Read Integer Variables)

Purpose - Read current values of parameters, initial conditions and variables which 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
****
```

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 1 - 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
DACO( 1) = IOUT..(    1) /      1.0000
ENTER NAME
****  AYMAX
SCALE FACTOR
****  1.
ENTER DAC ARRAY NUM OR NAME
****
OPTION
```

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 1 - 28

Example -

```
OPTION
 ****  ADCA
 TO RETURN TO OPTIONS  HIT CR
 ENTER ADC ARRAY NUM OR NAME
 ****  20
 QUAN2.(    1) = ADCO(20) *      1.0000
 ENTER NAME
 ****  SLIPI(2)
 SCALE FACTOR
 ****  1.
 ENTER ADC ARRAY NUM OR NAME
 ****
```

MULTI (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 multi-loop. If a zero 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 zero increment or a series can be setup 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 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
```

TEST (Test Run or Abend)

Purpose - To run the problem without real-time service or produce an abnormal termination, 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
```

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.

Inputs Requested - A message that is less than 80 characters long per line.

Example -

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

TABLE (Tabular Output)

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

Input Requested - Up to nine interactive variables.

Example -

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

TRACK (Track Real-Time Variables)

Purpose - To collect and output simulation data as a function of time.

Input Requested -

"TIME ON, OFF, STEP, VARIABLES"

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) Input 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

## LA (List Array Values)

Purpose - To output the values of variables which are array members.

Input Requested - Any Interactive Variable which is an array followed by the range of the array desired.

Example -

```
OPTION
****  LA
UNIT,MODE
****  T XER
ENTER  NAME,INDEX1,INDEX2
****  FRI 1 4
****  FS1 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
```

REMOVE (Suspend Output)

Purpose - To cancel the execution of a selected Interactive Subroutine.

Input Requested - Any Interactive Subroutine name.

Example -

```
OPTION
****  REMOVE
WHAT
****  TRACK
```

The following routines have no inputs. Output is directed to the CRT.

T+D (Time + Date)

Purpose - To display the time and date.

Example -

```
OPTION
****  T+D
UNIT/MODE
****  T XEQ
JUNE       21   1974
TIME  14:30:40.67
```

STD (Standard Output)

Purpose - Select standard end of run data.

Example -

```
OPTION
****  STD
UNIT/MODE
****  I XEQ
 AXAV=   0.0   DECL TIME=   0.0   AVCUR=   0.0   BTDMAX=   0.0   BTMAX=   0.0   DELBT=   0.0
AYMAX=   0.000 PHIMAX=   0.0   RMAX=   0.0   LANE CHNG DEL=   0.0   DELPSI=   0.0   MAX STEER=   0.0
FTRQMAX=   0.0   RTRQMAX=   0.0
```

## DUMP (Dump Data List)

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          OIM...=  63.28       S3P...= -38.00
ABI...= 0.1962E-01  DEL2DA= 0.0          P.....= 0.0          S4P...= -38.00
AFA...=  1.000      DEL2DT= 0.0          PARAM.=  8.430       TBCR3.=  2.923
AIXBR.=  3928.      DEL3DA= 0.0          PBF...= 0.0          TBCR4.=  2.923
AIXP..=  169.8      DEL3DT= 0.0          PBR...= 0.0          TBSR3.=  1.038
AIXZBR=  177.5      DLI...= -.8000       P.....= -.3097E-03   TBSR4.= 0.9047
AIXZP.= -352.5      DLYTB.= -.2453E-54   PFI...=  1000.       TERDAC= -.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          PHIDAX= 0.0          THEDT.= 0.0
AKK1..=  1.000      D2....= -1.299       PHIDT.= 0.0          THEFNT= 0.7500
AKE2..=  1.000      D3....= 0.0          PHIFNT= -.3800       THEO..= -.1215E-02
ALFI..= -.2262E 08  D4....= 0.1146E-68   PHII..= -.6405E 02   THERR.= 0.0
ALIO..= -46.06      EIAL..= -.1133E-05   PHIMAX= 0.0          THRD..= 0.3333
AMI1..=  25.85      EIAX..= -.2176E-03   PHIO..= 0.0          THS1..= 0.1309E-01
AMI2..= -25.85      EXIAB.= -.1278E-56   PHIRD.= 0.0          THS2..= 0.1309E-01
AMUI..= 0.9657      E1....= 0.1156E 09   PHIRDA= 0.0          TIMBMP= 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...=  8.430       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      FOTM..= -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      PSR4..= 0.0         TRO2..=  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         TSO2..=  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         UGI...=  880.0
A2T...=  1900.      GI....= -.1882E-01  RDT...= -.2380E-05  UGIP..=  880.0
BAMI..= 0.2221E-02  GP1...= 0.2864E 06  RMAX..= 0.0         UI....=  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...= 0.6966
BETIP.= 0.6625E-03  GV2...= 0.1252E 06  RTAB..= -.8457E-53  U1I...= 0.6500
BMPN..= 0.0         IAX...= 0.5148E-84  RWZI..= 0.7219      U1P...= 0.0
BMPS..= 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      VHTPNO=  6.000
CA23..=  3293.      IOUTA.= 0.2031E 38  SFOUT.=  1.000      VI....= 0.0
CIP...=  4105.      IPOT..= 0.1524E-81  SFXU..= -4.643      VO....= 0.0
CIVP..=  2046.      IPOTAD= 0.1524E-81  SFYU..= 0.0         VOUT..= 0.0
COSPSI=  1.000      IPRT..= 0.0         SINPSI= -.1558E-02  W.....= 0.0
CPSR3.=  1.000      ISW1..= 0.0         SLIPI.= 0.0         WCTH1.= -.7869
CPSR4.=  1.000      ISW7..= 0.0         SM....=  9.760      WCTH2.= -.9782
CURTBP= 0.0         ITMP..= 0.7892E-04  SN....= 0.0         WDT...=  18.51
CURVAV= 0.0         IVHTP.= 0.3089E-83  SNI...=  1.000      WI....= 0.0
CUVRAT= 0.0         JJTIME= 0.0         SNPHTU= -1.218      WO....= 0.0
CVI...=  50.00      JUMP..= 0.0         SNPSIU= 0.0         WSTH1.= 0.6163
DACO..= 0.7892E-04  MUP...= 0.8563      SNTHEU=  1166.      WSTH2.= 0.2056
DEL...= 0.0         NCAM..= 0.5432E 09  SPSR3.= 0.3551      X.....= 0.0
DELBET= 0.0         NCAS..= -.7418E-67  SPSR4.= 0.3095      XDT...=  880.0
DELFW1= 0.0         NFA...= 0.5148E-83  STR1..= 0.0         XO....= 0.0
DELFW2= 0.0         NTF...= 0.1030E-83  STR2..= 0.0         Y.....= 0.0
DELPHI= -.7662E 55  NTR...= 0.1030E-83  STR3..= 0.0         YDT...= 0.0
DELPSI= 0.0         N1....= 0.1519E-81  STR4..= 0.0         YO....= 0.0
DELSTR= 0.0         N2....= 0.6126E-82  STR5..=  223.4      Z.....= -23.84
DELTA.= 0.1118E 10  ONEOA.= -.6480E-03  STR6..=  223.4      ZDT...=  1.069
DELTHE= -.1079E-49  ONEOD.= 0.8947E-09  S1P...= -40.00      ZI....= -12.48
DEL1DA= 0.0         ONER..= -.5653E-09  S2P...= -40.00      ZIMX..= 0.7219
OPTION
```

## DACL (DAC List)

Purpose - To list the DAC assignments and scale factors.

Example -

```
OPTION
****  DACL
UNIT/MODE
****  T 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..(  32)/     1.0000
DACO(22) = IOUT..(  31)/     1.0000
DACO(23) = IOUT..(  23)/     1.0000
DACO(24) = IOUT..(  29)/     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
DACO(29) = IOUT..(  24)/     1.0000
DACO(30) = IOUT..(  30)/     1.0000
DACO(31) = IOUT..(  22)/     1.0000
DACO(32) = IOUT..(  21)/     1.0000
DACO(33) = IOUT..(  33)/     1.0000
DACO(34) = IOUT..(  34)/     1.0000
DACO(35) = IOUT..(  35)/     1.0000
DACO(36) = IOUT..(  36)/     1.0000
DACO(37) = IOUT..(  37)/     1.0000
DACO(38) = ANTI1.(   1)/     10000.
DACO(39) = ANTI2.(   1)/     10000.
DACO(40) = ANTI3.(   1)/     10000.
DACO(41) = ANTI4.(   1)/     10000.
DACO(42) = ETAX..(   1)/     1.4000
DACO(43) = ETAL..(   1)/     1.4000
DACO(44) = ROUT..(   1)/     1.0000
DACO(45) = UOUT..(   1)/     1200.0
DACO(46) = VOUT..(   1)/     1200.0
DACO(47) = BTV...(   1)/     3.1400
DACO(48) = ONER..(   1)/   0.41700E-02
```

ADCL (ADC List)

Purpose - To list the ADC assignment and scale factors.

Example -

```
OPTION
****  ADCL
UNIT,MODE
****  T XEQ
DEL1DT(    1) = ADCO( 1)*    -100.00
DEL2DT(    1) = ADCO( 2)*    -100.00
DEL3DT(    1) = ADCO( 3)*    -100.00
DEL1DA(    1) = ADCO( 4)*     10.000
DEL2DA(    1) = ADCO( 5)*     10.000
DEL3DA(    1) = ADCO( 6)*     10.000
PHIRD.(    1) = ADCO( 7)*     1.0000
PHIRDA(    1) = ADCO( 8)*    0.25000
DELFW1(    1) = ADCO( 9)*    0.50000
DELFW2(    1) = ADCO(10)*    0.50000
U1P...(    1) = ADCO(11)*     2.0000
U2P...(    1) = ADCO(12)*     2.0000
U3P...(    1) = ADCO(13)*     2.0000
U4P...(    1) = ADCO(14)*     2.0000
S1P...(    1) = ADCO(15)*     1000.0
S2P...(    1) = ADCO(16)*     1000.0
S3P...(    1) = ADCO(17)*     1000.0
S4P...(    1) = ADCO(18)*     1000.0
QUAN1.(    1) = ADCO(19)*     1.0000
QUAN2.(    1) = ADCO(20)*     1.0000
QUAN3.(    1) = ADCO(21)*     1.0000
QUAN4.(    1) = ADCO(22)*     1.0000
ARPS1.(    1) = ADCO(23)*     100.00
ARPS2.(    1) = ADCO(24)*     100.00
WSTH1.(    1) = ADCO(25)*     1.0000
WCTH1.(    1) = ADCO(26)*     1.0000
WSTH2.(    1) = ADCO(27)*     1.0000
WCTH2.(    1) = ADCO(28)*     1.0000
OPTION
```

TERM (Terminate Program)

Purpose - To terminate program.

Example -

```
OPTION
****  TERM
JUNE       21  1974
TIME  17: 5:38.72
PROGRAM TERMINATED
```

If the OPTION cue detects an error or an error is forced by user, the active Subroutines can be determined by the input of a question mark (?).

Example -

```
OPTION
****
ERROR
****  ?
OPTION NOT FOUND
TO XEQ. PROGRAM          TYPE X
TO TERMINATE PROGRAM     TYPE TERM
FOR MULTIPLE RUNS        TYPE MULTI
FOR TEST RUN OR ABEND    TYPE TEST
TO ALTER DAC ARRAY       TYPE DACA
TO ALTER ADC ARRAY       TYPE ADCA
TO SET IC ONLY           TYPE IC
TO SEND MESSAGE TO LP    TYPE MES
FOR TIME AND DATE                 TYPE T+D
TO DUMP DATA LIST                 TYPE DUMP
FOR STANDARD OUTPUT               TYPE STD
TO TRACK REAL TIME VARIABLES      TYPE TRACK
FOR TABULAR OUTPUT                TYPE TABLE
TO LIST DAC ARRAY                 TYPE DACL
TO LIST ADC ARRAY                 TYPE ADCL
```

# APPENDIX E

# SIMULATION DATA

1. PRESENTED HERE IS THE LISTING OF THE INPUT DATA DECKS

```
VEHICLE MODEL - 1971 DODGE CORONET
-0.38      .1061661  .1684393  .01604185 -.00579372-.00220835 0.0
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
0.         0.             TABLE I - FRONT BRAKE TORQUE FUNCTION
1000.      20640.
99999.                                                                    MAIN9190
0.         0.             TABLE II - REAR BRAKE TORQUE FUNCTION
1000.      20640.
99999.                                                                    MAIN9230
0.0         1.00     TABLE III- SIDE FORCE SHAPING FUNCTION
0.05        0.99
0.1         0.97
0.15        0.93
0.2         0.86
0.30        0.72
0.4         0.56
0.6         0.34
0.8         0.25
1.0         0.18
99999.                                                                    MAIN9410
 T+D       DUMP     STD      TESTO    LA                                  MAIN9470
 RESET     TRACK    TABLE    PLOT     DACL                                MAIN9480
 ADCL      ZZZZZZZZSTAT      PC       TM                                  MAIN9490
 CHANGE    READ              CONTROL                                      MAIN9500
 I         TEST     X        RE-STR   DACA                                MAIN9510
 ADCA      OUTPUT   F        MULTI    TERM                                MAIN9520
 MES       IC         ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ                MAIN9530
  PSIDT PHIDT PHI ZIMX(1) ZIMX(3)

 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)
     BMPN BMPS AYMAX RMAX CUVRAT BETDMX
 STR4 BETAMX BETDMX CUVRAT AYMAX RMAX
 STR5 AYMAX DEL BETAMX DELPSI  UIN
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
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  0.                                                                   MAIN9730
017  40400.
018  40.
 19  105.
```

```
021 -2.4
022  2.1
023  0.                                                          MAIN9800
024  -5100.
025  38.
 26  120.
027  2.0
028 -4.4
029  3.6
030  0.020
031  13.2
032  0.0
033   0.75                                                       MAIN9900
034  2701.
035  10.14
036  2533.
037  1.30
038  4591.
039  0.0
040  1.27
041  8000.
042  14.2
043  1.8
044  5.6
045  2.7
046  7.2
047  6.4
 48  0.0
049  9.4
050  9.4
051  0.7
052  2.71
 53  0.0
 54  0.0
055 -0.66
056  4.59
057 -4.59
058 -.1309
059  .1309
060  1.0
061  0.0
062  0.0                                                         MAIN0190
063                                                              MAIN0200
064                                                              MAIN0210
065                                                              MAIN0220
066  40.
067                                                              MAIN0240
068                                                              MAIN0250
069                                                              MAIN0260
070                                                              MAIN0270
071
072                                                              MAIN0290
073                                                              MAIN0300
074                                                              MAIN0310
075 .010                                                         MAIN0320
 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                MAIN0460
089                             MAIN0470
090                             MAIN0480
091   0.0
092  -0.8
093 -.68                        MAIN0510
094                             MAIN0520
095                             MAIN0530
096                             MAIN0540
097                             MAIN0550
098                             MAIN0560
099                             MAIN0570
100                             MAIN0580
101                             MAIN0590
102                             MAIN0600
103                             MAIN0610
104                             MAIN0620
105                             MAIN0630
106                             MAIN0640
107   1.0                       MAIN0650
108                             MAIN2560
109 0.
110  0.0
111  0.0
112  0.0                        MAIN0700
113  1.
114  25.
115  1.0
116  0.5
117  3.
118  3.                         MAIN0760
119                             MAIN0770
120
121  300.                       MAIN0790
122                             MAIN0800
123                             MAIN0810
124                             MAIN0820
125                             MAIN0830
126                             MAIN0840
127
128  3.0                        MAIN0860
129 0.
130  0.06
131  16.0
132  55900.
133  55900.
134  6.62
135  6.62
136  11.0
137  54.
138  5.20
139  0.45
```

```
-0.45
 0.                                                              MAIN0980
 0.                                                              MAIN0990
                                                                 MAIN1000
                                                                 MAIN1010
 0.0
 0.0
                                                                 MAIN1040
                                                                 MAIN1050
                                                                 MAIN1060
                                                                 MAIN1070
                                                                 MAIN1080
                                                                 MAIN1090
                                                                 MAIN1100
                                                                 MAIN1110
                                                                 MAIN1120
                                                                 MAIN1130
                                                                 MAIN1140
                                                                 MAIN1150
                                                                 MAIN1160
                                                                 MAIN1170
                                                                 MAIN1180
                                                                 MAIN1190
                                                                 MAIN1200
                                                                 MAIN1210
                                                                 MAIN1220
                                                                 MAIN1230
                                                                 MAIN1240
                                                                 MAIN1250
 73.
 73.
 73.
2.                                                               MAIN1290
                                                                 MAIN1300
                                                                 MAIN1310
0.25                                                             MAIN1320
                                                                 MAIN1330
                                                                 MAIN1340
                                                                 MAIN1350
1.                                                               MAIN1360
3.                                                               MAIN1370
 1.                                                              MAIN1380
 0.17
 0.17
 0.17
 0.17
                                                                 MAIN1430
                                                                 MAIN1440
                                                                 MAIN1450
 0.0
                                                                 MAIN1470
                                                                 MAIN1480
 1.                                                              MAIN1490
                                                                 MAIN1500
                                                                 MAIN1510
                                                                 MAIN1520
 0.
 0.
```

```
200  1.5                    MAIN1570
201
202  0.94
203  -.00008
204  0.94
205  -.00008
206  0.65
207  0.65
208  0.
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.
224  0.
225  0.
226  0.
227  0.
228  0.
229  0.
230  0.
231  400.
232  400.
233  0.
234  105.
235  105.
236  120.
237  120.
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
277  0.                                                    MAIN2340
278  0.                                                    MAIN2350
279  0.                                                    MAIN2360
280  0.                                                    MAIN2370
281  1.                                                    MAIN2380
282  1.                                                    MAIN2390
283  0.                                                    MAIN2400
284  2.7
285  3.9
286  0.0
287  1.
288  0.                                                    MAIN2450
289  0.                                                    MAIN2460
290  0.75                                                  MAIN2470
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
304                                                        MAIN2660
IOUT(01)  1.                                               MAIN2670
IOUT(02)  1.                                               MAIN2680
IOUT(03)  1.                                               MAIN2690
IOUT(04)  1.                                               MAIN2700
IOUT(05)  1.                                               MAIN2710
IOUT(06)  1.                                               MAIN2720
IOUT(07)  1.                                               MAIN2730
IOUT(08)  1.                                               MAIN2740
IOUT(09)  1.                                               MAIN2750
IOUT(10)  1.                                               MAIN2760
IOUT(11)  1.                                               MAIN2770
IOUT(12)  1.                                               MAIN2780
IOUT(13)  1.                                               MAIN2790
```

```
                                   MAIN2800
IOUT(14)  1.                       MAIN2810
IOUT(15)  1.                       MAIN2820
IOUT(16)  1.                       MAIN2830
IOUT(17)  1.                       MAIN2840
IOUT(18)  1.                       MAIN2850
IOUT(19)  1.                       MAIN2860
IOUT(20)  1.                       MAIN2980
IOUT(32)  1.                       MAIN2970
IOUT(31)  1.                       MAIN2890
IOUT(23)  1.                       MAIN2950
IOUT(29)  1.                       MAIN2910
IOUT(25)  1.                       MAIN2920
IOUT(26)  1.                       MAIN2930
IOUT(27)  1.                       MAIN2940
IOUT(28)  1.                       MAIN2900
IOUT(24)  1.                       MAIN2960
IOUT(30)  1.                       MAIN2880
IOUT(22)  1.                       MAIN2870
IOUT(21)  1.                       MAIN2990
IOUT(33)  1.                       MAIN3000
IOUT(34)  1.                       MAIN3010
IOUT(35)  1.                       MAIN3020
IOUT(36)  1.                       MAIN3030
IOUT(37)  1.
ANTI1 10000.
ANTI2 10000.
ANTI3 10000.
ANTI4 10000.
ETAX 1.4
ETAL 1.4
ROUT  1.0
UOUT  1200.
VOUT  1200.
BTV 3.14
                                   MAIN3070
ONER .00417                        MAIN3080
 DEL1DT -100.                      MAIN3090
 DEL2DT -100.                      MAIN3100
 DEL3DT -100.                      MAIN3110
 DEL1DA 10.                        MAIN3120
 DEL2DA 10.                        MAIN3130
 DEL3DA 10.                        MAIN3140
 PHIRD 1.                          MAIN3150
PHIRDA 0.25                        MAIN3160
DELFW1 0.5                         MAIN3170
DELFW2 0.5                         MAIN3180
U1P 2.                             MAIN3190
U2P 2.                             MAIN3200
U3P 2.                             MAIN3210
U4P 2.                             MAIN3220
S1P 1000.                          MAIN3230
S2P 1000.                          MAIN3240
S3P 1000.                          MAIN3250
S4P 1000.                          MAIN3260
QUAN1 1.                           MAIN3270
QUAN2 1.                           MAIN3280
QUAN3 1.                           MAIN3290
QUAN4 1.                           MAIN3300
ARPS1 100.                         MAIN3310
ARPS2 100.
WSTH1 1.
```

```
WCTH1 1.
WSTH2 1.
WCTH2 1.
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  0.        0.        0.        0.        0.        0.        0.
114  25.       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.
122  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
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.
238  1.        1.        1.        0.00      0.00      0.00      1.
239  1.        1.        1.        0.00      0.00      0.00      1.
240  .67       .67       .67       0.00      0.00      0.00      .67
241  .67       .67       .67       0.00      0.00      0.00      .67
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
./     ENDUP
```

```
VEHICLE MODEL - 1971 CHEVROLET BROOKWOOD STATION WAGON
-0.5       .3834042  .1484607  .00647286 -.00358714-.00071117 0.0
-1.0       0.0       0.0       0.0       0.0       0.0       0.0
-0.37      -.1824622 -.03434468-.0031657 .001503944.000329646 0.0
0.0        0.0       0.0       0.0       0.0       0.0       0.0
0.0        0.0       0.0       0.0       0.0       0.0       0.0                MAIN  60
0.0        0.0       0.0       0.0       0.0       0.0       0.0                MAIN  70
0.         0.        TABLE I   -FRONT BRAKE TORQUE                              MAIN  80
1000.      17000.
99999.                                                                          MAIN 110
0.         0.        TABLE II -REAR BRAKE TORQUE                                MAIN 120
1000.      17000.
99999.                                                                          MAIN 150
0.0         1.00     TABLE III- SIDE FORCE SHAPING FUNCTION
0.05        0.99
0.1         0.97
0.15        0.93
0.2         0.86
0.30        0.72
0.4         0.56
0.6         0.34
0.8         0.25
1.0         0.18
99999.                                                                          MAIN 330
 T+D     DUMP    STD     TESTO   LA                                             MAIN 390
 RESET   TRACK   TABLE   PLOT    DACL                                           MAIN 400
 ADCL    ZZZZZZZZSTAT    PC      TM                                             MAIN 410
 CHANGE  READ            CONTROL                                                MAIN 420
 I       TEST    X       RE-STR  DACA                                           MAIN 430
 ADCA    OUTPUT  F       MULTI   TERM                                           MAIN 440
 MES     IC        ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ                          MAIN 450
  PSIDT PHIDT PHI ZIMX(1)  ZIMX(3)
                                                                                MAIN 480
 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)
     BMPN BMPS AYMAX RMAX CUVRAT BETDMX
 STR4 BETAMX BETDMX CUVRAT AYMAX RMAX
 STR5 AYMAX DEL BETAMX DELPSI  UIN
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
001  11.2
002  0.63
003  1.03
004  11.1
005  10.9
006  65.0
007  60.0
008  63.5
009  63.5
010  45.3
011  6124.
012  41529.
013  42445.
014  1790.
015  750.
016  0.                                                                         MAIN 650
017  408000.
018  43.
 19  141.
```

```
021 -3.5
022  2.3
023  0.                                                                MAIN 720
024  -62000.
025  73.
 26  210.
027  2.0
028 -3.6
029  2.3
030  0.033
031  14.4
032  0.0
033  1.0
034  585.91
035  14.47
036  2886.
037  2.29
038  4057.
039  0.0
040  1.08
041  8000.
042  16.2
043  2.0
044  4.2
045  1.9
046  5.1
047  10.0
 48  0.0
049  14.8
050  14.8
051  0.7
052  3.08
 53  0.0
 54  0.0
055  0.16
056  5.25
057 -5.25
058 -.1745
059  .1745
060   1.0
061  0.0
062  0.0                                                               MAIN1110
063                                                                    MAIN1120
064                                                                    MAIN1130
065                                                                    MAIN1140
066  40.
067                                                                    MAIN1160
068                                                                    MAIN1170
069                                                                    MAIN1180
070                                                                    MAIN1190
071  0.0
072                                                                    MAIN1210
073                                                                    MAIN1220
074                                                                    MAIN1230
075 .010                                                               MAIN1240
076  5.0
077  1724.
078  1724.
079  1906.
```

```
080  1906.
081  0.0
082  0.0
083  0.0
084  0.0
085  -.000208
086  0.0
087  1.267
088  .0000000437                                   MAIN1380
089                                                MAIN1390
090                                                MAIN1400
091   0.0
092  -0.6
093 -.42                                           MAIN1430
094                                                MAIN1440
095                                                MAIN1450
096                                                MAIN1460
097                                                MAIN1470
098                                                MAIN1480
099                                                MAIN1490
100                                                MAIN1500
101                                                MAIN1510
102                                                MAIN1520
103                                                MAIN1530
104                                                MAIN1540
105                                                MAIN1550
106                                                MAIN1560
107   1.0                                          MAIN1570
108
109  0.0
110  0.0
111  0.0
112  0.0                                           MAIN1620
113  1.
114  25.
115  1.0                                           MAIN3510
116 .5
117  3.0
118  3.0                                           MAIN1680
119                                                MAIN1690
120
121  300.                                          MAIN1710
122                                                MAIN1720
123                                                MAIN1730
124                                                MAIN1740
125                                                MAIN1750
126                                                MAIN1760
127
128  3.0                                           MAIN1780
129 0.
130  0.06
131  12.0
132  91700.
133  91700.
134  6.26
135  6.26
136  11.0
137  77.
138  5.80
139  0.40
```

```
140 -0.40
141  0.                                                    MAIN1900
142  0.                                                    MAIN1910
143                                                        MAIN1920
144                                                        MAIN1930
145  0.0
146  0.0
147                                                        MAIN1960
148                                                        MAIN1970
149                                                        MAIN1980
150                                                        MAIN1990
151                                                        MAIN2000
152                                                        MAIN2010
153                                                        MAIN2020
154                                                        MAIN2030
155                                                        MAIN2040
156                                                        MAIN2050
157                                                        MAIN2060
158                                                        MAIN2070
159                                                        MAIN2080
160                                                        MAIN2090
161                                                        MAIN2100
162                                                        MAIN2110
163                                                        MAIN2120
164                                                        MAIN2130
165                                                        MAIN2140
166                                                        MAIN2150
167                                                        MAIN2160
168                                                        MAIN2170
169  73.
170  73.
171  73.
172 2.                                                     MAIN2210
173                                                        MAIN2220
174                                                        MAIN2230
175 0.25                                                   MAIN2240
176                                                        MAIN2250
177                                                        MAIN2260
178                                                        MAIN2270
179 1.                                                     MAIN2280
180 3.                                                     MAIN2290
181  1.                                                    MAIN2300
182  0.11
183  0.11
184  0.14
185  0.14
186                                                        MAIN2350
187                                                        MAIN2360
188                                                        MAIN2370
189  0.0
190                                                        MAIN2390
191                                                        MAIN2400
192  1.0
193                                                        MAIN2420
194                                                        MAIN2430
195                                                        MAIN2440
196  0.
197  0.
198  0.0
199  0.0
```

| | |
|---|---|
| 200 | 1.5 |
| 201 | 0.0 |
| 202 | 0.94 |
| 203 | -.0000893 |
| 204 | 1.20 |
| 205 | -.000177 |
| 206 | 0.61 |
| 207 | 0.70 |
| 208 | 0.0 |
| 209 | 0.0 |
| 210 | 0.0 |
| 211 | 0.0 |
| 212 | 0.0 |
| 213 | 0.0 |
| 214 | 0.0 |
| 215 | 0.0 |
| 216 | 0.0 |
| 217 | 0.0 |
| 218 | 0.0 |
| 219 | 0. |
| 220 | 0. |
| 221 | 0. |
| 222 | 0. |
| 223 | 0.0 |
| 224 | 0.0 |
| 225 | 0.0 |
| 226 | 0.0 |
| 227 | 0.0 |
| 228 | 0.0 |
| 229 | 0.0 |
| 230 | 0.0 |
| 231 | 400. |
| 232 | 400. |
| 233 | 0.0 |
| 234 | 141. |
| 235 | 141. |
| 236 | 210. |
| 237 | 210. |
| 238 | 1.50 |
| 239 | 1.50 |
| 240 | 1.00 |
| 241 | 1.00 |
| 242 | -.0000232 |
| 243 | -.0000372 |
| 244 | .00000233 |
| 245 | -.000109 |
| 246 | 0.0 |
| 247 | 1.216 |
| 248 | -.0000000135 |
| 249 | -.003024 |
| 250 | .003024 |
| 251 | 1.86 |
| 252 | -.00247 |
| 253 | .00217 |
| 254 | 1.90 |
| 255 | 0.0 |
| 256 | -.00166 |
| 257 | -.00428 |
| 258 | -3.122 |
| 259 | 0.0 |

```
260  -.00126
261  -.00377
262  -5.48
263  -0.13
264  -.03
265  .0
266  0.15
267  .015
268  .0
269  0.022
270  .01
271  .0
272  0.0
273  .0
274  .0
275  0.0
276  0.0
277  0.                                                         MAIN3260
278  0.                                                         MAIN3270
279  0.                                                         MAIN3280
280  0.                                                         MAIN3290
281  1.                                                         MAIN3300
282  1.                                                         MAIN3310
283  0.                                                         MAIN3320
284  0.7
285  4.0
286  0.0
287  1.
288  0.                                                         MAIN3370
289  0.                                                         MAIN3380
290  1.0
291  -230.1
292  16.07
293  3473.
294  2.42
295  4590.
001  11.6
004  10.9
005  10.8
006  64.9
007  60.1
011  6800.
012  42551.
013  43465.
092  -0.9
093 -.56
304                                                             MAIN3580
IOUT(01)  1.                                                    MAIN3590
IOUT(02)  1.                                                    MAIN3600
IOUT(03)  1.                                                    MAIN3610
IOUT(04)  1.                                                    MAIN3620
IOUT(05)  1.                                                    MAIN3630
IOUT(06)  1.                                                    MAIN3640
IOUT(07)  1.                                                    MAIN3650
IOUT(08)  1.                                                    MAIN3660
IOUT(09)  1.                                                    MAIN3670
IOUT(10)  1.                                                    MAIN3680
IOUT(11)  1.                                                    MAIN3690
IOUT(12)  1.                                                    MAIN3700
IOUT(13)  1.                                                    MAIN3710
```

```
                                  MAIN3720
IOUT(14) 1.                       MAIN3730
IOUT(15) 1.                       MAIN3740
IOUT(16) 1.                       MAIN3750
IOUT(17) 1.                       MAIN3760
IOUT(18) 1.                       MAIN3770
IOUT(19) 1.                       MAIN3780
IOUT(20) 1.                       MAIN3900
IOUT(32) 1.                       MAIN3890
IOUT(31) 1.                       MAIN3810
IOUT(23) 1.                       MAIN3870
IOUT(29) 1.                       MAIN3830
IOUT(25) 1.                       MAIN3840
IOUT(26) 1.                       MAIN3850
IOUT(27) 1.                       MAIN3860
IOUT(28) 1.                       MAIN3820
IOUT(24) 1.                       MAIN3880
IOUT(30) 1.                       MAIN3800
IOUT(22) 1.                       MAIN3790
IOUT(21) 1.                       MAIN3910
IOUT(33) 1.                       MAIN3920
IOUT(34) 1.                       MAIN3930
IOUT(35) 1.                       MAIN3940
IOUT(36) 1.                       MAIN3950
IOUT(37) 1.
ANTI1 10000.
ANTI2 10000.
ANTI3 10000.
ANTI4 10000.
ETAX 1.4
ETAL 1.4
ROUT 1.0
UOUT 1200.
BTV 3.14
VOUT 1200.
ONER .00417                       MAIN3990
 DEL1DT -100.                     MAIN4000
 DEL2DT -100.                     MAIN4010
 DEL3DT -100.                     MAIN4020
 DEL1DA 10.                       MAIN4030
 DEL2DA 10.                       MAIN4040
 DEL3DA 10.                       MAIN4050
 PHIRD 1.                         MAIN4060
 PHIRDA 0.25                      MAIN4070
 DELFW1 0.5                       MAIN4080
 DELFW2 0.5                       MAIN4090
 U1P 2.                           MAIN4100
 U2P 2.                           MAIN4110
 U3P 2.                           MAIN4120
 U4P 2.                           MAIN4130
 S1P 1000.                        MAIN4140
 S2P 1000.                        MAIN4150
 S3P 1000.                        MAIN4160
 S4P 1000.                        MAIN4170
 QUAN1 1.                         MAIN4180
 QUAN2 1.                         MAIN4190
 QUAN3 1.                         MAIN4200
 QUAN4 1.                         MAIN4210
 ARPS1 100.                       MAIN4220
 ARPS2 100.                       MAIN4230
 WSTH1 1.
```

```
WCTH1 1.                                                                              MAIN4240
WSTH2 1.                                                                              MAIN4250
WCTH2 1.                                                                              MAIN4260
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   0.         0.         0.         0.         0.         0.         0.
114   25.        0.         62.        85.        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.
122   0.         0.         0.         0.         0.         0.         0.
123   0.         0.         0.         0.         0.         0.         0.
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   1.0        .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.
238   1.50       1.50       1.50       0.0        0.0        0.0        1.50
239   1.50       1.50       1.50       0.0        0.0        0.0        1.50
240   1.00       1.00       1.00       0.0        0.0        0.0        1.00
241   1.00       1.00       1.00       0.0        0.0        0.0        1.00
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
./      ENDUP
```

```
VEHICLE MODEL - 1971 VOLKWAGEN SUPER BETTLE - CALSPAN -
-1.0        -.5421219 -.03507042-.00111927.000554971.000195158 0.0
2.0         0.0         0.0         0.0         0.0         0.0         0.0         COMM 520
-.16        -.2063332 -.03317212.001250005.000874341.000083333 0.0
-1.3        .7300002  -.01333302.000833121.003333263-.0008333  0.0
0.0         0.0         0.0         0.0         0.0         0.0         0.0         COMM 550
0.0         .03416665 -.02541667-.00291666.005416665-.00125    0.0
0.0         0.0               TABLE I- FRONT BRAKE TORQUE FUNCTION
1000.       5904.
99999.                                                                          COMM 590
0.0         0.0               TABLE II - REAR BRAKE TORQUE FUNCTION
1000.       5904.
99999.                                                                          COMM 620
0.0          1.00      TABLE III- SIDE FORCE SHAPING FUNCTION
0.05         0.99
0.1          0.97
0.15         0.93
0.2          0.86
0.30         0.72
0.4          0.56
0.6          0.34
0.8          0.25
1.0          0.18
99999.                                                                          COMM 830
 T+D      DUMP    STD      TESTO    LA                                          COMM 890
 RESET    TRACK   TABLE    PLOT     DACL                                        COMM 900
 ADCL     ZZZZZZZZSTAT     PC       TM                                          COMM 910
 CHANGE   READ             CONTROL                                              COMM 920
 I        TEST    X        RE-STR   DACA                                        COMM 930
 ADCA     OUTPUT  F        MULTI    TERM                                        COMM 940
 MES      IC        ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ                         COMM 950
  PSIDT PHIDT PHI ZIMX(1)  ZIMX(3)
                                                                                COMM 980
 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)
     BMPN BMPS AYMAX RMAX CUVRAT BETDMX
 STR4 BETAMX BETDMX CUVRAT AYMAX RMAX
 STR5 AYMAX DEL BETAMX DELPSI  UIN
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
001  5.09
002   0.33
003   0.57
004  11.5
005  11.8
006   56.1
007   39.7
008  53.8
009  51.5
010  50.
011  1937.
012  9139.
013  8528.
014   0.0
015   800.
016  0.                                                                         COMM1150
017  93000.
018  35.
019  65.7
```

```
020  5.0
021 -1.80
022  3.40
023  0.                                                    COMM1220
024  28300.
025  40.
026  115.
027  2.5
028 -1.85
029  3.35
030  0.0
031  12.6
032  0.                                                    COMM1310
033  1.0                                                   COMM1320
034  5835.
035  -2.89
036  2860.
037  1.79
038  2499.
039  0.0
040   0.957
041  7000.
042   17.0
043  2.5
044  8.0
045  1.6
046  3.9
047   4.4
048 0.0
049   7.35
050   7.35
051   0.3
052   4.13
053  0.0
054  0.0
055  1.66
056  3.75
057 -3.75
058 -.1745
059  .1745
060   1.0                                                  COMM1590
061  0.0
062  0.0
063                                                        COMM1620
064                                                        COMM1630
065                                                        COMM1640
066  40.
067                                                        COMM1660
068                                                        COMM1670
069                                                        COMM1680
070                                                        COMM1690
071  0.0
072                                                        COMM1710
073                                                        COMM1720
074                                                        COMM1730
075  0.010                                                 COMM1740
076  5.0
077  746.
078  746.
079  956.
```

```
VEHICLE MODEL - 1971 VOLKWAGEN SUPER BETTLE - CALSPAN -
-1.0       -.5421219 -.03507042-.00111927.000554971.000195158 0.0
2.0        0.0       0.0       0.0       0.0       0.0       0.0          COMM 520
-.16       -.2063332 -.03317212.001250005.000874341.000083333 0.0
-1.3       .7300002  -.01333302.000833121.003333263-.0008333  0.0
0.0        0.0       0.0       0.0       0.0       0.0       0.0          COMM 550
0.0        .03416665 -.02541667-.0029166.005416665-.00125    0.0
0.0        0.0             TABLE I- FRONT BRAKE TORQUE FUNCTION
1000.      5904.
99999.                                                                  COMM 590
0.0        0.0             TABLE II - REAR BRAKE TORQUE FUNCTION
1000.      5904.
99999.                                                                  COMM 620
0.0         1.00      TABLE III- SIDE FORCE SHAPING FUNCTION
0.05        0.99
0.1         0.97
0.15        0.93
0.2         0.86
0.30        0.72
0.4         0.56
0.6         0.34
0.8         0.25
1.0         0.18
99999.                                                                  COMM 830
 T+D       DUMP     STD      TESTO    LA                                COMM 890
 RESET     TRACK    TABLE    PLOT     DACL                              COMM 900
 ADCL      ZZZZZZZZSTAT      PC       TM                                COMM 910
 CHANGE    READ              CONTROL                                    COMM 920
 I         TEST     X        RE-STR   DACA                              COMM 930
 ADCA      OUTPUT   F        MULTI    TERM                              COMM 940
 MES       IC         ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ              COMM 950
  PSIDT PHIDT PHI ZIMX(1)  ZIMX(3)
                                                                        COMM 980
 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)
      BMPN BMPS AYMAX RMAX CUVRAT BETDMX
 STR4 BETAMX BETDMX CUVRAT AYMAX RMAX
 STR5 AYMAX DEL BETAMX DELPSI  UIN
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
001  5.09
002   0.36
003   0.57
004  11.5
005  11.8
006   56.1
007   39.7
008  53.8
009  51.5
010  50.
011  1937.
012  9139.
013  8528.
014   0.0
015   800.
016  0.                                                                 COMM1150
017  93000.
018  .35.
019  65.7
```

```
020  5.0
021 -1.80
022  3.40
023  0.                                                  COMM1220
024  28300.
025  40.
026  115.
027  2.5
028 -1.85
029  3.35
030  0.0
031  12.6
032   0.                                                 COMM1310
033  1.0                                                 COMM1320
034  5835.
035  -2.89
036  2860.
037  1.79
038  2499.
039  0.0
040   0.957
041  7000.
042   17.0
043  2.5
044  8.0
045  1.6
046  3.9
047   4.4
048 0.0
049   7.35
050   7.35
051   0.3
052   4.13
053  0.0
054  0.0
055  1.66
056  3.75
057 -3.75
058 -.1745
059  .1745
060   1.0                                                COMM1590
061  0.0
062  0.0
063                                                      COMM1620
064                                                      COMM1630
065                                                      COMM1640
066  40.
067                                                      COMM1660
068                                                      COMM1670
069                                                      COMM1680
070                                                      COMM1690
071  0.0
072                                                      COMM1710
073                                                      COMM1720
074                                                      COMM1730
075  0.010                                               COMM1740
076  5.0
077  746.
078  746.
079  956.
```

```
080  956.
081  0.0
082  0.0
083  0.0
084  0.0
085  -.00030
086  0.0
087  1.20
088  0.0                                                    COMM1880
089                                                         COMM1890
090                                                         COMM1900
091   0.0
092  -1.3
093  -0.8                                                   COMM1930
094                                                         COMM1940
095                                                         COMM1950
096                                                         COMM1960
097                                                         COMM1970
098                                                         COMM1980
099                                                         COMM1990
100                                                         COMM2000
101                                                         COMM2010
102                                                         COMM2020
103                                                         COMM2030
104                                                         COMM2040
105                                                         COMM2050
106                                                         COMM2060
107    1.0                                                  COMM2070
108                                                         COMM2080
109 0.
110  0.0
111  0.0                                                    COMM2110
112 0.                                                      COMM2120
113  1.
114  25.
115  1.0                                                    COMM2150
116 .5
117  3.0
118  3.0                                                    COMM2180
119                                                         COMM2190
120
121  300.                                                   COMM2210
122 0.                                                      COMM2220
123                                                         COMM2230
124                                                         COMM2240
125                                                         COMM2250
126 0.                                                      COMM2260
127
128  3.0                                                    COMM2280
129 0.
130  0.05
131  18.
132  106000.
133  106000.
134  5.50
135  5.50
136  3.75
137  57.
138  5.75
139  0.0
```

```
140  0.0
141                                                              COMM2400
142                                                              COMM2410
143  0.                                                          COMM2420
144  0.                                                          COMM2430
145  0.0
146  0.0
147                                                              COMM2460
148                                                              COMM2470
149                                                              COMM2480
150                                                              COMM2490
151                                                              COMM2500
152                                                              COMM2510
153                                                              COMM2520
154                                                              COMM2530
155                                                              COMM2540
156                                                              COMM2550
157                                                              COMM2560
158                                                              COMM2570
159                                                              COMM2580
160                                                              COMM2590
161                                                              COMM2600
162                                                              COMM2610
163                                                              COMM2620
164                                                              COMM2630
165                                                              COMM2640
166                                                              COMM2650
167                                                              COMM2660
168                                                              COMM2670
169  73.
170  73.
171  73.
172 2.                                                           COMM2710
173                                                              COMM2720
174                                                              COMM2730
175 .2500                                                        COMM2740
176                                                              COMM2750
177                                                              COMM2760
178                                                              COMM2770
179 1.                                                           COMM2780
180 3.                                                           COMM2790
181  1.                                                          COMM2800
182  0.13
183  0.13
184  0.20
185  0.20
186                                                              COMM2850
187                                                              COMM2860
188 0.                                                           COMM2870
189 0.                                                           COMM2880
190                                                              COMM2890
191                                                              COMM2900
192  1.0
193                                                              COMM2920
194                                                              COMM2930
195                                                              COMM2940
196  0.
197  0.
198
199
```

```
200  1.5
201
202  0.88
203  0.0
204  0.93
205  0.0
206  0.64
207  0.70
208  0.0
209  0.0
210  0.0
211  0.0
212  0.0
213  0.0
214  0.0
215  0.0
216  0.0
217  0.0
218  0.0
219  0.
220  0.
221  0.
222  0.
223  0.0
224  0.0
225  0.0
226  0.0
227  0.0
228  0.0
229  0.0
230  0.0
231  200.
232  200.
233  0.0
234  65.7
235  65.7
236  115.
237  115.
238  1.44
239  1.44                                         COMM3390
240    1.0                                        COMM3400
241    1.0
     -.0000107
243  -.0000241
244  .00000218
245  -.0000868
246  0.0
247  1.185
248  -.000000134
249  -.00593
250   .00612
251  1.671
252  -.00445
253   .00440
254  .6885
255  0.0
256  -.00245
257  -.00537
258  -.811
259  0.0
```

```
260  -.00184
261  -.00503
262  -1.85
263  0.0
264  .03
265  .0
266  0.29
267  .03
268  0.
269  0.089
270  .01
271  0.
272  0.13
273  .03
274  .0
275  0.0
276  0.0
277  0.                                                            COMM3760
278 0.                                                             COMM3770
279 0.                                                             COMM3780
280  0.                                                            COMM3790
281  1.                                                            COMM3800
282  1.                                                            COMM3810
283  0.                                                            COMM3820
284  2.4
285  3.4
286  0.0
287  2.
288  0.0                                                           COMM3870
289  0.0                                                           COMM3880
290 1.0                                                            COMM3890
291  4037.
292  3.87
293  1728.
294  1.41
295  3902.
001  5.50
004  10.8
005  11.2
006  55.9
007  39.9
011  2060.
012  9927.
013  9385.
092  -1.9
093  -1.3
304                                                                COMM3950
IOUT(01)  1.                                                       COMM3960
IOUT(02)  1.                                                       COMM3970
IOUT(03)  1.                                                       COMM3980
IOUT(04)  1.                                                       COMM3990
IOUT(05)  1.                                                       COMM4000
IOUT(06)  1.                                                       COMM4010
IOUT(07)  1.                                                       COMM4020
IOUT(08)  1.                                                       COMM4030
IOUT(09)  1.                                                       COMM4040
IOUT(10)  1.                                                       COMM4050
IOUT(11)  1.                                                       COMM4060
IOUT(12)  1.                                                       COMM4070
IOUT(13)  1.                                                       COMM4080
```

```
IOUT(14) 1.                                                     COMM4090
IOUT(15) 1.                                                     COMM4100
IOUT(16) 1.                                                     COMM4110
IOUT(17) 1.                                                     COMM4120
IOUT(18) 1.                                                     COMM4130
IOUT(19) 1.                                                     COMM4140
IOUT(20) 1.                                                     COMM4150
IOUT(32) 1.                                                     COMM4270
IOUT(31) 1.                                                     COMM4260
IOUT(23) 1.                                                     COMM4180
IOUT(29) 1.                                                     COMM4240
IOUT(25) 1.                                                     COMM4200
IOUT(26) 1.                                                     COMM4210
IOUT(27) 1.                                                     COMM4220
IOUT(28) 1.                                                     COMM4230
IOUT(24) 1.                                                     COMM4190
IOUT(30) 1.                                                     COMM4250
IOUT(22) 1.                                                     COMM4170
IOUT(21) 1.                                                     COMM4160
IOUT(33) 1.                                                     COMM4280
IOUT(34) 1.                                                     COMM4290
IOUT(35) 1.                                                     COMM4300
IOUT(36) 1.                                                     COMM4310
IOUT(37) 1.                                                     COMM4320
ANTI1 10000.
ANTI2 10000.
ANTI3 10000.
ANTI4 10000.
ETAX 1.4
ETAL 1.4
ROUT 1.0
UOUT 1200.
VOUT 1200.
BTV 3.14
ONER .00417
 DEL1DT -100.                                                   COMM4360
 DEL2DT -100.                                                   COMM4370
 DEL3DT -100.                                                   COMM4380
 DEL1DA 10.                                                     COMM4390
 DEL2DA 10.                                                     COMM4400
 DEL3DA 10.                                                     COMM4410
PHIRD -100.
 PHIRDA 10.                                                     COMM4440
DELFW1 0.5                                                      COMM4450
DELFW2 0.5                                                      COMM4460
U1P 2.                                                          COMM4470
U2P 2.                                                          COMM4480
U3P 2.                                                          COMM4490
U4P 2.                                                          COMM4500
S1P 1000.                                                       COMM4510
S2P 1000.                                                       COMM4520
S3P 1000.                                                       COMM4530
S4P 1000.                                                       COMM4540
QUAN1 1.                                                        COMM4550
QUAN2 1.                                                        COMM4560
QUAN3 1.                                                        COMM4570
QUAN4 1.                                                        COMM4580
ARPS1 100.                                                      COMM4590
ARPS2 100.                                                      COMM4600
WSTH1 1.
```

```
WCTH1 1.                                                                                  COMM4610
WSTH2 1.                                                                                  COMM4620
WCTH2 1.                                                                                  COMM4630
066  40.        40.        40.        30.        40.        45.        50.
074  0.         0.         0.         30.        0.         C.         0.
076  5.         10.        10.        5.         5.5        4.         3.
112  0.         0.         0.         0.         0.         0.         0.
114  25.        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.
122  0.         0.         0.         0.         0.         0.         0.
123  0.         0.         0.         0.         0.         0.         0.
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.
238  1.44       1.44       1.44       0.0        0.0        0.0        1.44
239  1.44       1.44       1.44       0.0        0.0        0.0        1.44
240  1.00       1.00       1.00       0.0        0.0        0.0        1.00
241  1.00       1.00       1.00       0.0        0.0        0.0        1.00
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
./      ENDUP
```

```
VEHICLE MODEL - 1971 PONTIAC TRANS. AM
-0.75     .09643334 .1009879  .009461831.001592898-.0015      0.0
-1.0      0.0       0.0       0.0       0.0       0.0       0.0
-0.42     -.039254340-.03157894-.00458558.001719316.000124999 0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0               MAIN4600
0.0       0.0       0.0       0.0       0.0       0.0       0.0               MAIN4610
0.        0.                TABLE I - FRONT BRAKE TORQUE FUNCTION
1000.     9874.
99999.                                                                        MAIN4650
0.        0.                TABLE II - REAR BRAKE TORQUE FUNCTION
1000.     9874.
99999.                                                                        MAIN4690
0.0        1.00       TABLE III- SIDE FORCE SHAPING FUNCTION
0.05       0.99
0.1        0.97
0.15       0.93
0.2        0.86
0.30       0.72
0.4        0.56
0.6        0.34
0.8        0.25
1.0        0.18
99999.                                                                        MAIN4870
 T+D      DUMP     STD      TESTO    LA                                       MAIN4930
 RESET    TRACK    TABLE    PLOT     DACL                                     MAIN4940
 ADCL     ZZZZZZZZSTAT      PC       TM                                       MAIN4950
 CHANGE   READ              CONTROL                                           MAIN4960
 I        TEST     X        RE-STR   DACA                                     MAIN4970
 ADCA     OUTPUT   F        MULTI    TERM                                     MAIN4980
 MES      IC        ZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZZ                        MAIN4990
  PSIDT PHIDT PHI ZIMX(1) ZIMX(3)

 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)
     BMPN BMPS AYMAX RMAX CUVRAT BETDMX
 STR4 BETAMX BETDMX CUVRAT AYMAX RMAX
 STR5 AYMAX DEL BETAMX DELPSI  UIN
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
001  8.82
002  0.53
003  0.86
004  7.6
005  7.2
006  42.60
007  65.40
008  61.9
009  60.4
010  45.5
011  3523.
012  19125.
013  20092.
014  230.
015  530.
016  0.                                                                       MAIN5190
017  356000.
018  35.
 19  99.
```

```
020  2.0
021 -2.0
022  2.5
023  0.                                                          MAIN5260
024  190000.
025  55.
 26  147.
027  2.0
028 -3.3
029  3.7
030 -0.008
031  12.8
032  0.0
033  1.0
034  -401.85
035  19.08
036  3143.
037  2.82
038  4737.
039  0.0
040  1.07
041  8000.
042  15.5
043  2.0
044  3.5
045  2.0
046  5.0
047  8.0
 48  0.0
049  10.0
050  10.0
051  0.7
052  3.42
 53  0.0
 54  0.0
055 -0.24
056  5.0
057  -5.0
058 -.1527
059  .1527
060  1.0
061  0.0
062  0.0                                                         MAIN5650
063                                                              MAIN5660
064                                                              MAIN5670
065                                                              MAIN5680
066  40.
067                                                              MAIN5700
068                                                              MAIN5710
069                                                              MAIN5720
070                                                              MAIN5730
071  0.0
072                                                              MAIN5750
073                                                              MAIN5760
074                                                              MAIN5770
075 .010                                                         MAIN5780
076  5.0
077  1736.
078  1736.
079  1736.
```

```
080  1736.
081  0.0
082  0.0
083  0.0
084  0.0
085  -.000398
086  0.0
087  1.325
088  .0000000940
089                                   MAIN5920
090                                   MAIN5930
091   0.0                             MAIN5940
092  -0.6
093 -.67
094                                   MAIN5970
095                                   MAIN5980
096                                   MAIN5990
097                                   MAIN6000
098                                   MAIN6010
099                                   MAIN6020
100                                   MAIN6030
101                                   MAIN6040
102                                   MAIN6050
103                                   MAIN6060
104                                   MAIN6070
105                                   MAIN6080
106                                   MAIN6090
107   1.0                             MAIN6100
108                                   MAIN6110
109  0.0
110  0.0
111  0.0
112  0.0
113  1.                               MAIN6160
114  25.
115  1.0
116  0.5
117  3.0
118  3.0
119                                   MAIN6220
120                                   MAIN6230
121   300.
122                                   MAIN6250
123                                   MAIN6260
124                                   MAIN6270
125                                   MAIN6280
126                                   MAIN6290
127                                   MAIN6300
128  3.0
129 0.                                MAIN6320
130  0.06
131  14.0
132  87000.
133  87000.
134  6.26
135  6.26
136  11.0
137  69.
138  5.87
139  0.67
```

```
0   140 -0.67
0   141  0.                                             MAIN6440
0   142  0.                                             MAIN6450
C   143                                                 MAIN6460
C   144                                                 MAIN6470
0   145  0.0
    146  0.0
C   147                                                 MAIN6500
C   148                                                 MAIN6510
C   149                                                 MAIN6520
C   150                                                 MAIN6530
C   151                                                 MAIN6540
C   152                                                 MAIN6550
C   153                                                 MAIN6560
C   154                                                 MAIN6570
C   155                                                 MAIN6580
C   156                                                 MAIN6590
C   157                                                 MAIN6600
C   158                                                 MAIN6610
C   159                                                 MAIN6620
C   160                                                 MAIN6630
C   161                                                 MAIN6640
C   162                                                 MAIN6650
C   163                                                 MAIN6660
C   164                                                 MAIN6670
C   165                                                 MAIN6680
C   166                                                 MAIN6690
C   167                                                 MAIN6700
    168                                                 MAIN6710
C   169  73.
C   170  73.
C   171  73.
C   172 2.                                              MAIN6750
    173                                                 MAIN6760
    174                                                 MAIN6770
C   175 0.25                                            MAIN6780
C   176                                                 MAIN6790
C   177                                                 MAIN6800
C   178                                                 MAIN6810
C   179 1.                                              MAIN6820
C   180 3.                                              MAIN6830
    181  1.                                             MAIN6840
C   182  0.14
C   183  0.14
C   184  0.14
    185  0.14
    186                                                 MAIN6890
    187                                                 MAIN6900
    188                                                 MAIN6910
    189  0.0
    190                                                 MAIN6930
    191                                                 MAIN6940
    192  1.0
    193                                                 MAIN6960
    194                                                 MAIN6970
    195                                                 MAIN6980
    196  0.
    197  0.
    198  0.
    199  0.
```

```
200   1.5                                              MAIN7030
201   0.
202   1.09
203   0.0
204   1.09
205   0.0
206   0.79
207   0.79
208   0.0
209   0.0
210   0.0
211   0.0
212   0.0
213   0.0
214   0.0
215   0.0
216   0.0
217   0.0
218   0.0
219   0.
220   0.
221   0.
222   0.
223   0.0
224   0.0
225   0.0
226   0.0
227   0.0
228   0.0
229   0.0
230   0.0
231   400.
232   400.
233   0.0
234   99.
235   99.
236   147.
237   147.
238   1.67
239   1.67
240    1.0                                             MAIN7430
241    1.0                                             MAIN7440
242   -.0000281
243   -.0000346
244   .00000262
245   -.000398
246   0.0
247   1.325
248   .0000000940
249   -.002796
250   .00282
251   2.298
252   -.002796
253   .00282
254   2.298
255   0.0
256   -.0008976
257   -.00419
258   -10.04
259   0.0
```

```
260  -.0008976
261   -.00419
262  -10.04
263  -0.09
264  -.03
265  .0
266  0.15
267  .015
268  .0
269  0.064
270  .01
271  .0
272  0.0
273  .0
274  .0
275  0.0
276  0.0
277  0.
278  0.
279  0.
280  0.
281  1.
282  1.
283  0.
284  2.0
285  5.7
286  0.0
287  1.
288  0.
289  0.
290  1.0
291  -401.85
292  19.08
293  3143.
294  2.82
295  4737.
001  9.27
004  6.7
005  6.7
006  42.25
007  65.75
011  3724.
012  20199.
013  21291.
092   -1.3
093 -.79
304
IOUT(01)  1.
IOUT(02)  1.
IOUT(03)  1.
IOUT(04)  1.
IOUT(05)  1.
IOUT(06)  1.
IOUT(07)  1.
IOUT(08)  1.
IOUT(09)  1.
IOUT(10)  1.
IOUT(11)  1.
IOUT(12)  1.
IOUT(13)  1.
```

```
IOUT(14)  1.                                                        MAIN8260
IOUT(15)  1.                                                        MAIN8270
IOUT(16)  1.                                                        MAIN8280
IOUT(17)  1.                                                        MAIN8290
IOUT(18)  1.                                                        MAIN8300
IOUT(19)  1.                                                        MAIN8310
IOUT(20)  1.                                                        MAIN8320
IOUT(32)  1.                                                        MAIN8440
IOUT(31)  1.                                                        MAIN8430
IOUT(23)  1.                                                        MAIN8350
IOUT(29)  1.                                                        MAIN8410
IOUT(25)  1.                                                        MAIN8370
IOUT(26)  1.                                                        MAIN8380
IOUT(27)  1.                                                        MAIN8390
IOUT(28)  1.                                                        MAIN8400
IOUT(24)  1.                                                        MAIN8360
IOUT(30)  1.                                                        MAIN8420
IOUT(22)  1.                                                        MAIN8340
IOUT(21)  1.                                                        MAIN8330
IOUT(33)  1.                                                        MAIN8450
IOUT(34)  1.                                                        MAIN8460
IOUT(35)  1.                                                        MAIN8470
IOUT(36)  1.                                                        MAIN8480
IOUT(37)  1.                                                        MAIN8490
ANTI1 10000.
ANTI2 10000.
ANTI3 10000.
ANTI4 10000.
ETAX 1.4
ETAL 1.4
ROUT 1.0
UOUT 1200.
BTV 3.14
 PHIDT .8
 PHI .2
 DEL1DT -100.                                                       MAIN8530
 DEL2DT -100.                                                       MAIN8540
 DEL3DT -100.                                                       MAIN8550
 DEL1DA 10.                                                         MAIN8560
 DEL2DA 10.                                                         MAIN8570
 DEL3DA 10.                                                         MAIN8580
 PHIRD 1.                                                           MAIN8590
PHIRDA 0.25                                                         MAIN8600
DELFW1 0.5                                                          MAIN8610
DELFW2 0.5                                                          MAIN8620
U1P 2.                                                              MAIN8630
U2P 2.                                                              MAIN8640
U3P 2.                                                              MAIN8650
U4P 2.                                                              MAIN8660
S1P 1000.                                                           MAIN8670
S2P 1000.                                                           MAIN8680
S3P 1000.                                                           MAIN8690
S4P 1000.                                                           MAIN8700
QUAN1 1.                                                            MAIN8710
QUAN2 1.                                                            MAIN8720
QUAN3 1.                                                            MAIN8730
QUAN4 1.                                                            MAIN8740
ARPS1 100.                                                          MAIN8750
ARPS2 100.                                                          MAIN8760
WSTH1 1.                                                            MAIN8770
```

```
WCTH1 1.                                                                       MAIN8780
WSTH2 1.                                                                       MAIN8790
WCTH2 1.                                                                       MAIN8800
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  0.        0.        0.        0.        0.        0.        0.
114  25.       0.        52.       90.       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       0.        3.        0.        0.        0.        0.
121  300.      200.      200.      0.        0.        0.        1500.
122  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
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  1.0       .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.
238  1.67      1.67      1.67      0.0       0.0       0.0        1.67
239  1.67      1.67      1.67      0.0       0.0       0.0       1.67
240  1.00      1.00      1.00      0.00      0.00      0.00      1.00
241  1.00      1.00      1.00      0.00      0.00      0.00      1.00
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
./      ENDUP
```

2. PRESENTED HERE ARE THE WHEEL SPRING AND SHOCK ABSORBER CHARACTERISTICS

## WHEEL SPRING CHARACTERISTICS

The entries in this table are the values of the slopes versus suspension displacement for the no-load vehicle configuration. The units of the entries are lbs/in and inches.

| Vehicle | Spring Force Effective at the Front Wheel | Spring Force Effective at the Spring for the Rear Suspension |
|---|---|---|
| Dodge Coronet | | |
| | 588 for $\delta \geq 2.1$ | 864 for $\zeta \geq 3.6$ |
| | 105 for $-2.4 < \delta < 2.1$ | 120 for $-4.4 < \zeta < 3.6$ |
| | 189 for $\delta \leq -2.4$ | 324 for $\zeta \leq -4.4$ |
| Pontiac Trans Am | | |
| | 347 for $\delta \geq 2.5$ | 735 for $\zeta \geq 3.7$ |
| | 99 for $-2.0 < \delta < 2.5$ | 147 for $-3.3 < \zeta < 3.7$ |
| | 198 for $\delta \leq -2.0$ | 294 for $\zeta \leq -3.3$ |
| Chevrolet Brookwood | | |
| | 592 for $\delta \geq 2.3$ | 1071 for $\zeta \geq 2.3$ |
| | 141 for $-3.5 < \delta < 2.3$ | 210 for $-3.6 < \zeta < 2.3$ |
| | 282 for $\delta \leq -3.5$ | 399 for $\zeta \leq -3.6$ |
| Volkswagen Super Beetle | | |
| | 526 for $\delta \geq 3.40$ | 449 for $\zeta \geq 3.35$ |
| | 65.7 for $-1.80\ \delta <. 3.40$ | 115 for $-1.85 < \zeta < 3.35$ |
| | 164 for $\delta \leq -1.80$ | 184 for $\zeta \leq -1.85$ |

## SHOCK ABSORBER CHARACTERISTICS

The entries in this table are the values of the slopes versus wheel ride motion. The units of the entries are lbs/(in/sec) and in/sec.

| Vehicle | For Shock Absorber Damping Effective at the Front Wheel | For Shock Absorber Damping Effective at the Rear Wheel |
|---|---|---|
| Dodge Coronet | | |
| | 4.33 for $V \geq 0$ | 1.50 for $V \geq 7.2$ |
| | 9.36 for $V < 0$ | 8.32 for $0 \leq V < 7.2$ |
| | | 6.63 for $V < 0$ |
| Pontiac Trans Am | | |
| | 1.79 for $V \geq 21.9$ | 0.79 for $V \geq 15.8$ |
| | 7.78 for $10.2 \leq V < 21.9$ | 1.99 for $0 \leq V < 15.8$ |
| | 2.74 for $0 \leq V < 10.2$ | 4.58 for $-11.3 \leq V < 0$ |
| | 21.0 for $-7.46 \leq V < 0$ | 1.01 for $V < -11.3$ |
| | 3.10 for $V < -7.46$ | |
| Chevrolet Brookwood | | |
| | 1.94 for $V \geq 0$ | 1.62 for $V \geq 0$ |
| | 12.1 for $-10.2 \leq V < 0$ | 9.99 for $-10.1 \leq V < 0$ |
| | 1.17 for $V < -10.2$ | 1.61 for $V < -10.1$ |
| Volkswagen Super Beetle | | |
| | 1.81 for $V \geq 12.0$ | 1.89 for $V \geq 0$ |
| | 4.28 for $0 \leq V < 12.0$ | 8.06 for $-19.1 \leq V < 0$ |
| | 5.73 for $-12.6 \leq V < 0$ | 2.87 for $V < -19.1$ |
| | 11.4 for $-16.5 \leq V < -12.6$ | |
| | 4.44 for $V < -16.5$ | |

3. PRESENTED HERE ARE THE CAMBER AND TOE DATA

## CAMBER 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 and toe at a reference value of suspension displacement which depends upon vehicle loading. The data presented here were measured with reference to a no-load vehicle configuration.

| Vehicle | Displacement | Camber | Toe |
|---|---|---|---|
| Dodge Coronet (left front) | 0 | 0 | 0 |
| (static displacement = 3.0) | 1 | 0.41 | -0.37 |
| | 2 | 0.98 | -0.59 |
| | 3 | 1.26 | -0.85 |
| | 4 | 1.22 | -1.05 |
| | 5 | 0.95 | -1.21 |
| | 6 | 0.43 | -1.36 |
| Pontiac Trans Am (left front) | 0 | 0 | 0 |
| (static displacement = 4.0) | 1 | 0.26 | -0.03 |
| | 2 | 0.83 | -0.18 |
| | 3 | 1.27 | -0.31 |
| | 4 | 1.48 | -0.39 |
| | 5 | 1.48 | -0.40 |
| | 6 | 1.27 | -0.40 |
| Chevrolet Brookwood (left front) | 0 | 0 | 0 |
| (static displacement = 3.0) | 1 | 0.85 | -0.24 |
| | 2 | 1.68 | -0.53 |
| | 3 | 2.18 | -0.73 |
| | 4 | 2.43 | -0.89 |
| | 5 | 2.47 | -1.01 |
| | 6 | 2.29 | -1.10 |
| | 7 | 1.96 | -1.17 |

CAMBER AND TOE DATA (Cont'd)

| Vehicle | Displacement | Camber | Toe |
|---|---|---|---|
| VW Super Beetle (right rear) | 0 | 0 | 0 |
| (static displacement = 3.0) | 1 | -0.72 | 0.06 |
| | 2 | -1.44 | 0.08 |
| | 3 | -2.16 | 0.07 |
| | 4 | -2.90 | 0.02 |
| | 5 | -3.60 | 0.05 |
| VW Super Beetle (left front) | 0 | 0 | 0 |
| (static displacement = 4.0) | 1 | -0.57 | -0.17 |
| | 2 | -1.25 | -0.45 |
| | 3 | -1.87 | -0.73 |
| | 4 | -2.46 | -0.96 |
| | 5 | -2.96 | -1.14 |
| | 6 | -3.42 | -1.25 |
| | 7 | -3.79 | -1.30 |
| | 8 | -4.08 | -1.32 |

4. PRESENTED HERE ARE THE PARAMETER TABLE OUTPUT

```
PARAMETER VALUES - MODEL C - VEHICLE MODEL - 1971 DODGE CORONET
  1   MS=  8.4300      ,  2   MUF= 0.51000      ,  3   MUP= 0.82000      ,  4   ZF=  11.300      ,  5   ZR=  11.300      ,
  6   A=   49.300      ,  7   B=   68.700       ,  8   TF=  59.800       ,  9   TR=  61.800      , 10   TS=  47.000      ,
 11   IX=  3758.0      , 12   IY=  23047.       , 13   IZ=  23327.       , 14   IXZ= 530.00      , 15   IR=  550.00      ,
 16   CF= 0.0          , 17   RF=  40400.       , 18   CFPR= 40.000      , 19   KF=  105.00      , 20   LAMF= 2.0000     ,
 21   OMFC= -2.4000    , 22   OMFT= 2.1000      , 23   CR= 0.0           , 24   RR= -5100.0      , 25   CRPR= 38.000     ,
 26   KR=  120.00      , 27   LAMR= 2.0000      , 28   OMPC= -4.4000     , 29   OMRT= 3.6000     , 30   KRS= 0.20000E-01,
 31   RW=  13.200      , 32   = 0.0             , 33   FOT= 0.75000      , 34   A0=  2701.0      , 35   A1=  10.140      ,
 36   A2=  2533.0      , 37   A3=  1.3000       , 38   A4=  4591.0       , 39   = 0.0            , 40   = 1.2700         ,
 41   KSC= 8000.0      , 42   NG=  14.200       , 43   LAFC= 1.8000      , 44   LAFT= 5.6000     , 45   LARC= 2.7000     ,
 46   LART= 7.2000     , 47   IFW= 6.4000       , 48   = 0.0             , 49   IWF= 9.4000      , 50   IWR= 9.4000      ,
 51   ID= 0.70000      , 52   AR=  2.7100       , 53   = 0.0             , 54   = 0.0            , 55   PT=-0.66000      ,
 56   YSA1= 4.5900     , 57   YSA2= -4.5900     , 58   PHS1=-0.13090     , 59   PHS2= 0.13090    , 60   CTSW= 1.0000     ,
 61   = 0.0            , 62   = 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   W-IN= 0.0         , 69   X-IN= 0.0        , 70   Y-IN= 0.0        ,
 71   Z-IN= -23.838    , 72   THIN=-0.69610E-01 , 73   PHIN= 0.0         , 74   PSIN= 0.0        , 75   DT= 0.10000E-01  ,
 76   TN=  5.0000      , 77   KT1= 1450.0       , 78   KT2= 1450.0       , 79   KT3= 1450.0      , 80   KT4= 1450.0      ,
 81   RPS1= 56.419     , 82   RPS2= 56.419      , 83   RPS3= 55.778      , 84   RPS4= 55.778     , 85   B1=-0.33000E-03  ,
 86   B2= 0.0          , 87   B3=  1.2280       , 88   B4= 0.75900E-07   , 89   O1OT= 0.0        , 90   O2DT= 0.0        ,
 91   D3DT= 0.0        , 92   DEL1=-0.80000     , 93   DEL2=-0.68000     , 94   DEL3= 0.0        , 95   PHDT= 0.0        ,
 96   PHIR= 0.0        , 97   DFW1= 0.0         , 98   DFW2= 0.0         , 99   U1PR= 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   = 0.0             ,109   = 0.0            ,110   TQMX= 0.0        ,
111   KTQ= 0.0         ,112   VC= 0.0           ,113   MTSW= 1.0000      ,114   OSWM= 25.000     ,115   TST= 1.0000      ,
116   DSLP= 0.50000    ,117   CGAM= 3.0000      ,118   CS= 3.0000        ,119   = 0.0            ,120   = 0.0            ,
121   PFL= 300.00      ,122   TI= 0.0           ,123   DSW= 0.0          ,124   TSW= 0.0         ,125   ISWS= 0.0        ,
126   SW15= 0.0        ,127   PQSW= 0.0         ,128   VTPS= 3.0000      ,129   VHTP= 0.0        ,130   AMCR= 0.60000E-01,
131   ESP= 16.000      ,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= 0.45000     ,140   EP2=-0.45000     ,
141   ERR1= 0.0        ,142   ERR2= 0.0         ,143   AML1= 0.0         ,144   AML2= 0.0        ,145   RRIM= 0.0        ,
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   = 0.0            ,157   = 0.0             ,158   = 0.0             ,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   SNSO= 73.000     ,
171   SNS1= 73.000     ,172   SNSW= 2.0000      ,173   OIST= 0.0         ,174   PL = 0.0         ,175   TSCP= 0.25000    ,
176   = 0.0            ,177   = 0.0             ,178   = 0.0             ,179   = 1.0000         ,180   PASS= 3.0000     ,
181   = 1.0000         ,182   SI1= 0.17000      ,183   SI2= 0.17000      ,184   SI3= 0.17000     ,185   SI4= 0.17000     ,
186   = 0.0            ,187   = 0.0             ,188   = 0.0             ,189   = 0.0            ,190   = 0.0            ,
191   = 0.0            ,192   MTQB= 1.0000      ,193   ORSW= 0.0         ,194   LDF= 0.0         ,195   LORF= 0.0        ,
196   EK1= 0.0         ,197   EK2= 0.0          ,198   BMPL= 0.0         ,199   BMPS= 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=-0.80000F-04,
206   MUSF= 0.65000    ,207   MUSR= 0.65000     ,208   = 0.0             ,209   = 0.0            ,210   = 0.0            ,
211   = 0.0            ,212   = 0.0             ,213   = 0.0             ,214   = 0.0            ,215   = 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   = 0.0             ,224   = 0.0            ,225   = 0.0            ,
226   = 0.0            ,227   = 0.0             ,228   = 0.0             ,229   = 0.0            ,230   = 0.0            ,
231   HI= 400.00       ,232   H2= 400.00        ,233   = 0.0             ,234   AKF1= 105.00     ,235   AKF2= 105.00     ,
236   AKF3= 120.00     ,237   AKF4= 120.00      ,238   BR1= 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   K5R= 0.17500E-05 ,245   RB1=-0.33000E-03 ,
246   RB2= 0.0         ,247   RB3= 1.2280       ,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   OFCO= 0.0        ,
256   OFC1=-0.15000E-02,257   OFC2=-0.52440E-02 ,258   OFC3= -5.5920     ,259   ORCO= 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   = 0.0            ,
276   = 0.0            ,277   BMPN= 0.0         ,278   TQ0R= 0.0         ,279   TQB1= 0.0        ,280   = 0.0            ,
281   = 1.0000         ,282   = 1.0000          ,283   = 0.0             ,284   HFC= 2.7000      ,285   HRC= 3.9000      ,
286   = 0.0            ,287   AXLE= 1.0000      ,288   = 0.0             ,289   = 0.0            ,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 - 1971 CHEVROLET BROOKWOOD STATION WAGON

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | MS= 11.600 | 2 | MUF= 0.63000 | 3 | MUR= 1.0300 | 4 | ZF= 10.900 | 5 | ZR= 10.800 |
| 6 | A= 64.900 | 7 | B= 60.100 | 8 | TF= 63.500 | 9 | TR= 63.500 | 10 | TS= 45.300 |
| 11 | IX= 6800.0 | 12 | IY= 42551. | 13 | IZ= 43465. | 14 | IXZ= 1790.0 | 15 | IR= 750.00 |
| 16 | CF= 0.0 | 17 | RF= 0.40800E 06 | 18 | CFPR= 43.000 | 19 | KF= 141.00 | 20 | LAMF= 2.0000 |
| 21 | OMFC= -3.5000 | 22 | OMFT= 2.3000 | 23 | CR= 0.0 | 24 | RR= -62000. | 25 | CRPR= 73.000 |
| 26 | KR= 210.00 | 27 | LAMR= 2.0000 | 28 | OMRC= -3.6000 | 29 | OMRT= 2.3000 | 30 | KRS= 0.33000E-01 |
| 31 | RW= 14.400 | 32 | = 0.0 | 33 | FOT= 1.0000 | 34 | A0= 585.91 | 35 | A1= 14.470 |
| 36 | A2= 2886.0 | 37 | A3= 2.2900 | 38 | A4= 4057.0 | 39 | = 0.0 | 40 | = 1.0800 |
| 41 | KSC= 8000.0 | 42 | NG= 16.200 | 43 | LAFC= 2.0000 | 44 | LAFT= 4.2000 | 45 | LARC= 1.9000 |
| 46 | LART= 5.1000 | 47 | IFW= 10.000 | 48 | = 0.0 | 49 | IWF= 14.800 | 50 | IWR= 14.800 |
| 51 | IJ= 0.70000 | 52 | AR= 3.0800 | 53 | = 0.0 | 54 | = 0.0 | 55 | PT= 0.16000 |
| 56 | YSA1= 5.2500 | 57 | YSA2= -5.2500 | 58 | PHS1=-0.17450 | 59 | PHS2= 0.17450 | 60 | CTSW= 1.0000 |
| 61 | = 0.0 | 62 | = 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 | W-IN= 0.0 | 69 | X-IN= 0.0 | 70 | Y-IN= 0.0 |
| 71 | Z-IN= -24.542 | 72 | THIN= 0.54671E-01 | 73 | PHIN= 0.0 | 74 | PSIN= 0.0 | 75 | DT= 0.10000E-01 |
| 76 | TN= 5.0000 | 77 | KT1= 1724.0 | 78 | KT2= 1724.0 | 79 | KT3= 1906.0 | 80 | KT4= 1906.0 |
| 81 | RPS1= 51.370 | 82 | RPS2= 51.370 | 83 | RPS3= 51.443 | 84 | RPS4= 51.443 | 85 | B1=-0.20800E-03 |
| 86 | B2= 0.0 | 87 | B3= 1.2670 | 88 | B4= 0.43700E-08 | 89 | D1DT= 0.0 | 90 | D2DT= 0.0 |
| 91 | D3DT= 0.0 | 92 | DEL1=-0.90000 | 93 | DEL2=-0.56000 | 94 | DEL3= 0.0 | 95 | PHDT= 0.0 |
| 96 | PHIR= 0.0 | 97 | DFW1= 0.0 | 98 | DFW2= 0.0 | 99 | U1PR= 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 | = 0.0 | 109 | = 0.0 | 110 | TQMX= 0.0 |
| 111 | KTQ= 0.0 | 112 | VC= 0.0 | 113 | MTSW= 1.0000 | 114 | DSWM= 25.000 | 115 | TST= 1.0000 |
| 116 | DSLP= 0.50000 | 117 | CGAM= 3.0000 | 118 | CS= 3.0000 | 119 | = 0.0 | 120 | = 0.0 |
| 121 | PFL= 300.00 | 122 | T1= 0.0 | 123 | DSW= 0.0 | 124 | TSW= 0.0 | 125 | ISW5= 0.0 |
| 126 | SW15= 0.0 | 127 | PQSW= 0.0 | 128 | VTPS= 3.0000 | 129 | VHTP= 0.0 | 130 | AMCR= 0.60000E-01 |
| 131 | ESP= 12.000 | 132 | KSL1= 91700. | 133 | KSL2= 91700. | 134 | AA1= 6.2600 | 135 | AA2= 6.2600 |
| 136 | CCR= 11.000 | 137 | CFCR= 77.000 | 138 | AP= 5.8000 | 139 | EP1= 0.40000 | 140 | EP2=-0.40000 |
| 141 | ERR1= 0.0 | 142 | ERR2= 0.0 | 143 | AML1= 0.0 | 144 | AML2= 0.0 | 145 | RR1M= 0.0 |
| 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 | = 0.0 | 157 | = 0.0 | 158 | = 0.0 | 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= 73.000 |
| 171 | SNS1= 73.000 | 172 | SNSW= 2.0000 | 173 | DIST= 0.0 | 174 | PL = 0.0 | 175 | TSCP= 0.25000 |
| 176 | = 0.0 | 177 | = 0.0 | 178 | = 0.0 | 179 | = 1.0000 | 180 | PASS= 3.0000 |
| 181 | = 1.0000 | 182 | S11= 0.11000 | 183 | S12= 0.11000 | 184 | S13= 0.14000 | 185 | S14= 0.14000 |
| 186 | = 0.0 | 187 | = 0.0 | 188 | = 0.0 | 189 | = 0.0 | 190 | = 0.0 |
| 191 | = 0.0 | 192 | MTQB= 1.0000 | 193 | DRSW= 0.0 | 194 | LDF= 0.0 | 195 | LDRF= 0.0 |
| 196 | EK1= 0.0 | 197 | EK2= 0.0 | 198 | BMPL= 0.0 | 199 | BMPS= 0.0 | 200 | BMPH= 1.5000 |
| 201 | XB= 0.0 | 202 | APF1= 0.94000 | 203 | APF2=-0.89300E-04 | 204 | APR1= 1.2000 | 205 | APR2=-0.17700E-03 |
| 206 | MUSF= 0.61000 | 207 | MUSR= 0.70000 | 208 | = 0.0 | 209 | = 0.0 | 210 | = 0.0 |
| 211 | = 0.0 | 212 | = 0.0 | 213 | = 0.0 | 214 | = 0.0 | 215 | = 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 | = 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 | = 0.0 | 234 | AKF1= 141.00 | 235 | AKF2= 141.00 |
| 236 | AKF3= 210.00 | 237 | AKF4= 210.00 | 238 | BR1= 1.5000 | 239 | BR2= 1.5000 | 240 | BR3= 1.0000 |
| 241 | BR4= 1.0000 | 242 | KCF=-0.23200E-04 | 243 | KCR=-0.37200E-04 | 244 | KSR= 0.23300E-05 | 245 | RB1=-0.10900E-03 |
| 246 | RB2= 0.0 | 247 | RB3= 1.2160 | 248 | RB4=-0.13500E-07 | 249 | AFK1=-0.30240E-02 | 250 | AFK2= 0.30240E-02 |
| 251 | AFK3= 1.8600 | 252 | ARK1=-0.24700E-02 | 253 | ARK2= 0.21700E-02 | 254 | ARK3= 1.9000 | 255 | OFC0= 0.0 |
| 256 | OFC1=-0.16600E-02 | 257 | DFC2=-0.42800E-02 | 258 | DFC3= -3.1220 | 259 | DRC0= 0.0 | 260 | ORC1=-0.12600E-02 |
| 261 | ORC2=-0.37700E-02 | 262 | DRC3= -5.4800 | 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= 0.22000E-01 | 270 | CR1F= 0.10000E-01 |
| 271 | CR2F= 0.0 | 272 | CR0R= 0.0 | 273 | CR1R= 0.0 | 274 | CR2R= 0.0 | 275 | = 0.0 |
| 276 | = 0.0 | 277 | RMPN= 0.0 | 278 | TQR0= 0.0 | 279 | TUB1= 0.0 | 280 | = 0.0 |
| 281 | = 1.0000 | 282 | = 1.0000 | 283 | = 0.0 | 284 | HFC= 0.70000 | 285 | HRC= 4.0000 |
| 286 | = 0.0 | 287 | AXLE= 1.0000 | 288 | = 0.0 | 289 | = 0.0 | 290 | ROT = 1.0000 |
| 291 | RA0 = -230.10 | 292 | RA1 = 16.070 | 293 | RA2 = 3473.0 | 294 | RA3 = 2.4200 | 295 | RA4 = 4590.0 |

PARAMETER VALUES - MODEL C - VEHICLE MODEL - 1971 VOLKWAGEN SUPER BETTLE - CALSPAN -

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | MS= 5.5000 | 2 | F= 0.36000 | 3 | MUR= 0.57000 | 4 | ZF= 10.800 | 5 | ZR= 11.200 |
| 6 | A= 55.900 | 7 | B= 39.900 | 8 | TF= 53.800 | 9 | TR= 51.500 | 10 | TS= 50.000 |
| 11 | IX= 2060.0 | 12 | IY= 9927.0 | 13 | IZ= 9385.0 | 14 | IXZ= 0.0 | 15 | IR= 800.00 |
| 16 | CF= 0.0 | 17 | RF= 93000. | 18 | CFPR= 35.000 | 19 | KF= 65.700 | 20 | LAMF= 5.0000 |
| 21 | OMFC= -1.8000 | 22 | OMFT= 3.4000 | 23 | CR= 0.0 | 24 | RR= 28300. | 25 | CRPR= 40.000 |
| 26 | KR= 115.00 | 27 | LAMR= 2.5000 | 28 | OMRC= -1.8500 | 29 | OMRT= 3.3500 | 30 | KRS= 0.0 |
| 31 | RW= 12.600 | 32 | = 0.0 | 33 | FDT= 1.0000 | 34 | A0= 5835.0 | 35 | A1= -2.8900 |
| 36 | A2= 2860.0 | 37 | A3= 1.7900 | 38 | A4= 2499.0 | 39 | = 0.0 | 40 | = 0.95700 |
| 41 | KSC= 7000.0 | 42 | NG= 17.000 | 43 | LAFC= 2.5000 | 44 | LAFT= 8.0000 | 45 | LARC= 1.6000 |
| 46 | LART= 3.9000 | 47 | IFW= 4.4000 | 48 | = 0.0 | 49 | IWF= 7.3500 | 50 | IWR= 7.3500 |
| 51 | ID= 0.30000 | 52 | AR= 4.1300 | 53 | = 0.0 | 54 | = 0.0 | 55 | PT= 1.6600 |
| 56 | YSA1= 3.7500 | 57 | YSA2= -3.7500 | 58 | PHS1=-0.17450 | 59 | PHS2= 0.17450 | 60 | CTSW= 1.0000 |
| 61 | = 0.0 | 62 | = 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 | W-IN= 0.0 | 69 | X-IN= 0.0 | 70 | Y-IN= 0.0 |
| 71 | Z-IN= -22.902 | 72 | THIN=-0.19301 | 73 | PHIN= 0.0 | 74 | PSIN= 0.0 | 75 | DT= 0.10000E-01 |
| 76 | TN= 5.0000 | 77 | KT1= 746.00 | 78 | KT2= 746.00 | 79 | KT3= 956.00 | 80 | KT4= 956.00 |
| 81 | RPS1= 59.093 | 82 | RPS2= 59.093 | 83 | RPS3= 59.478 | 84 | RPS4= 59.478 | 85 | B1=-0.30000E-03 |
| 86 | B2= 0.0 | 87 | B3= 1.2000 | 88 | B4= 0.0 | 89 | D1DT= 0.0 | 90 | D2DT= 0.0 |
| 91 | D3DT= 0.0 | 92 | DEL1= -1.9000 | 93 | DEL2= -1.3000 | 94 | DEL3= 0.0 | 95 | PHDT= 0.0 |
| 96 | PHIR= 0.0 | 97 | DFW1= 0.0 | 98 | DFW2= 0.0 | 99 | U1PR= 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 | = 0.0 | 109 | = 0.0 | 110 | TQMX= 0.0 |
| 111 | KTJ= 0.0 | 112 | VC= 0.0 | 113 | MTSW= 1.0000 | 114 | DSWM= 25.000 | 115 | TST= 1.0000 |
| 116 | DSLP= 0.50000 | 117 | CGAM= 3.0000 | 118 | CS= 3.0000 | 119 | = 0.0 | 120 | = 0.0 |
| 121 | PFL= 300.00 | 122 | T1= 0.0 | 123 | DSW= 0.0 | 124 | TSW= 0.0 | 125 | ISW5= 0.0 |
| 126 | SW15= 0.0 | 127 | PQSW= 0.0 | 128 | VTPS= 3.0000 | 129 | VHTP= 0.0 | 130 | AMCR= 0.50000E-01 |
| 131 | ESP= 18.000 | 132 | KSL1= 0.10600E 06 | 133 | KSL2= 0.10600E 06 | 134 | AA1= 5.5000 | 135 | AA2= 5.5000 |
| 136 | CCR= 3.7500 | 137 | CFCR= 57.000 | 138 | AP= 5.7500 | 139 | EP1= 0.0 | 140 | EP2= 0.0 |
| 141 | ERR1= 0.0 | 142 | ERR2= 0.0 | 143 | AML1= 0.0 | 144 | AML2= 0.0 | 145 | RRIM= 0.0 |
| 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 | = 0.0 | 157 | = 0.0 | 158 | = 0.0 | 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= 73.000 |
| 171 | SNS1= 73.000 | 172 | SNSW= 2.0000 | 173 | DIST= 0.0 | 174 | PL = 0.0 | 175 | TSCP= 0.25000 |
| 176 | = 0.0 | 177 | = 0.0 | 178 | = 0.0 | 179 | = 1.0000 | 180 | PASS= 3.0000 |
| 181 | = 1.0000 | 182 | SI1= 0.13000 | 183 | SI2= 0.13000 | 184 | SI3= 0.20000 | 185 | SI4= 0.20000 |
| 186 | = 0.0 | 187 | = 0.0 | 188 | = 0.0 | 189 | = 0.0 | 190 | = 0.0 |
| 191 | = 0.0 | 192 | MTQB= 1.0000 | 193 | DRSW= 0.0 | 194 | LDF= 0.0 | 195 | LDRF= 0.0 |
| 196 | EK1= 0.0 | 197 | EK2= 0.0 | 198 | BMPL= 0.0 | 199 | BMPS= 0.0 | 200 | BMPH= 1.5000 |
| 201 | XB= 0.0 | 202 | APF1= 0.88000 | 203 | APF2= 0.0 | 204 | APR1= 0.93000 | 205 | APR2= 0.0 |
| 206 | MUSF= 0.64000 | 207 | MUSR= 0.70000 | 208 | = 0.0 | 209 | = 0.0 | 210 | = 0.0 |
| 211 | = 0.0 | 212 | = 0.0 | 213 | = 0.0 | 214 | = 0.0 | 215 | = 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 | = 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= 200.00 | 232 | H2= 200.00 | 233 | = 0.0 | 234 | AKF1= 65.700 | 235 | AKF2= 65.700 |
| 236 | AKF3= 115.00 | 237 | AKF4= 115.00 | 238 | BR1= 1.4400 | 239 | BR2= 1.4400 | 240 | BR3= 1.0000 |
| 241 | BR4= 1.0000 | 242 | KCF=-0.40700E-04 | 243 | KCR=-0.24100E-04 | 244 | KSR= 0.21800E-05 | 245 | RB1=-0.86800E-04 |
| 246 | RB2= 0.0 | 247 | RB3= 1.1850 | 248 | RB4=-0.13400E-06 | 249 | AFK1=-0.59300E-02 | 250 | AFK2= 0.61200E-02 |
| 251 | AFK3= 1.5710 | 252 | ARK1=-0.44500E-02 | 253 | ARK2= 0.44000E-02 | 254 | ARK3= 0.68850 | 255 | OFC0= 0.0 |
| 256 | OFC1=-0.24500E-02 | 257 | DFC2=-0.53700E-02 | 258 | DFC3=-0.81100 | 259 | DRC0= 0.0 | 260 | DRC1=-0.18400E-02 |
| 261 | DRC2=-0.50300E-02 | 262 | DRC3= -1.8500 | 263 | CP0F= 0.0 | 264 | CP1F= 0.30000E-01 | 265 | CP2F= 0.0 |
| 266 | CP0R= 0.29000 | 267 | CP1R= 0.30000E-01 | 268 | CP2R= 0.0 | 269 | CH0F= 0.89000E-01 | 270 | CR1F= 0.10000E-01 |
| 271 | CR2F= 0.0 | 272 | CR0R= 0.13000 | 273 | CR1R= 0.30000E-01 | 274 | CR2R= 0.0 | 275 | = 0.0 |
| 276 | = 0.0 | 277 | BMPN= 0.0 | 278 | TQB0= 0.0 | 279 | TQB1= 0.0 | 280 | = 0.0 |
| 281 | = 1.0000 | 282 | = 1.0000 | 283 | = 0.0 | 284 | HFC= 2.4000 | 285 | HRC= 3.4000 |
| 286 | = 0.0 | 287 | AXLE= 2.0000 | 288 | = 0.0 | 289 | = 0.0 | 290 | ROT = 1.0000 |
| 291 | RA0 = 4037.0 | 292 | RA1 = 3.8700 | 293 | RA2 = 1728.0 | 294 | RA3 = 1.4100 | 295 | RA4 = 3902.0 |

```
PARAMETER VALUES - MODEL C - VEHICLE MODEL - 1971 PONTIAC TRANS. AM
  1     MS=  9.2700     ,   2     MUF= 0.53000     ,   3     MUR= 0.86000     ,   4     ZF=  6.7000     ,   5     ZR=  6.7000     ,
  6      A=  42.250     ,   7       B=  65.750     ,   8      TF=  61.900     ,   9     TR=  60.400     ,  10     TS=  45.500     ,
 11     IX=  3724.0     ,  12      IY=  20199.     ,  13      IZ=  21291.     ,  14    IXZ=  230.00     ,  15     IR=  530.00     ,
 16     CF= 0.0         ,  17      RF= 0.35600E 06,  18    CFPR=  35.000     ,  19     KF=  99.000     ,  20   LAMF=  2.0000     ,
 21   OMFC= -2.0000     ,  22    OMFT=  2.5000     ,  23      CR= 0.0         ,  24     RR= 0.19000E 06,  25   CRPR=  55.000     ,
 26     KR=  147.00     ,  27    LAMR=  2.0000     ,  28    DMRC= -3.3000     ,  29   DMRT=  3.7000     ,  30    KRS=-0.80000E-02,
 31     RW=  12.800     ,  32       = 0.0         ,  33     FOT=  1.0000     ,  34     A0= -401.85     ,  35     A1=  19.080     ,
 36     A2=  3143.0     ,  37      A3=  2.8200     ,  38      A4=  4737.0     ,  39       = 0.0         ,  40       =  1.0700     ,
 41    KSC=  8000.0     ,  42      NG=  15.500     ,  43    LAFC=  2.0000     ,  44   LAFT=  3.5000     ,  45   LARC=  2.0000     ,
 46   LART=  5.0000     ,  47     IFW=  8.0000     ,  48       = 0.0         ,  49    IWF=  10.000     ,  50    IWR=  10.000     ,
 51     ID= 0.70000     ,  52      AR=  3.4200     ,  53       = 0.0         ,  54       = 0.0         ,  55     PT=-0.24000     ,
 56   YSA1=  5.0000     ,  57    YSA2= -5.0000     ,  58    PHS1=-0.15270     ,  59   PHS2= 0.15270     ,  60   CTSW=  1.0000     ,
 61       = 0.0         ,  62       = 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    W-IN= 0.0         ,  69   X-IN= 0.0         ,  70   Y-IN= 0.0         ,
 71   Z-IN= -18.886     ,  72    THIN=-0.99608E-01,  73    PHIN= 0.0         ,  74   PSIN= 0.0         ,  75     DT= 0.10000E-01,
 76     TN=  5.0000     ,  77     KT1=  1736.0     ,  78     KT2=  1736.0     ,  79    KT3=  1736.0     ,  80    KT4=  1736.0     ,
 81   RPS1=  58.120     ,  82    RPS2=  58.120     ,  83    RPS3=  57.233     ,  84   RPS4=  57.233     ,  85     B1=-0.39800E-03,
 86     B2= 0.0         ,  87      B3=  1.3250     ,  88      B4= 0.94000E-07,  89   D1DT= 0.0         ,  90   D2DT= 0.0         ,
 91   D3DT= 0.0         ,  92    DEL1= -1.3000     ,  93    DEL2=-0.79000     ,  94   DEL3= 0.0         ,  95   PHDT= 0.0         ,
 96   PHIR= 0.0         ,  97    DFW1= 0.0         ,  98    DFW2= 0.0         ,  99   U1PR= 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       = 0.0         , 109       = 0.0         , 110   TQMX= 0.0         ,
111    KTJ= 0.0         , 112      VC= 0.0         , 113    MTSW=  1.0000     , 114   DSWM=  25.000     , 115    TST=  1.0000     ,
116   DSLP= 0.50000     , 117    CGAM=  3.0000     , 118      CS=  3.0000     , 119       = 0.0         , 120       = 0.0         ,
121    PFL=  300.00     , 122      T1= 0.0         , 123     DSW= 0.0         , 124    TSW= 0.0         , 125   ISWS= 0.0         ,
126   SW15= 0.0         , 127    POSW= 0.0         , 128    VTPS=  3.0000     , 129   VHTP= 0.0         , 130   AMCR= 0.60000E-01,
131    ESP=  14.000     , 132    KSL1=  87000.     , 133    KSL2=  87000.     , 134    AA1=  6.2600     , 135    AA2=  6.2600     ,
136    CCR=  11.000     , 137    CFCR=  69.000     , 138      AP=  5.8700     , 139    EP1= 0.67000     , 140    EP2=-0.67000     ,
141   ERR1= 0.0         , 142    ERR2= 0.0         , 143    AML1= 0.0         , 144   AML2= 0.0         , 145   RRIM= 0.0         ,
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       = 0.0         , 157       = 0.0         , 158       = 0.0         , 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   SN50=  73.000     ,
171   SNS1=  73.000     , 172    SNSW=  2.0000     , 173    DIST= 0.0         , 174    PL = 0.0         , 175   TSCP= 0.25000     ,
176       = 0.0         , 177       = 0.0         , 178       = 0.0         , 179       =  1.0000     , 180   PASS=  3.0000     ,
181       =  1.0000     , 182     SI1= 0.14000     , 183     SI2= 0.14000     , 184    SI3= 0.14000     , 185    SI4= 0.14000     ,
186       = 0.0         , 187       = 0.0         , 188       = 0.0         , 189       = 0.0         , 190       = 0.0         ,
191       = 0.0         , 192    MTQB=  1.0000     , 193    DRSW= 0.0         , 194    LDF= 0.0         , 195   LDRF= 0.0         ,
196    EK1= 0.0         , 197     EK2= 0.0         , 198    BMPL= 0.0         , 199   BMPS= 0.0         , 200   BMPH=  1.5000     ,
201     XB= 0.0         , 202    APF1=  1.0900     , 203    APF2= 0.0         , 204   APR1=  1.0900     , 205   APR2= 0.0         ,
206   MUSF= 0.79000     , 207    MUSR= 0.79000     , 208       = 0.0         , 209       = 0.0         , 210       = 0.0         ,
211       = 0.0         , 212       = 0.0         , 213       = 0.0         , 214       = 0.0         , 215       = 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       = 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       = 0.0         , 234   AKF1=  99.000     , 235   AKF2=  99.000     ,
236   AKF3=  147.00     , 237    AKF4=  147.00     , 238     BR1=  1.6700     , 239    BR2=  1.6700     , 240    BR3=  1.0000     ,
241    BR4=  1.0000     , 242     KCF=-0.28100E-04, 243     KCR=-0.34600E-04, 244    KSR= 0.26200E-05, 245    RB1=-0.39800E-03,
246    RB2= 0.0         , 247     RB3=  1.3250     , 248     RR4= 0.94000E-07, 249   AFK1=-0.27960E-02, 250   AFK2= 0.28200E-02,
251   AFK3=  2.2980     , 252    ARK1=-0.27960E-02, 253    ARK2= 0.28200E-02, 254   ARK3=  2.2980     , 255   OFC0= 0.0         ,
256   OFC1=-0.89760E-03, 257    OFC2=-0.41900E-02, 258    OFC3= -10.040     , 259   ORC0= 0.0         , 260   ORC1=-0.89760E-03,
261   ORC2=-0.41900E-02, 262    ORC3= -10.040     , 263    CP0F=-0.90000E-01, 264   CP1F=-0.30000E-01, 265   CP2F= 0.0         ,
266   CP0R= 0.15000     , 267    CP1R= 0.15000E-01, 268    CP2R= 0.0         , 269   CR0F= 0.64000E-01, 270   CR1F= 0.10000E-01,
271   CR2F= 0.0         , 272    CR0R= 0.0         , 273    CR1R= 0.0         , 274   CR2R= 0.0         , 275       = 0.0         ,
276       = 0.0         , 277    RMPN= 0.0         , 278    TQB0= 0.0         , 279   TQB1= 0.0         , 280       = 0.0         ,
281       =  1.0000     , 282       =  1.0000     , 283       = 0.0         , 284    HFC=  2.0000     , 285    HRC=  5.7000     ,
286       = 0.0         , 287    AXLE=  1.0000     , 288       = 0.0         , 289       = 0.0         , 290    RDT =  1.0000     ,
291   RA0 = -401.85     , 292    RA1 =  19.080     , 293    RA2 =  3143.0     , 294    RA3 =  2.8200     , 295    RA4 =  4737.0     ,
```

# APPENDIX F

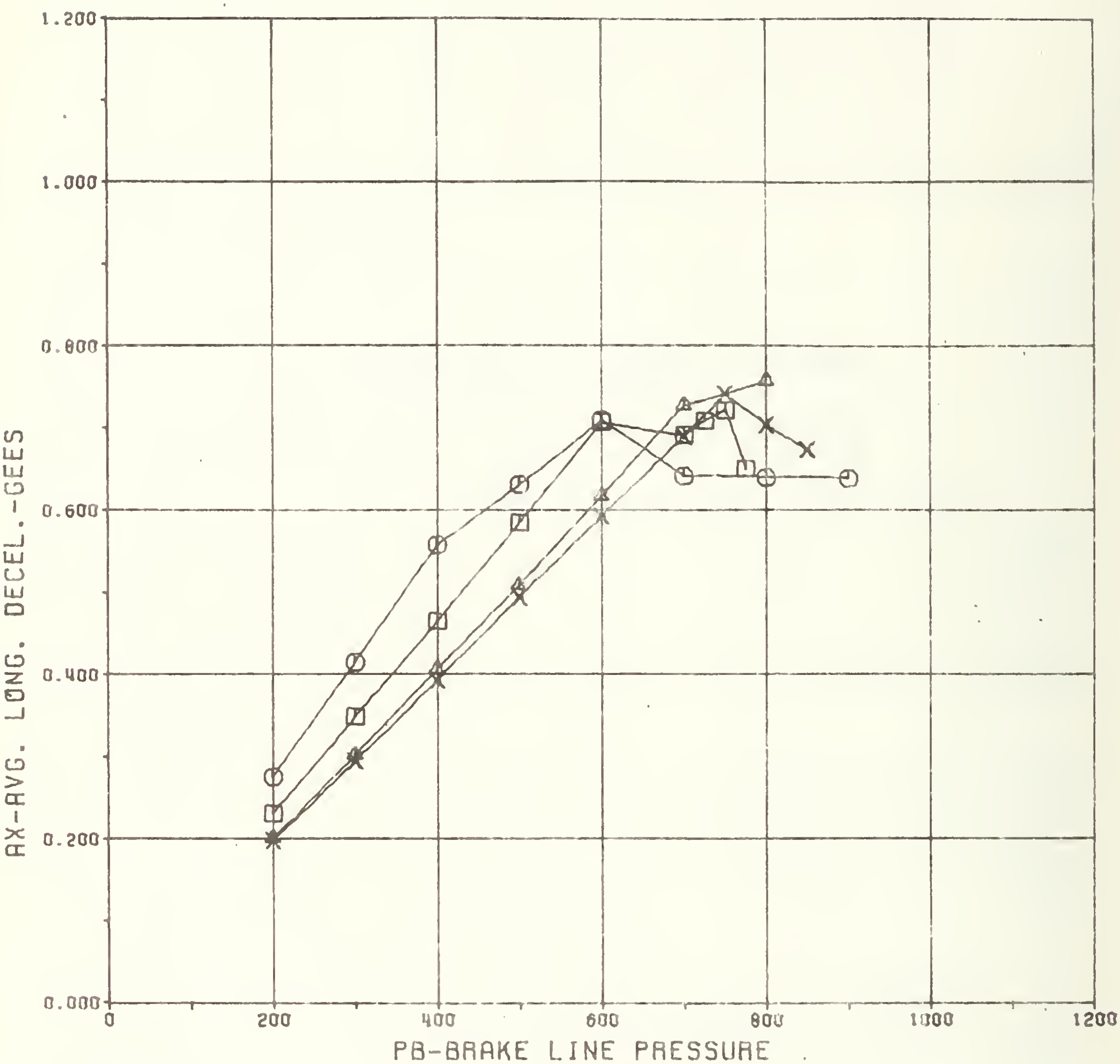
# COMPARISON VARIABLE GRAPHS

1. VHTP #1 - STRAIGHT LINE BRAKING

$A_x$ - Average Longitudinal Deceleration from 35 mph to 10 mph (GEES)

$P_B$ - Brake Line Pressure (PSI)

*** AVG. LONG. DECEL. VS. BRAKE LINE PRESSURE ***
(CALSPAN, O.E. TIRES, STRIGHT LINE BRAKING)




- DODGE CORONET
- CHEVY BROOKWOOD
- PONTIAC TRANS AM
- VW SUPERBEETLE



15 JUL 74

2. VHTP #2 - BRAKING IN A TURN

$A_x$ - Average Longitudinal Deceleration from 35 mph to 10 mph (GEES)

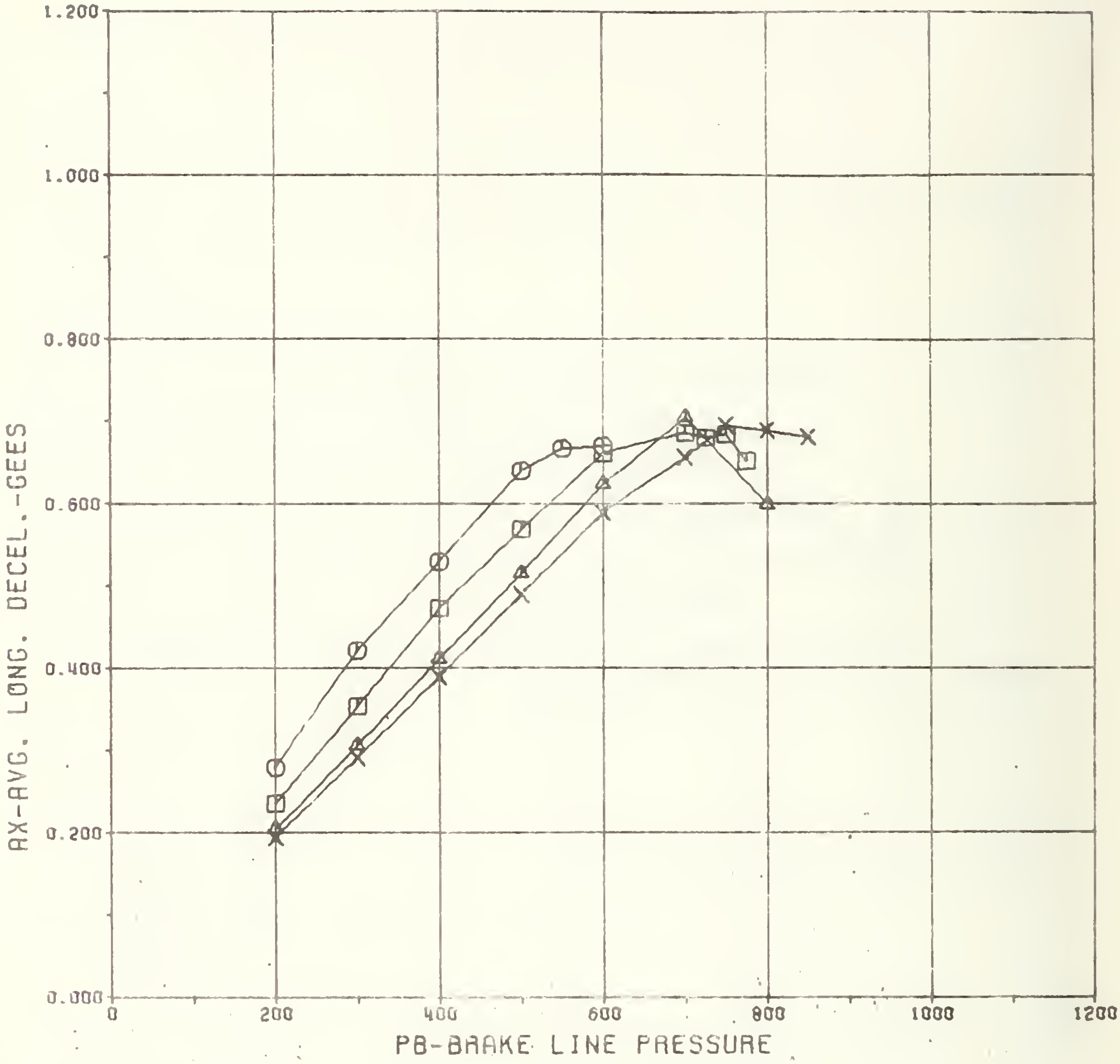
$P_B$ - Brake Line Pressure (PSI)

BETADOT - Peak Vehicle Sideslip Angle Rate (RADIANS/SEC)

$R_0$(1/R) - Average Path Curvature Ratio Relative to Initial Turn

*** AVG. LONG. DECEL. VS. BRAKE LINE PRESSURE ***

(CALSPAN, O.E. TIRES, BRAKING IN A TURN)



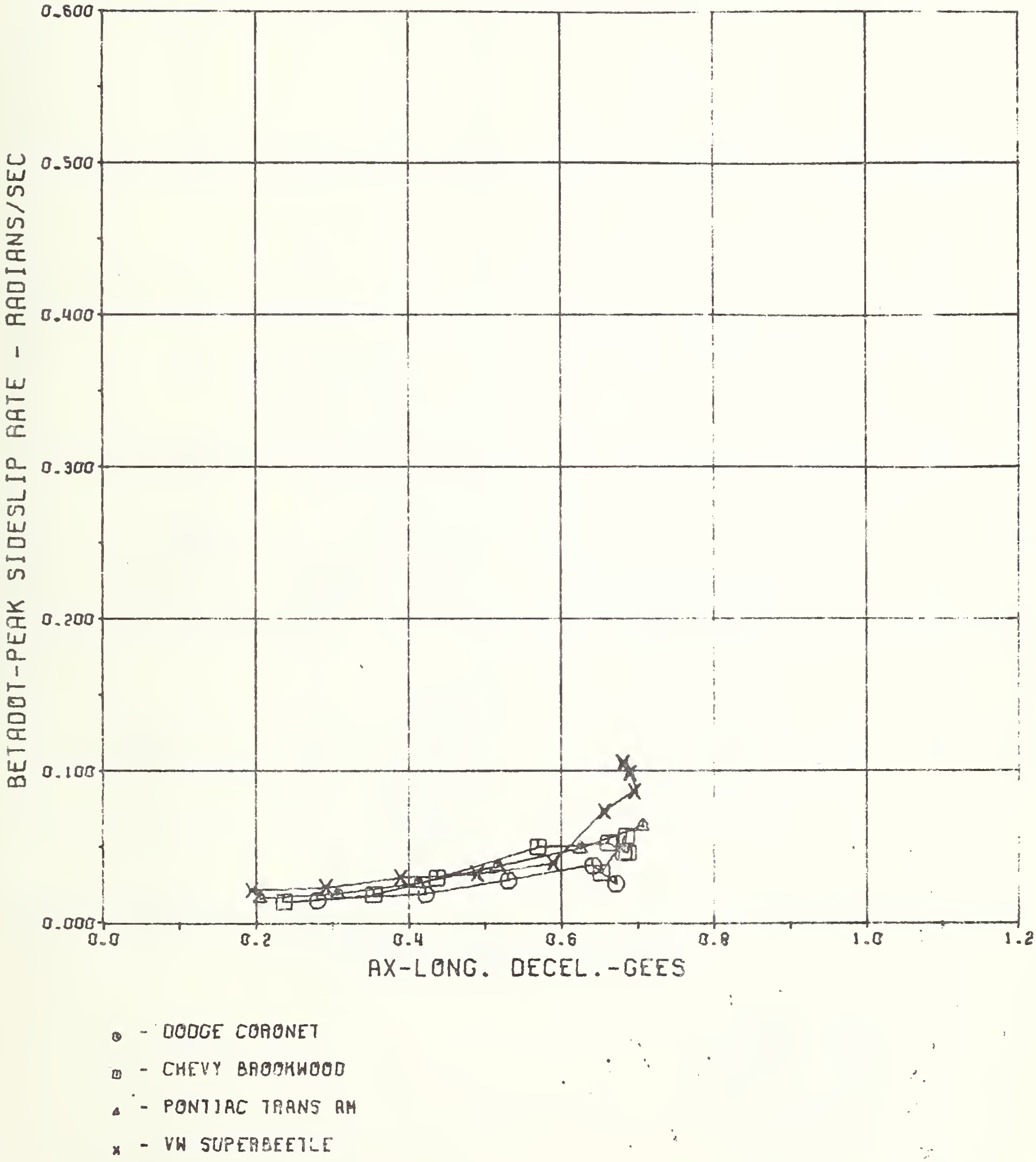

- DODGE CORONET
- CHEVY BROOKWOOD
- PONTIAC TRANS AM
- VW SUPERBEETLE



15 JUL 74

*** SIDESLIP RATE VS. AVG. LONG. DECEL. ***

(CALSPAN, O.E. TIRES, BRAKING IN A TURN)

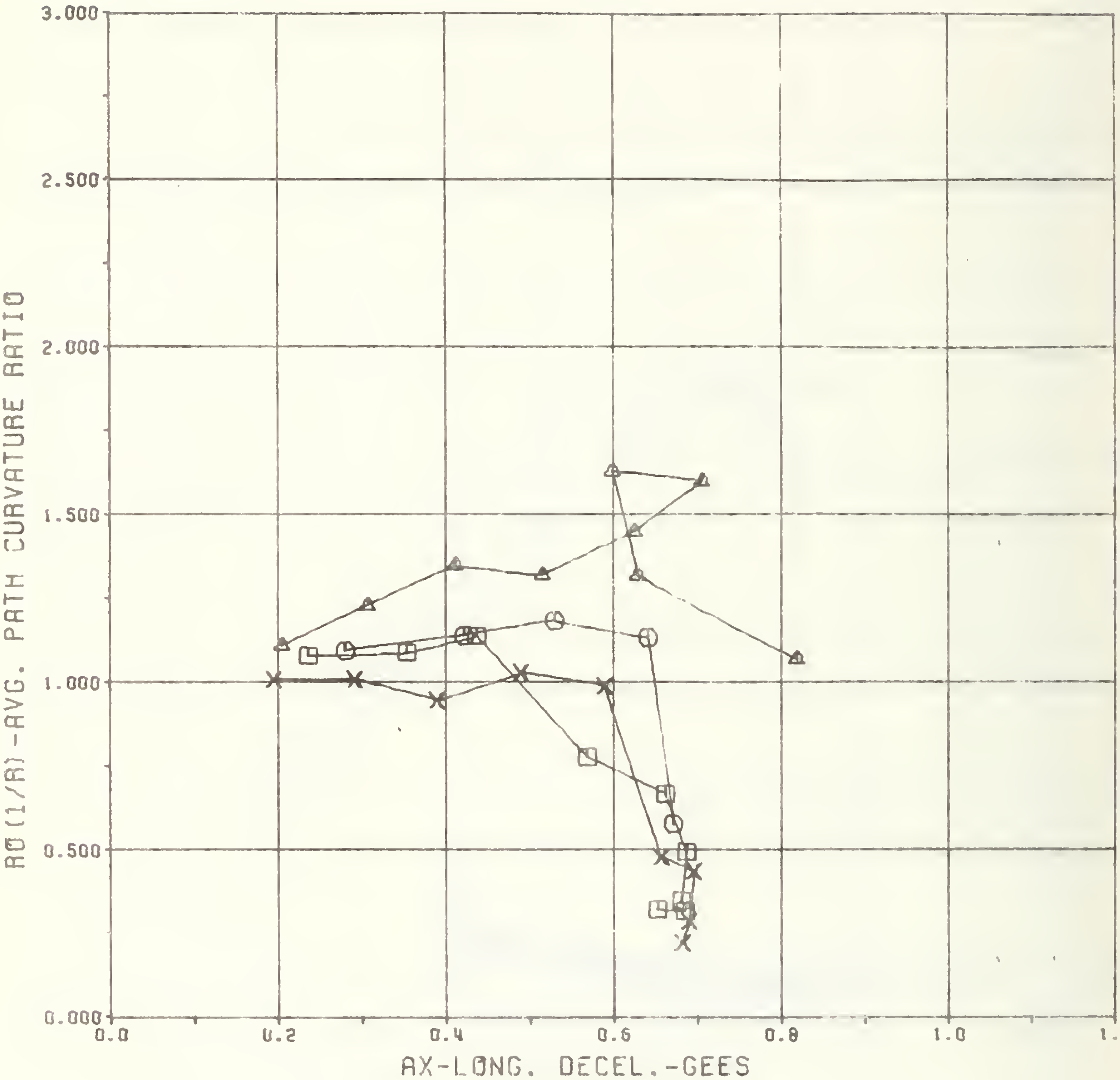





16 JUL 74

*** AVG. PATH CURV. RATIO VS. AVG. LONG. DECEL. ***

(CALSPAN, O.E. TIRES, BRAKING IN A TURN)




- DODGE CORONET
- CHEVY BROOKWOOD
- PONTIAC TRANS AM
- VW SUPERBEETLE



15 JUL 74

3. VHTP #3 - TURNING ON A ROUGH ROAD

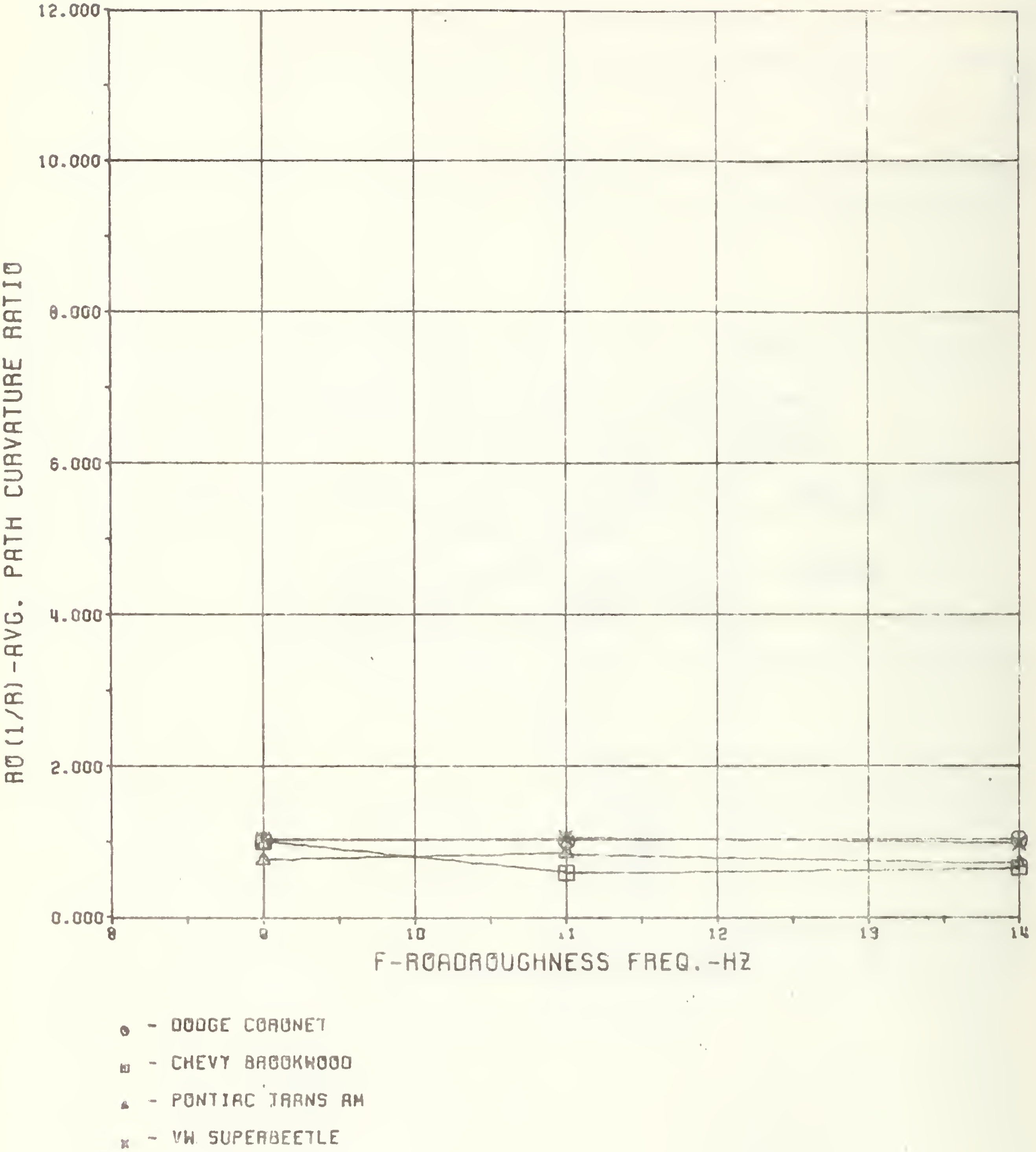
f - Roadroughness Fundamental Frequency - Determined by Spacing of the Disturbance Elements in Each Grid (HZ)

$R_0(1/R)$ - Average Path Curvature Ratio Relative to the Initial Turn

BETADOT - Peak Vehicle Sideslip Angle Rate (RADIANS/SEC)

*** AVG. PATH CURVATURE RATIO VS. ROADROUGHNESS FREQ. ***

(CALSPAN, O.E. TIRES, TURNING ON A ROUGH ROAD)

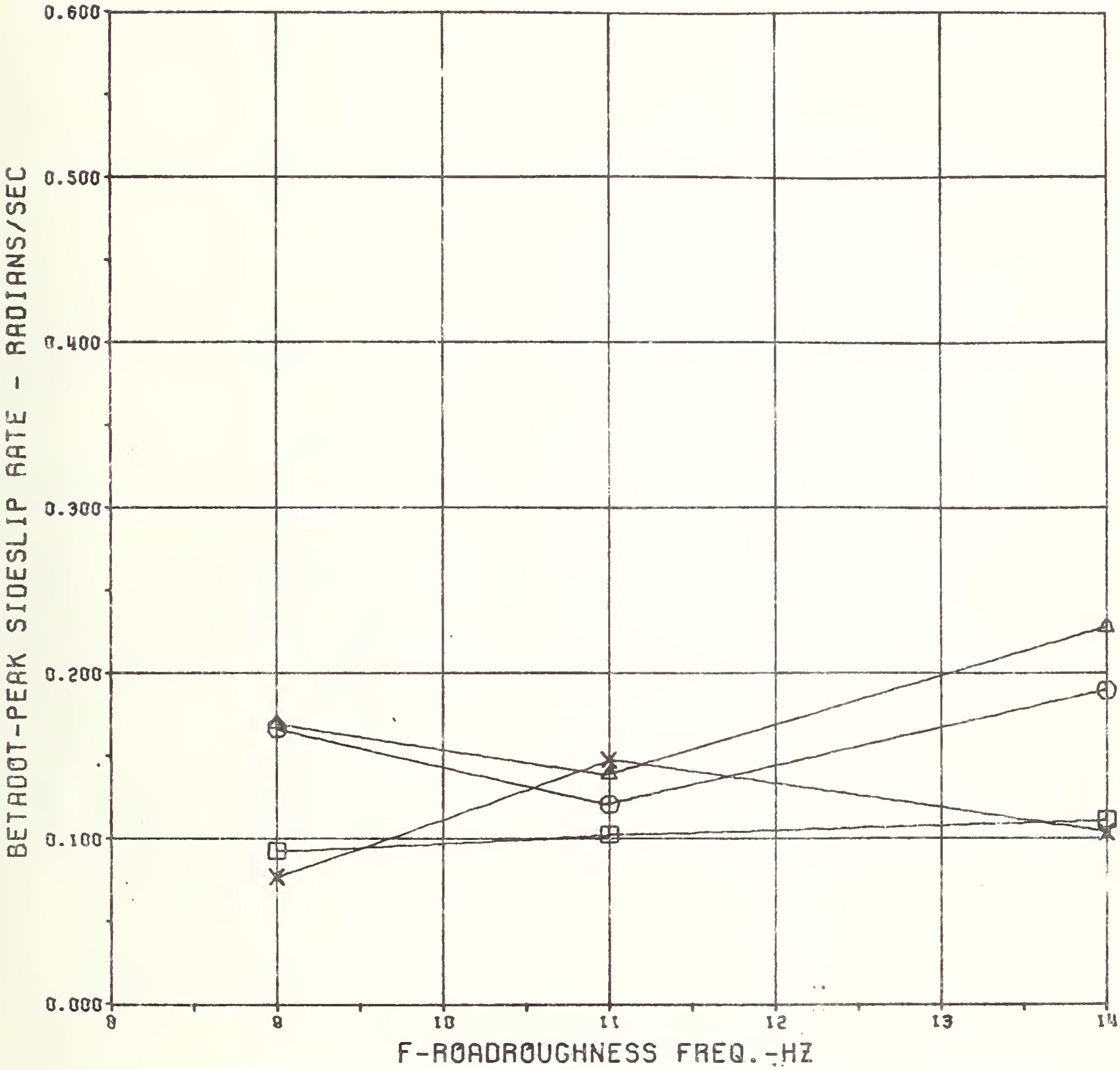





15 JUL 74

*** SIDESLIP RATE VS. ROADROUGHNESS FREQ. ***

(CALSPAN, O.E. TIRES, TURNING ON A ROUGH ROAD)




⊙ - DODGE CORONET

□ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

✕ - VW SUPERBEETLE



15 JUL 74

4. VHTP #4 - TRAPEZOIDAL STEER

$A_y$ - Peak Lateral Acceleration (GEES)

SIGMA - Normalized Steer Angle (DEGREES)

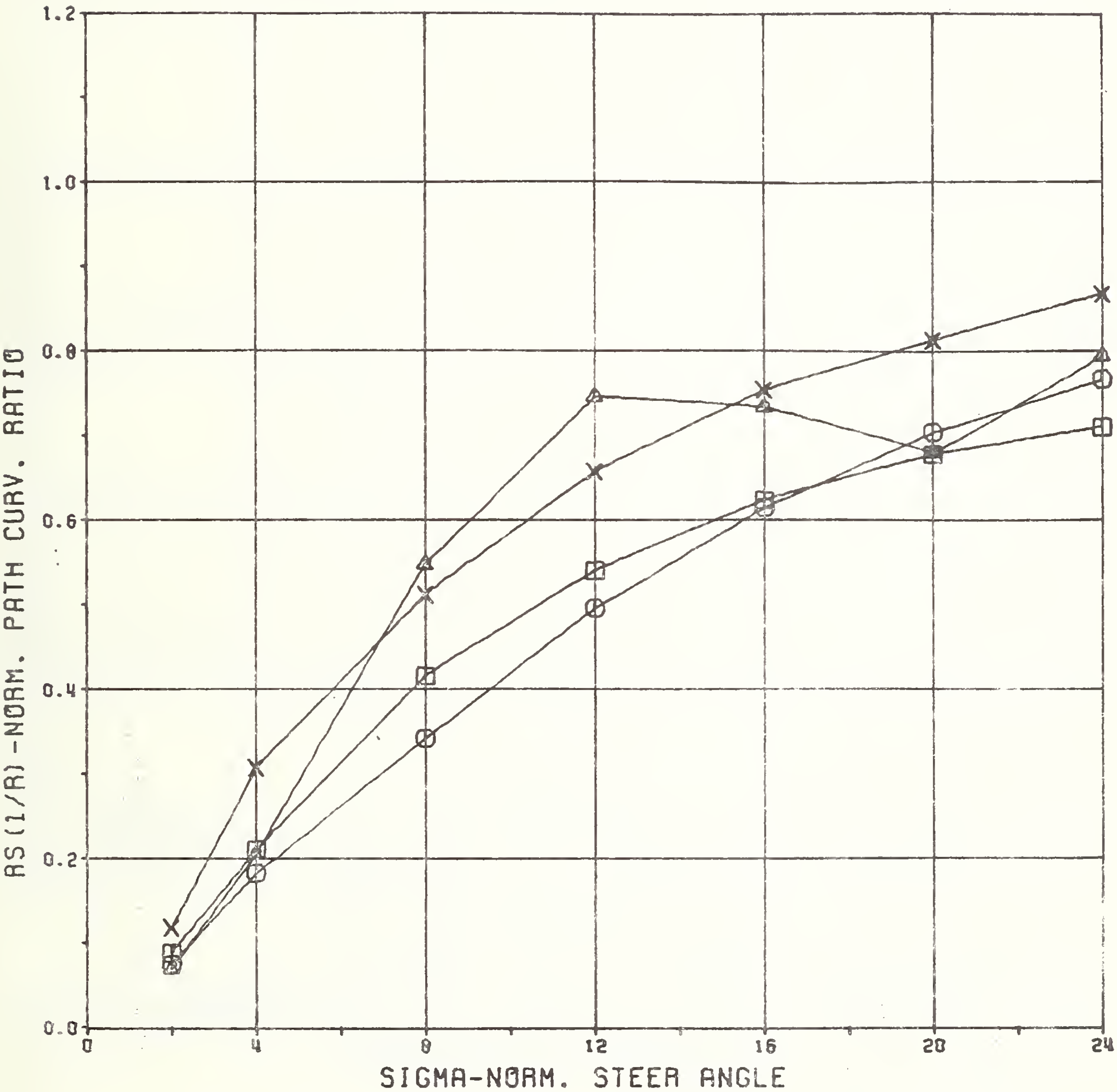
R - Peak Yaw Rate (RADIANS/SEC)

$R_s$(1/R) - Path Curvature Response Averaged Over Two Seconds 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 (RADIANS/SEC)

BETA - Peak Vehicle Sideslip Angle (RADIANS)

*** NORM. CURVATURE RATIO VS. NORM. STEER ANGLE ***
(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)



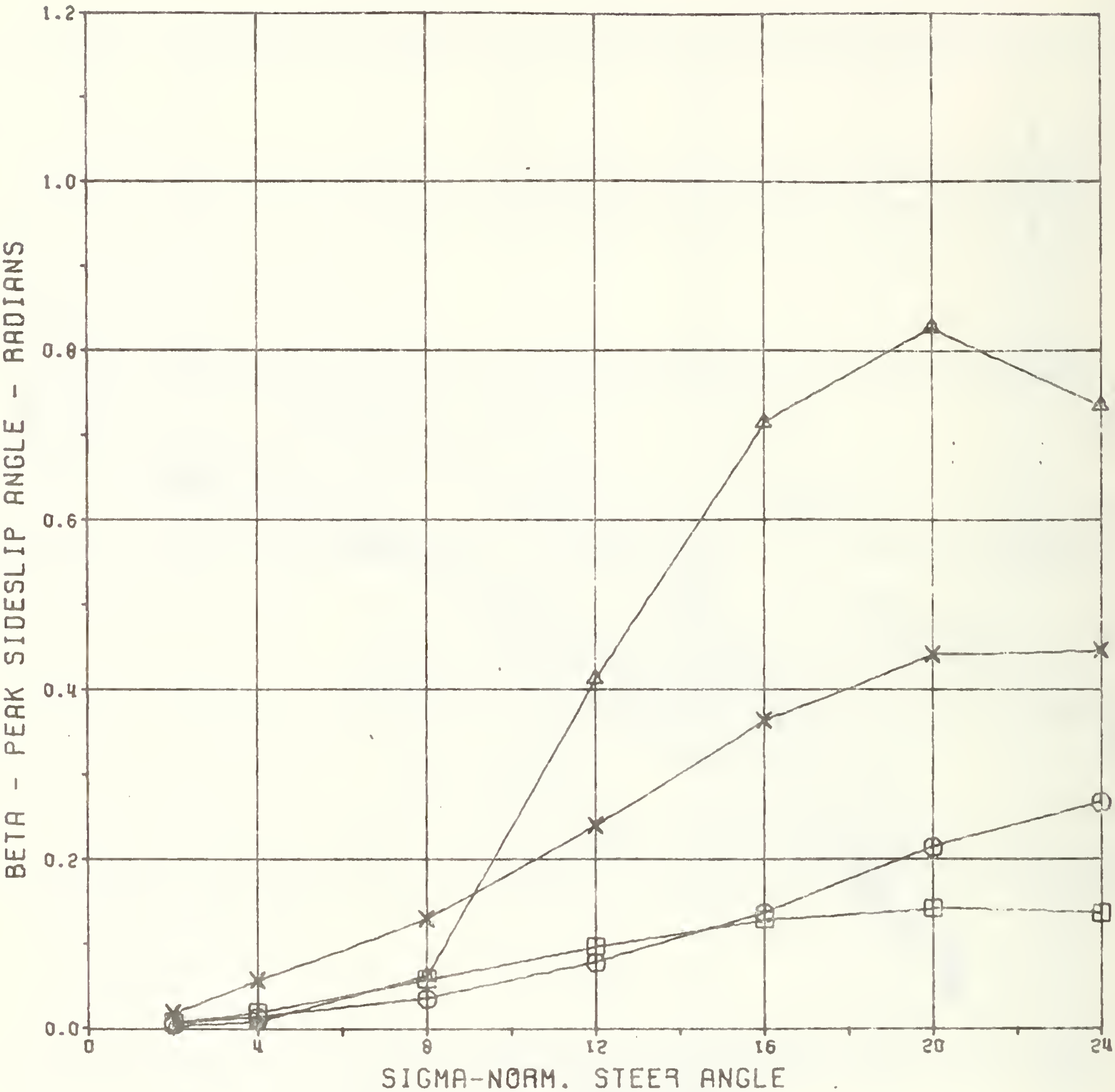

- DODGE CORONET
- CHEVY BROOKWOOD
- PONTIAC TRANS AM
- VW SUPERBEETLE



15 JUL 74

*** SIDESLIP ANGLE VERSUS NORMALIZED STEER ANGLE ***

(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)




o - DODGE CORONET

□ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

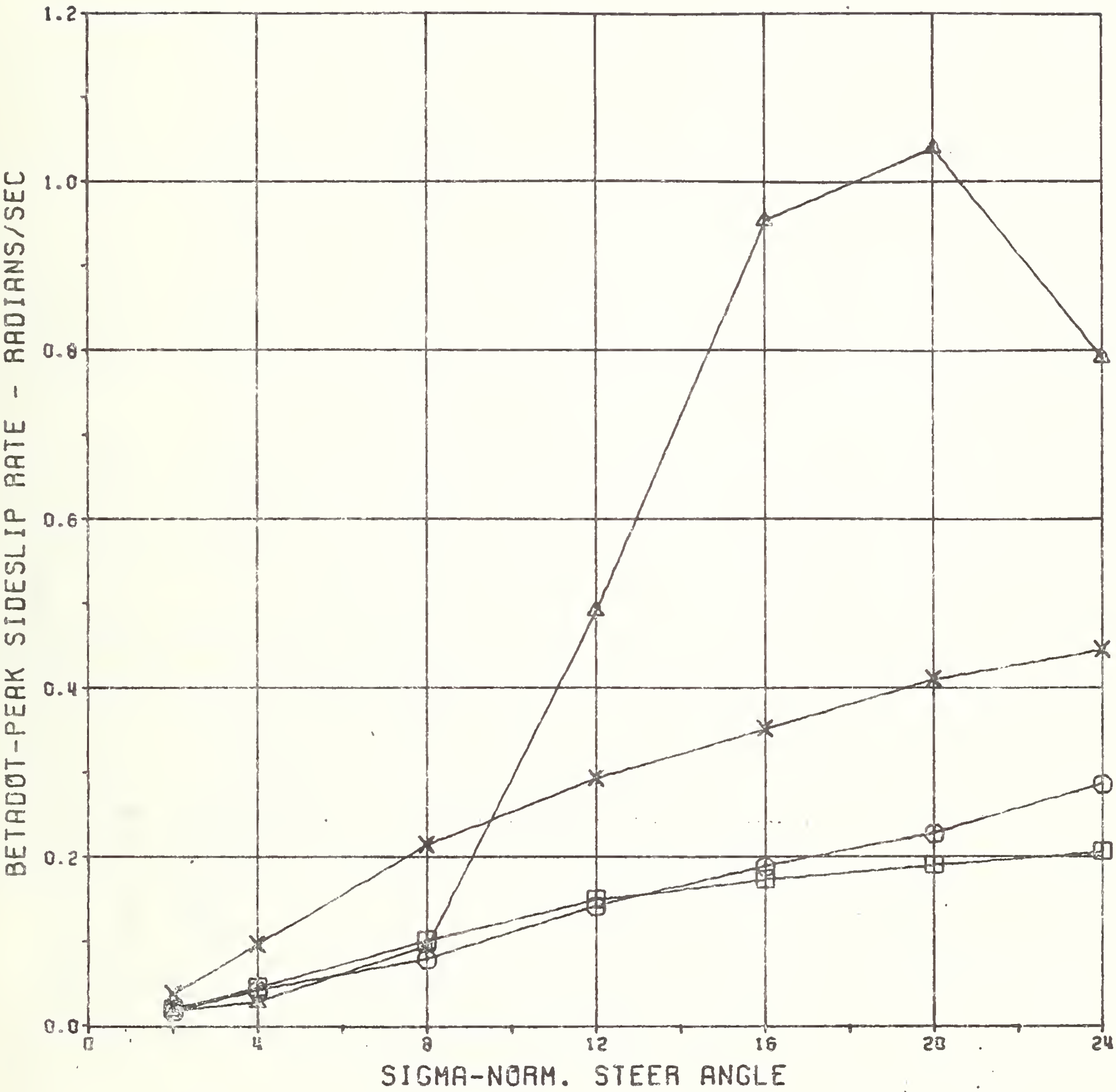
x - VW SUPERBEETLE



15-JUL 74

*** SIDESLIP RATE VERSUS NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)




⊙ - DODGE CORONET

⊡ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

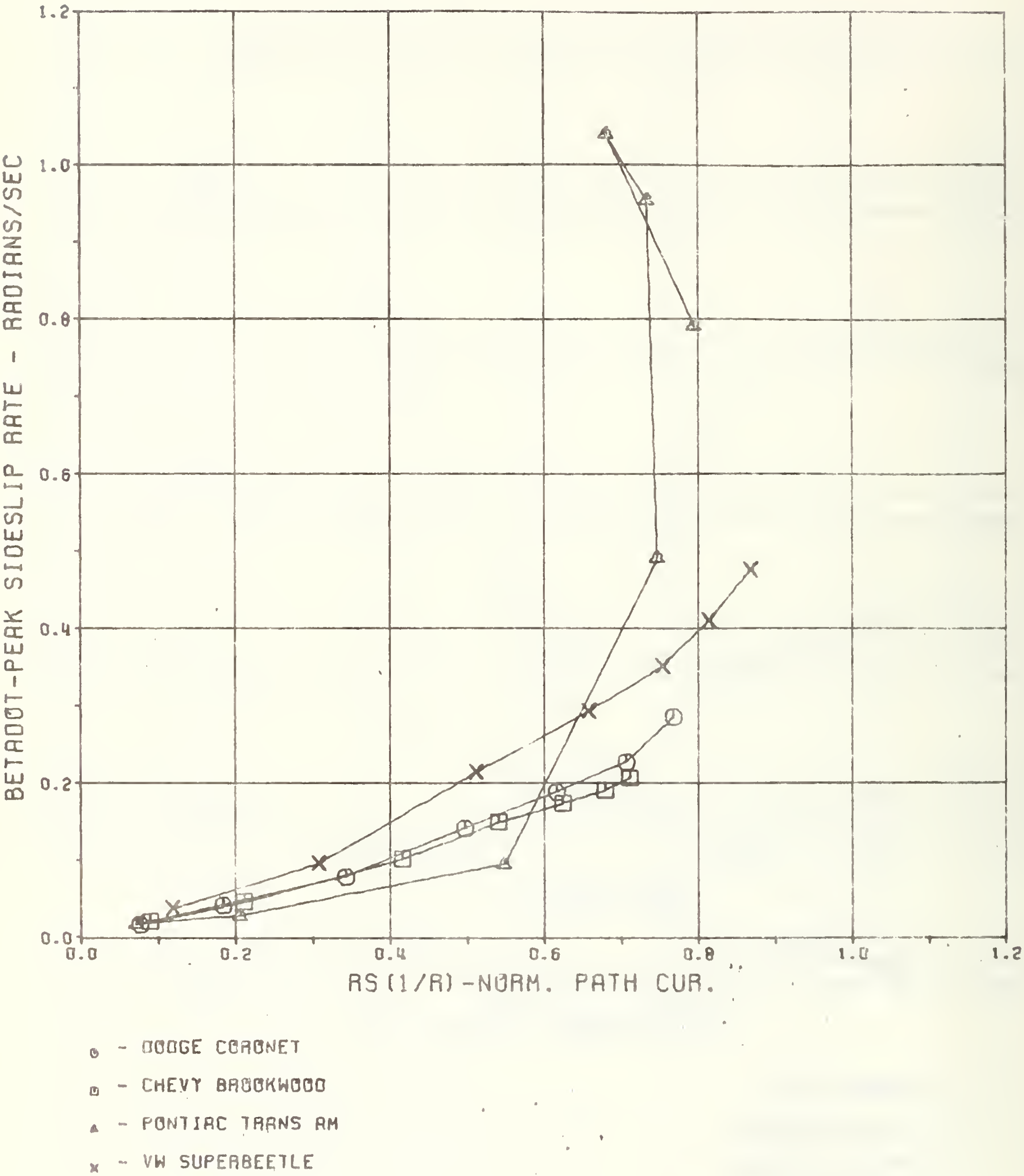
x - VW SUPERBEETLE



15 JUL 74

*** SIDESLIP RATE VERSUS NORM. PATH CURVATURE RATIO ***

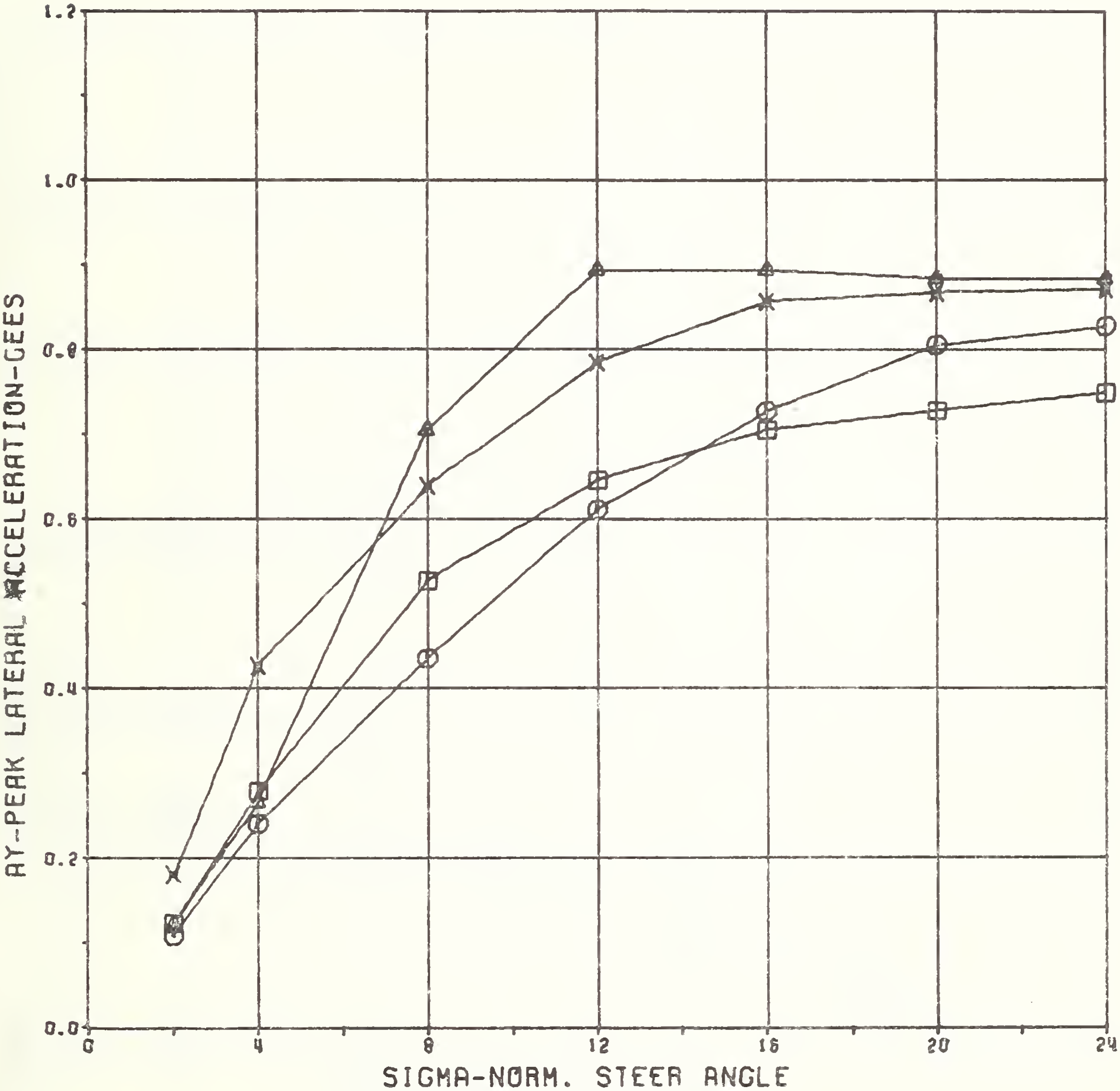
(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)






15 JUL 74

*** LATERAL ACCECERATION VS. NORM. STEER ANGLE ***
(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)



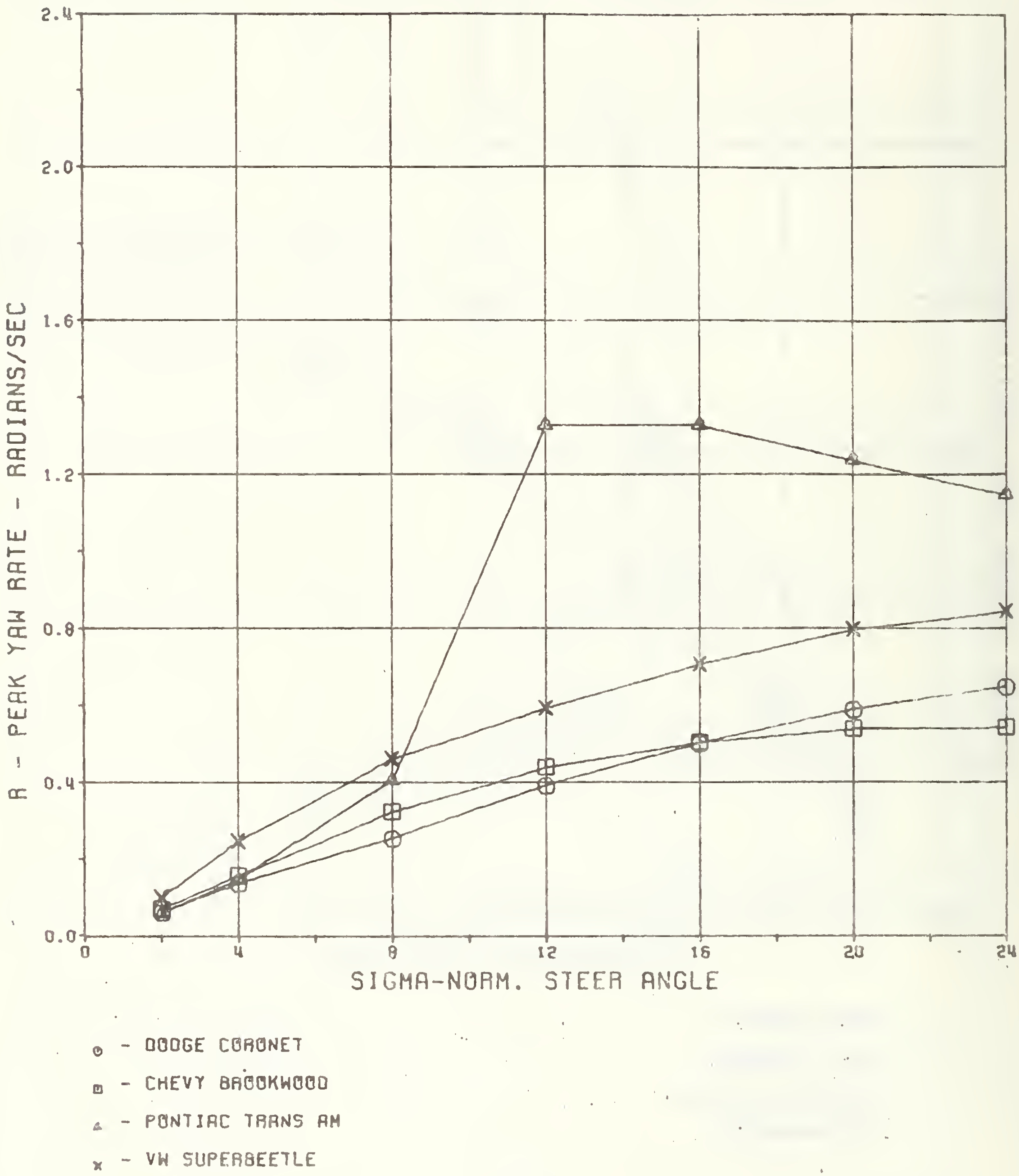

- DODGE CORONET
- CHEVY BROOKWOOD
- PONTIAC TRANS AM
- VW SUPERBEETLE



16 JUL 74

*** YAW RATE VERSUS NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)






15 JUL 74

5. VHTP #5 - SINUSOIDAL STEER

DEL PSI - Vehicle Heading Angle Deviation
After 3.4 Seconds (RADIANS)

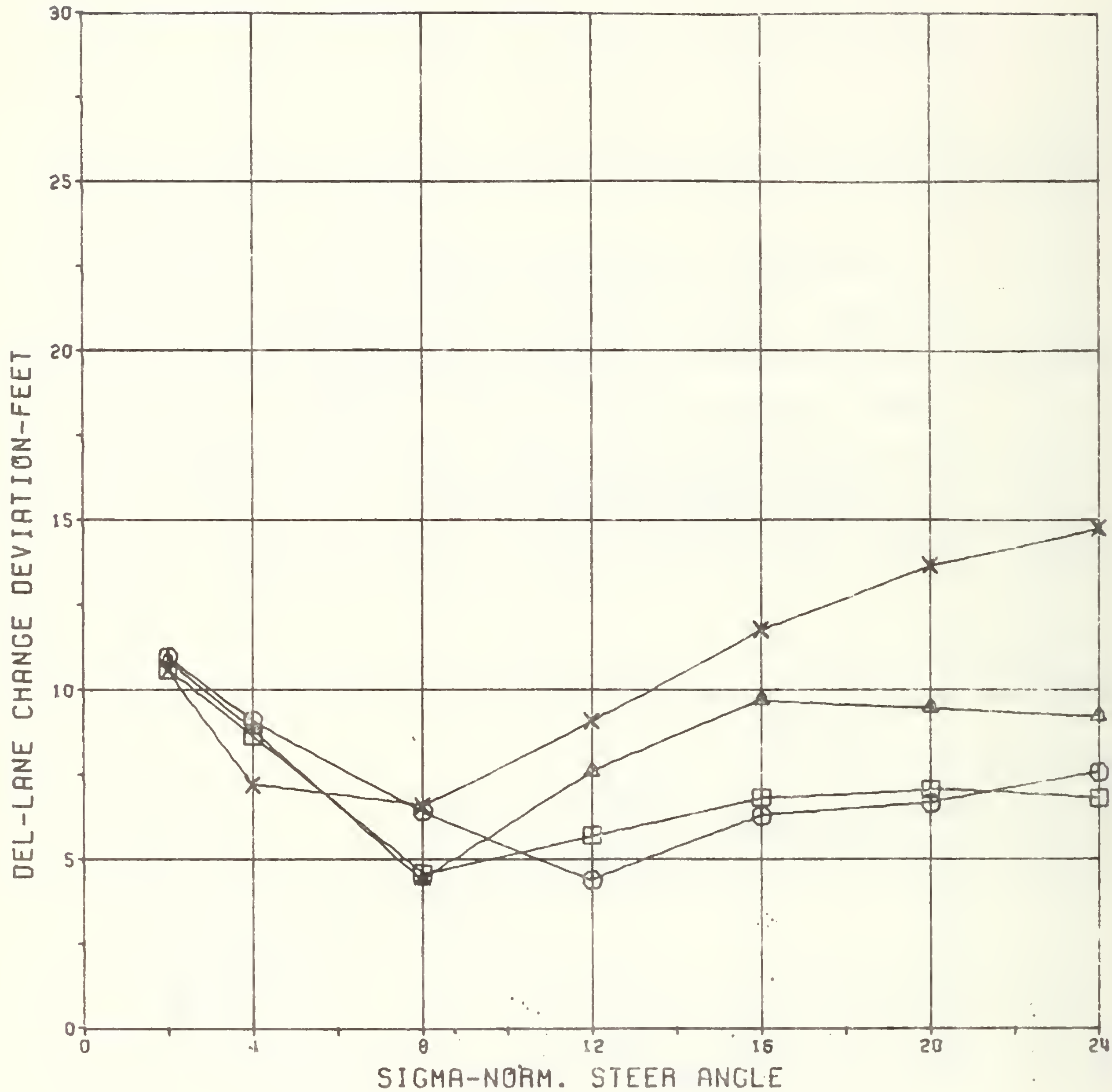
SIGMA - Normalized Steer Angle (DEGREES)

DEL - Lane Change Deviation from "IDEAL" Lane
Change Displacement (FEET)

BETA - Peak Vehicle Sideslip Angle (RADIANS)

*** LANE CHANGE DEV. VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-45 MPH)




⊙ - DODGE CORONET

⊡ - CHEVY BROOKWOOD

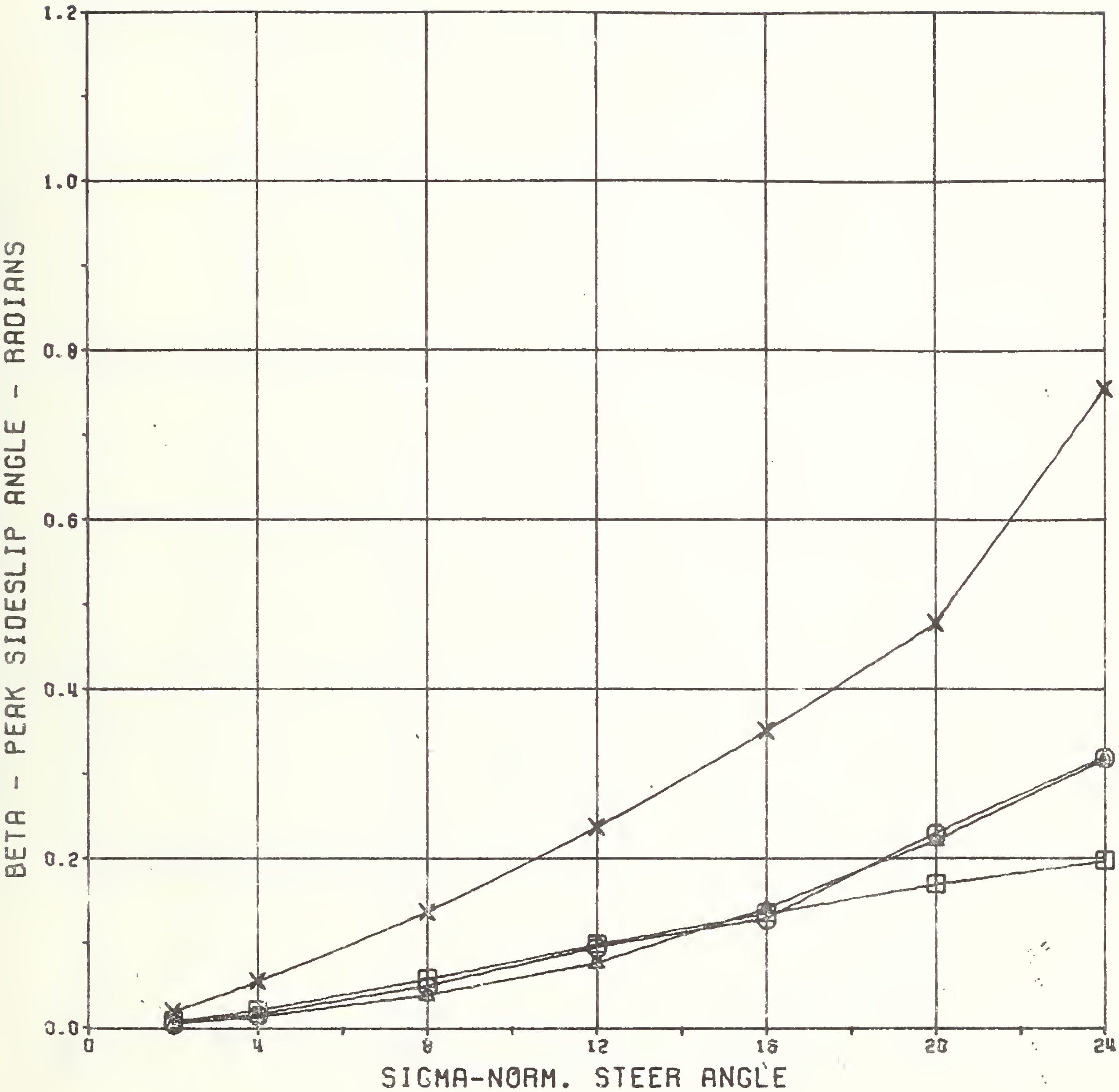
▲ - PONTIAC TRANS AM

✕ - VW SUPERBEETLE



15 JUL 74

*** SIDESLIP ANGLE VS. NORM. STEER ANGLE ***
(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-45 MPH)




o - DODGE CORONET

□ - CHEVY BROOKWOOD

△ - PONTIAC TRANS AM

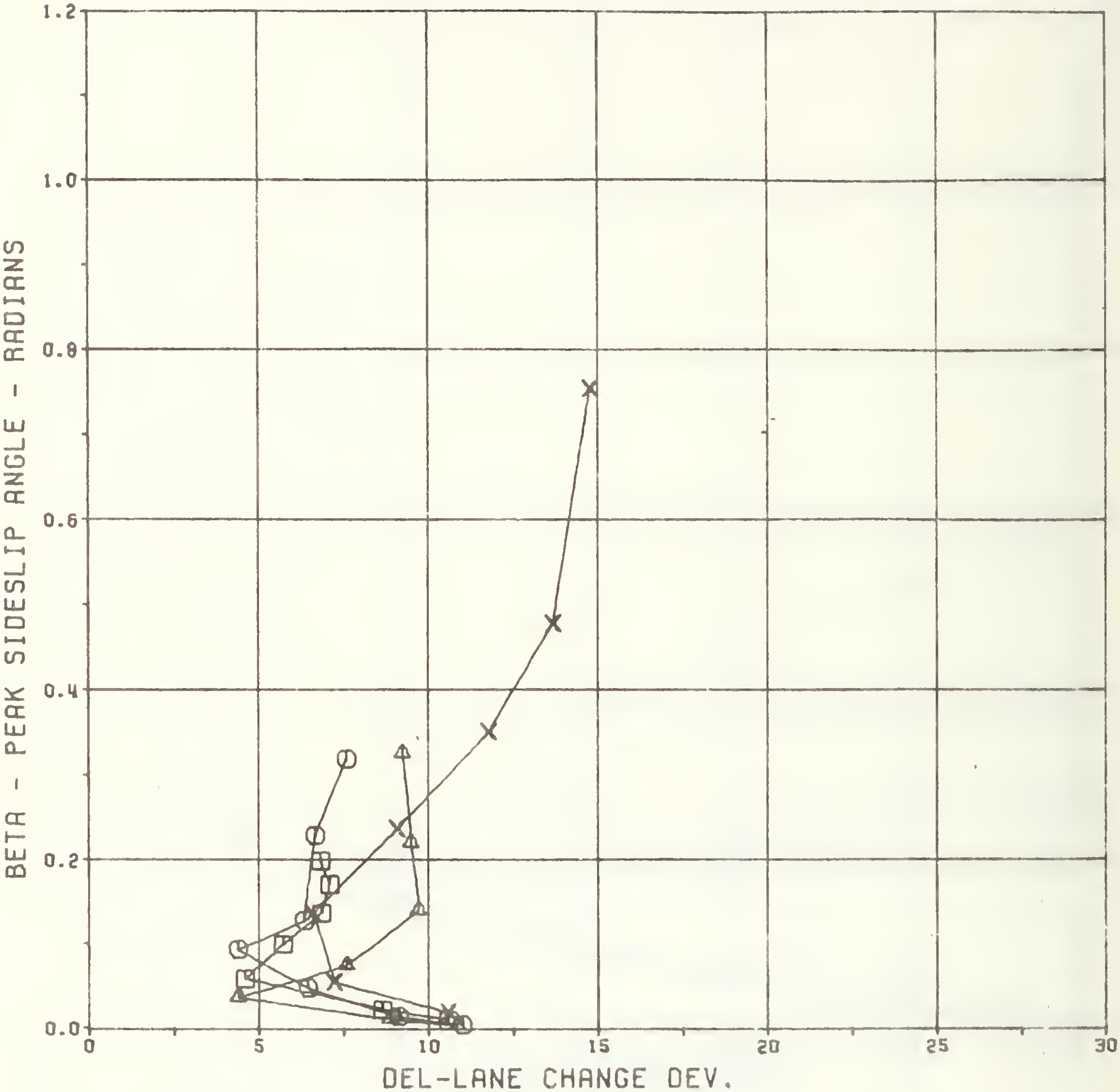
x - VW SUPERBEETLE



15 JUL 74

*** SIDESLIP ANGLE VS. LANE CHANGE DEV. ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-45 MPH)




○ - DODGE CORONET

□ - CHEVY BROOKWOOD

△ - PONTIAC TRANS AM

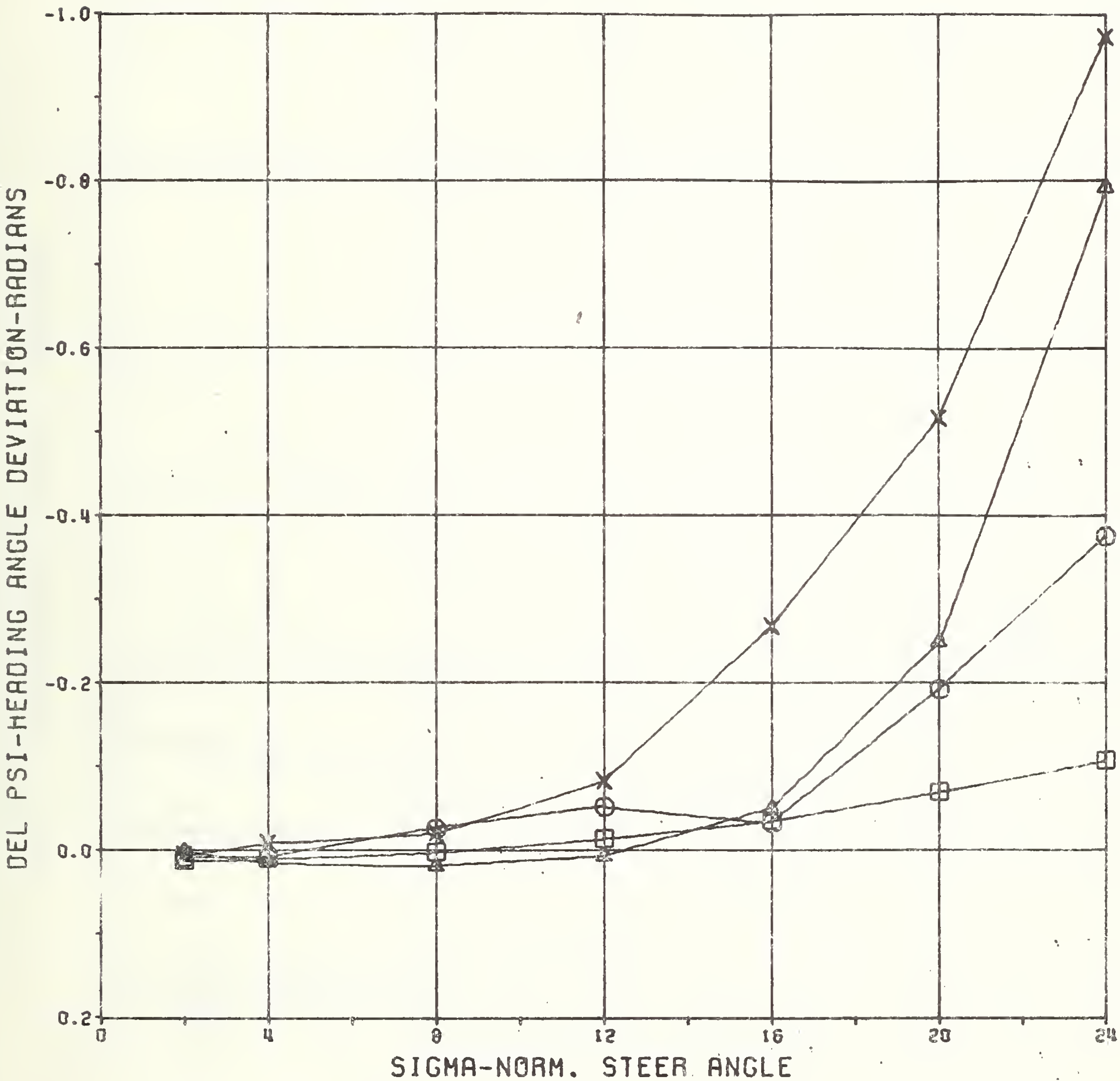
× - VW SUPERBEETLE



15 JUL 74

*** HEADING ANGLE DEV. VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-45 MPH)




o - DODGE CORONET

□ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

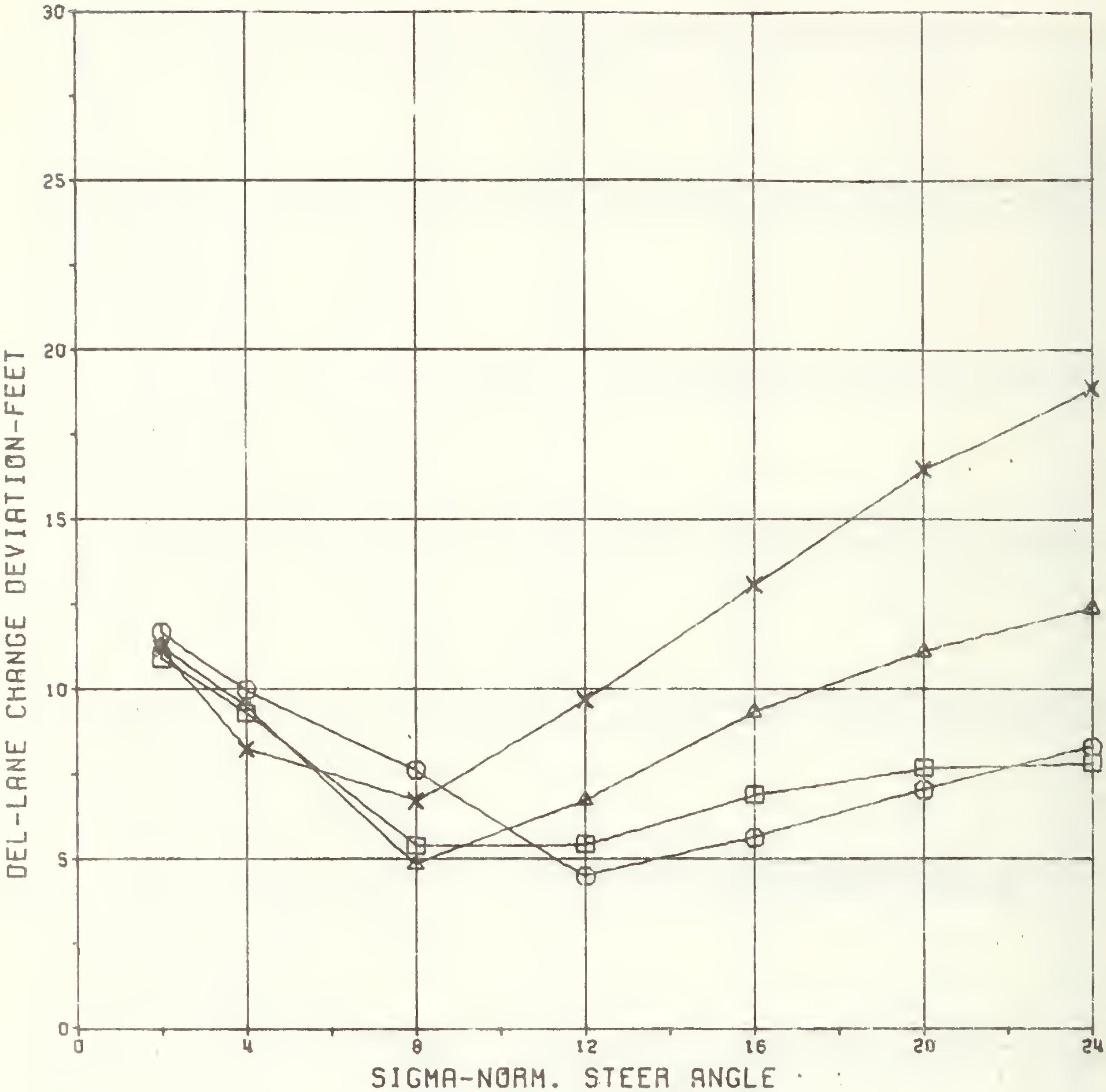
x - VW SUPERBEETLE



15 JUL 74

*** LANE CHANGE DEV. VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-60 MPH)




○ - DODGE CORONET

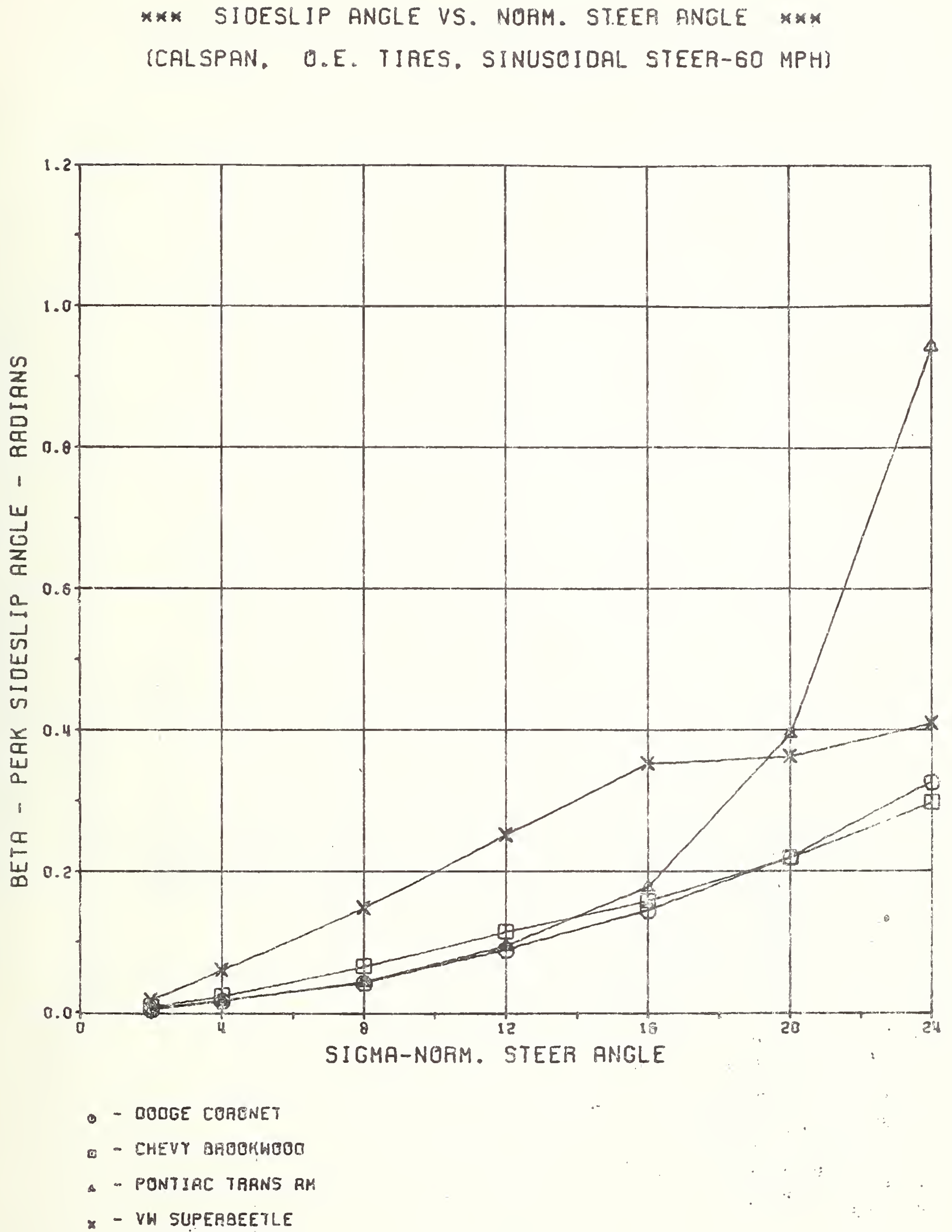
□ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

× - VW SUPERBEETLE



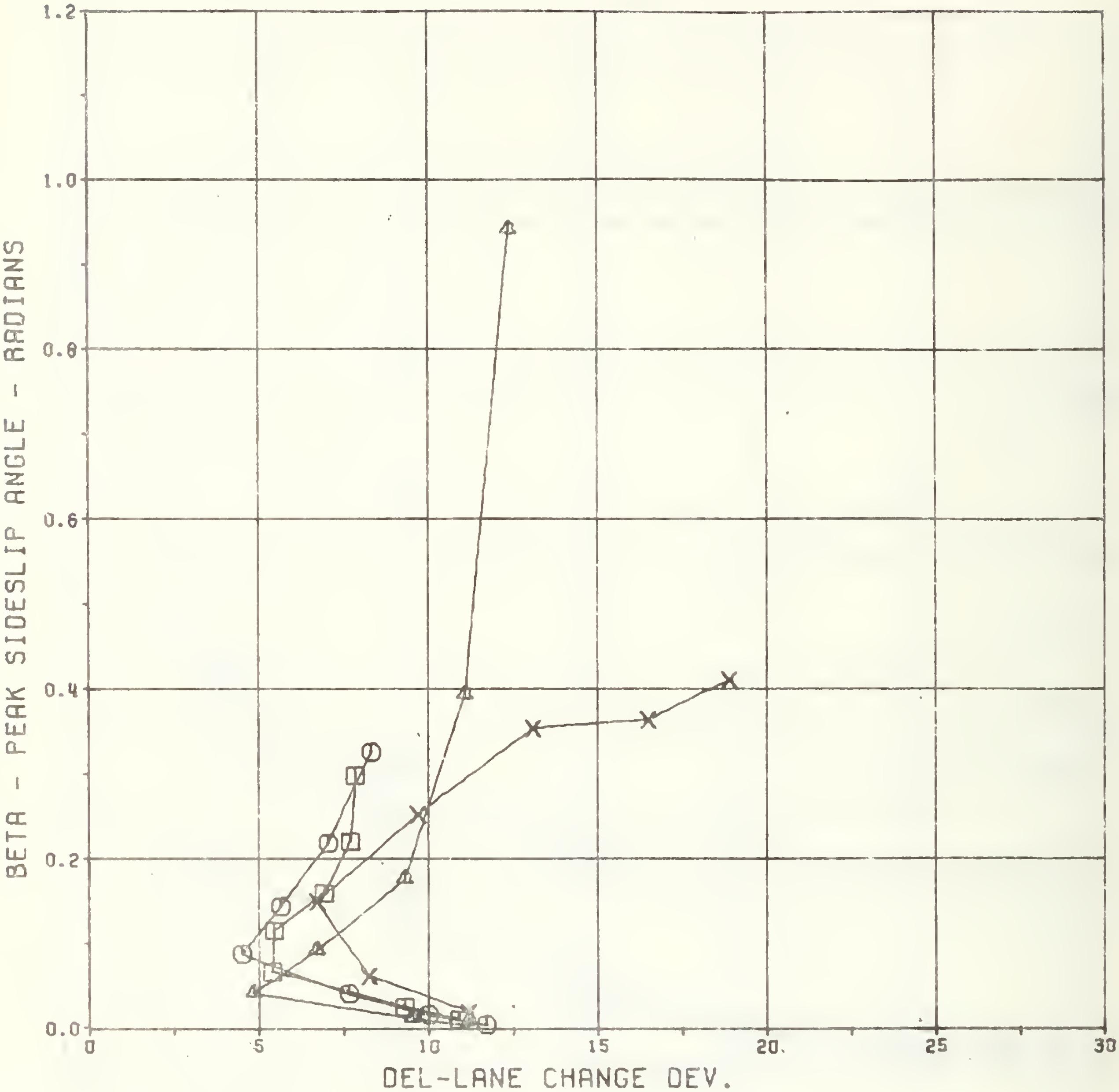
15 JUL 74


*** SIDESLIP ANGLE VS. NORM. STEER ANGLE ***
(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-60 MPH)
BETA - PEAK SIDESLIP ANGLE - RADIANS
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
4
8
12
16
20
24
SIGMA-NORM. STEER ANGLE
- DODGE CORONET
- CHEVY BROOKWOOD
- PONTIAC TRANS AM
- VW SUPERBEETLE



15 JUL 74

*** SIDESLIP ANGLE VS. LANE CHANGE DEV. ***
(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-60 MPH)



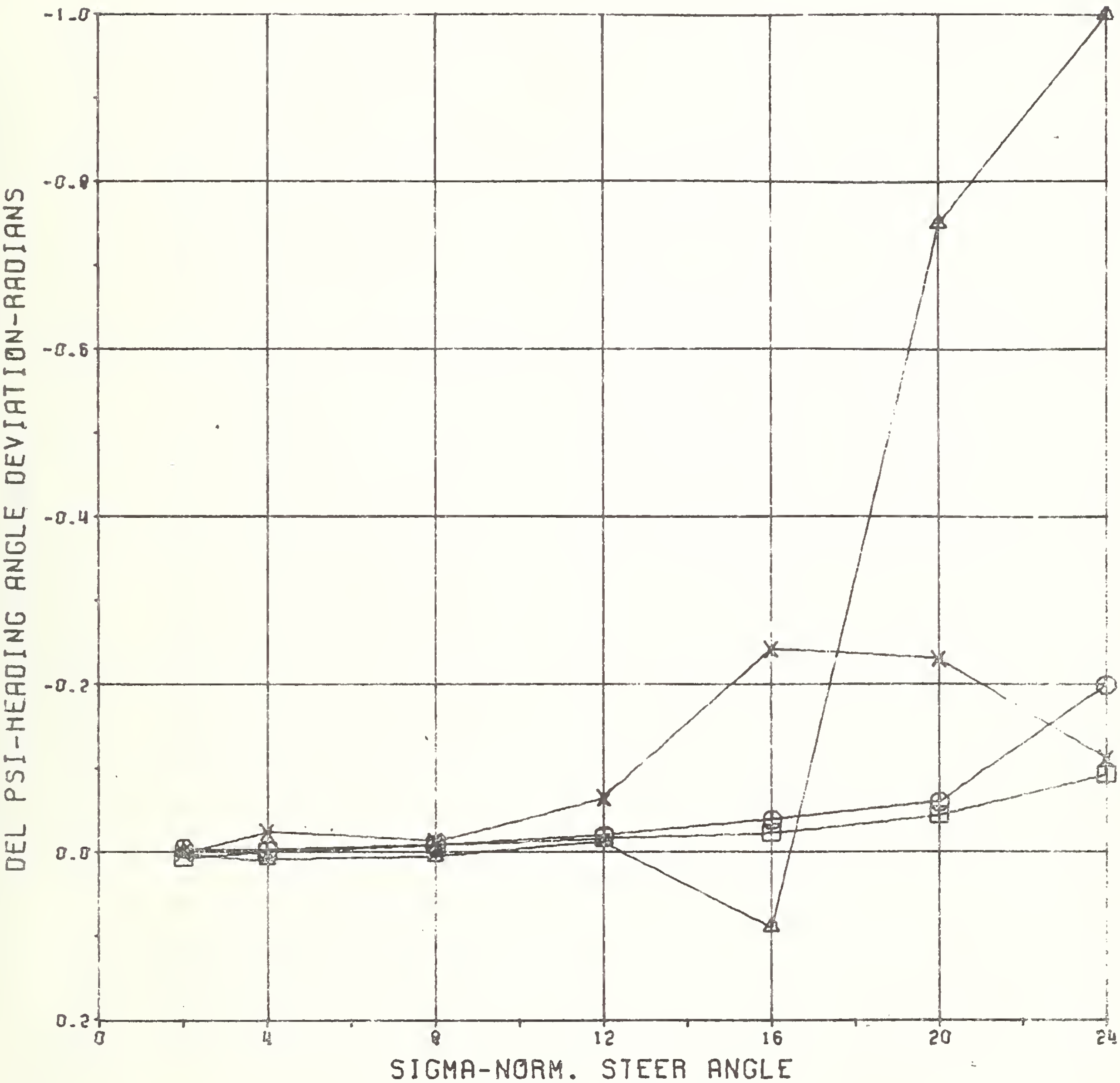

○ - DODGE CORONET
□ - CHEVY BROOKWOOD
△ - PONTIAC TRANS AM
✕ - VW SUPERBEETLE



15 JUL 74

*** HEADING ANGLE DEV. VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-60 MPH)




⊗ - DODGE CORONET

⊡ - CHEVY BROOKWOOD

△ - PONTIAC TRANS AM

✕ - VW SUPERBEETLE



16 JUL 74

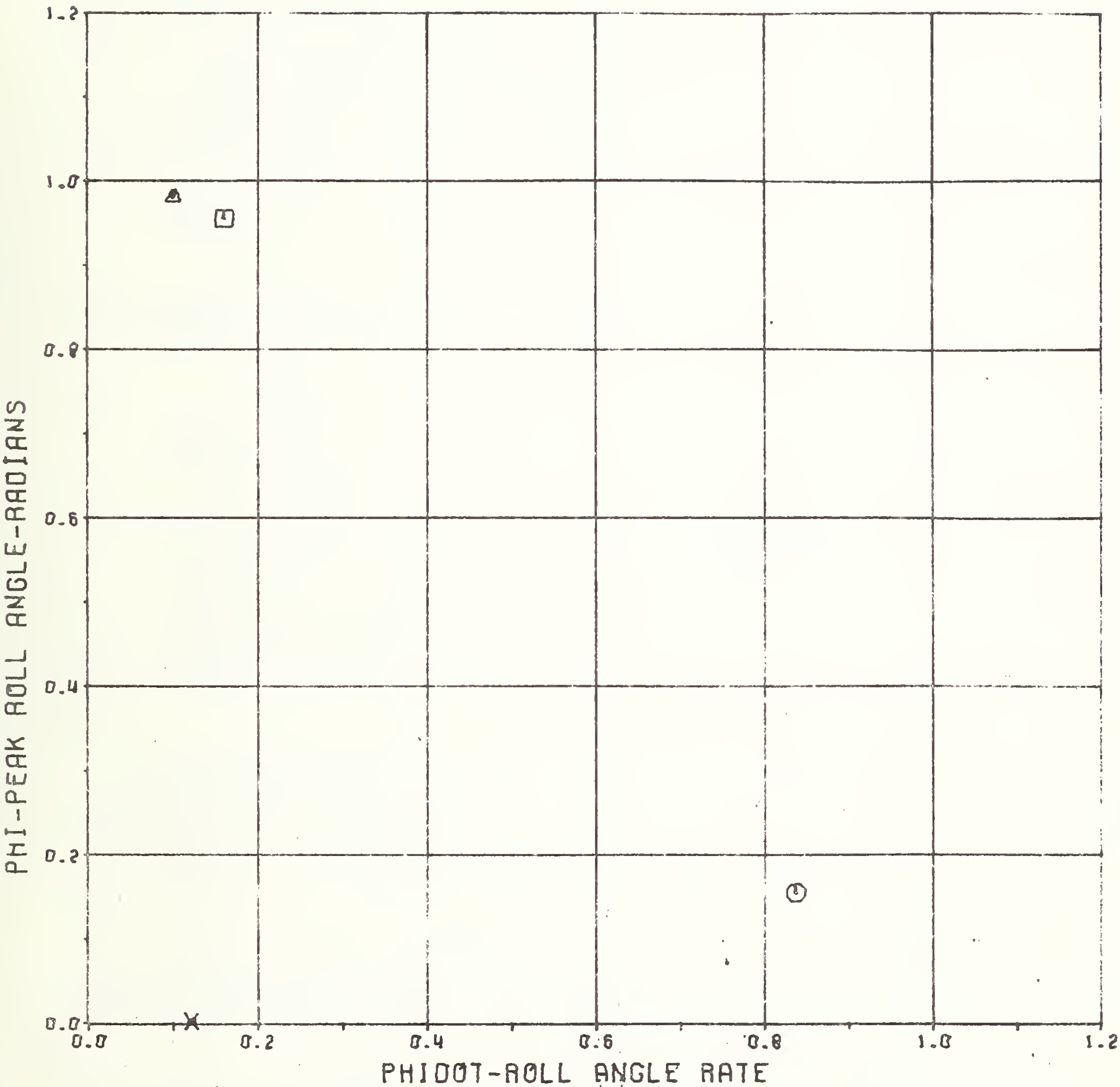
6. VHTP #6 - DRASTIC STEER AND BRAKE

PHI - Peak Roll Angle (RADIANS)

PHIDOT - Peak Roll Angle Rate (RADIANS/SEC)

*** ROLL ANGLE VS. ROLL ANGLE RATE ***

(CALSPAN, O.E. TIRES, DRASTIC STEER & BRAKE-50 MPH)



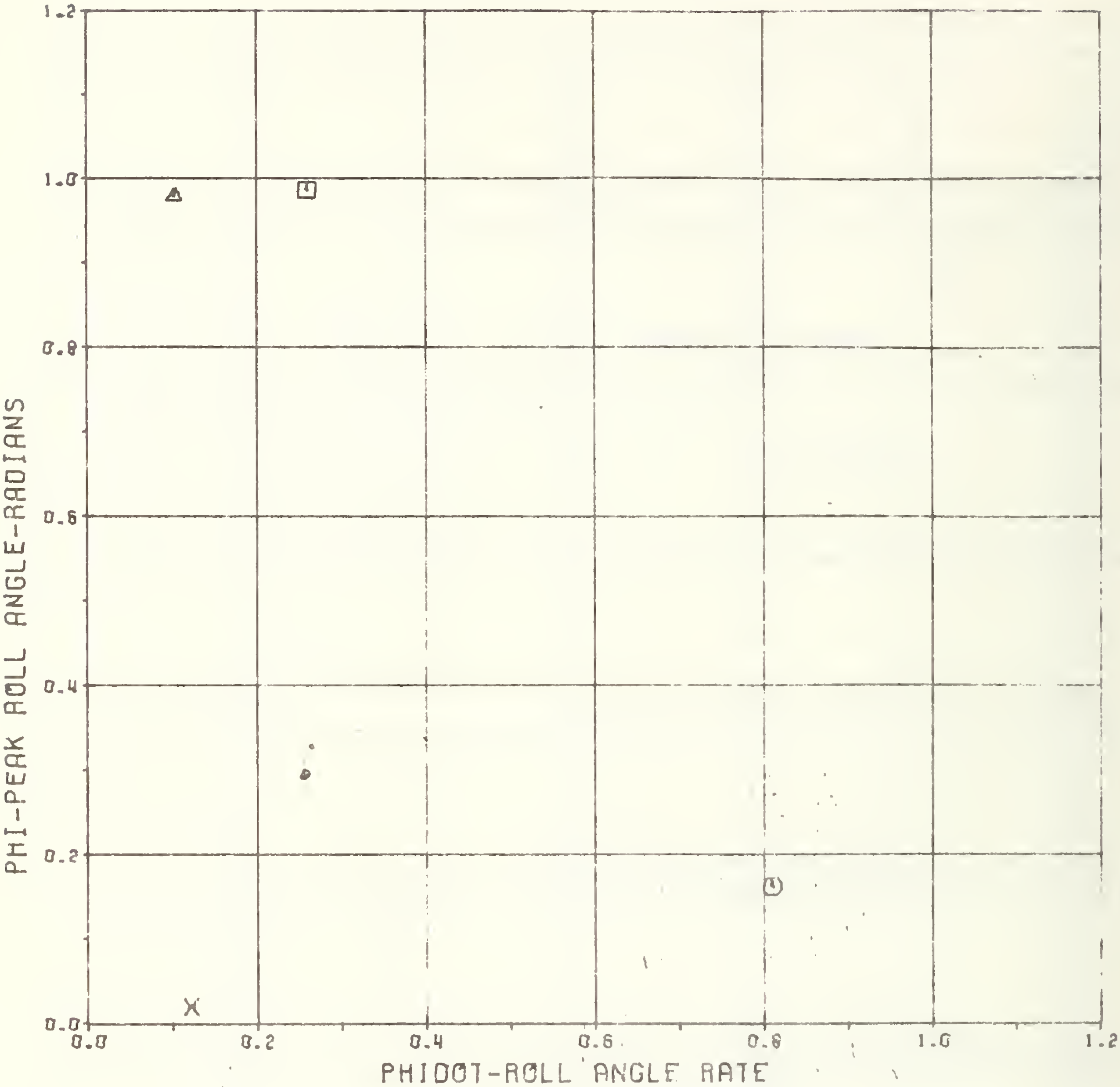

- o - DODGE CORONET
- ▫ - CHEVY BROOKWOOD
- ▵ - PONTIAC TRANS AM
- x - VW SUPERBEETLE



16 JUL 74

*** ROLL ANGLE VS. ROLL ANGLE RATE ***

(CALSPAN, O.E. TIRES, DRASTIC STEER & BRAKE-60 MPH)




⊕ - DODGE CORONET

⊡ - CHEVY BROOKWOOD

△ - PONTIAC TRANS AM

x - VW SUPERBEETLE



16 JUL 74

# REFERENCES


1) Task Z700 under Contract No. N00017-72-C-4401.

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

3) Calspan Corp. Final Report for Contract DOT HS-053-3-727, "Research on the Influence of Tire Properties on Vehicle Handling".

4) DOT-HS-800-374, Vehicle Handling Performance - Volume I, Ervin, Grote, etc., Highway Safety Research Institute, University of Michigan, November 1972.

5) DOT HS-82-306, "Modeling and Simulation in Vehicle Handling Research," P. F. Bohn, Vehicle Safety Research Integration Symposium, May 30, 1973.

6) DOT HS-800-374, Vehicle Handling Performance - Volume II, Ervin, Grote, etc., Highway Safety Research Institute, University of Michigan, November 1972.

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

8) EAI 680/IBM System 360 Reference Handbook, Electronic Associates, Inc., Publication No. 00800.3044-1, March 1970.

9) "The Real-Time Monitor," J. Clarke, presented at a hybrid seminar at DACS Development Center.

10) Introduction to the Real-Time Monitor (RTM), IBM Publication No. GH20-0824-0, July 1970.

11) Real Time Monitor (RTM) Operations and Programmer's Guide, IBM Publication No. GH20-0877-0, October 1970.

12) "Hybrid Techniques for Generation of Arbitrary Functions," A. I. Rubin, Simulation, December 1966.

13) "Program Generator for Real Time Simulations," P. F. Bohn, Proceedings of the Summer Computer Simulation Conference, July 1974.

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

References (cont'd.)

15) DOT NHTSA Contract FH-11-7563, Computer Simulation of Vehicle Handling, Bendix Research Laboratories, Southfield, Michigan, September 1972.

16) CAL Report No. VJ-2251-V-7, Automobile Dynamics - A Computer Simulation of Three-Dimensional Motions for Use in Studies of Braking Systems and of the Driving Task, August 1970.

GPO 884-680

handling program.

| ONE | DATE |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |