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User's Guide to DIANE Version 2.1: A Microcomputer Software Package for Modeling Battery Performance in Electric Vehicle Applications

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Availability of Computer Software

This computer software has been developed under the sponsorship of the United States Department of Energy (DOE). Any further distribution by any holder of the software package or other data therein outside of DOE offices or other DOE contractors, unless otherwise specifically provided for, is prohibited without the approval of the National Energy Software Center. Requests from outside the Department of Energy for DOE-developed computer software shall be directed to the Director, National Energy Software Center, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439.

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Abstract

DIANE is an interactive microcomputer software package for the analysis of battery performance in electric vehicle (EV) applications. The principal objective of this software package is to enable the prediction of EV performance on the basis of laboratory test data for batteries. The model provides a second-by-second simulation of battery voltage and current for any specified velocity/time or power/time profile. The capability of the battery is modeled by an algorithm that relates the battery voltage to the withdrawn current, taking into account the effect of battery depth-of-discharge (DOD). Because of the lack of test data and other constraints, the current version of DIANE deals only with vehicles using "fresh" batteries* with or without regenerative braking. Deterioration of battery capability due to aging can presently be simulated with user-input parameters accounting for an increase of effective internal resistance and/or a decrease of cell no-load voltage. DIANE 2.1 is written in FORTRAN language for use on IBM-compatible microcomputers.

1 Overview of DIANE Version 2.1

1.1 Introduction

In electric vehicle (EV) applications, the relationship between the performance of a battery and its operational history is extremely complex. The energy and power capabilities of the battery are generally influenced by the nature and number of discharges that the battery has experienced, which, in turn, are determined by the velocity/time profiles and the driving pattern of the vehicle. Evidence of the complexity of the relationship may be found in the occasionally

*An algorithm for simulating the aging and recuperation effects of batteries was included in a previous version of DIANE (Marr, Walsh, and Symons 1987).

poor correlation between the results of laboratory testing of EV battery modules, the results of dynamometer or track testing of EV performance, and the actual in-use ranges and accelerations that have been observed in precommercial demonstrations.

Numerous attempts have been made to analytically describe battery performance so that EV performance can be projected. Such attempts include the fractional utilization model in ELVEC (Slusser, Chapman, and Chazanoff 1982) and the design algorithms in MARVEL (Marr and Walsh 1984). In most cases, oversimplified or generalized representations of battery performance were used. The state of battery modeling has not yet advanced to the point where it is possible to uniquely determine the performance of a battery at any point in its life by analytically solving a set of equations. However, the simulation process employed in DIANE, which is described in this report, has the objective of enabling accurate predictions of EV performance by relating battery performance and empirical characteristics of the battery.

1.2 Development of the Model

The most fundamental assumption in the DIANE formulation is that the voltage of a battery cell under load can be represented, at any point in its discharge, by the simple electrical equation:

$$V = V_o - I R \quad (1)$$

where:

- V = the voltage of a cell being discharged (V);
- V_o = the effective no-load voltage, or NLV (V);
- I = the discharge current (A); and
- R = the effective internal resistance of the cell (Ω).

At any given time during the discharge cycle, the relationship between battery voltage and the current is more complicated than is indicated in the simple formulation given in Eq. 1. The internal resistance of a battery cell can rarely be represented by a simple ohmic resistance; among other effects, the effective resistance often varies with discharge rate. However, inspection of the discharge current/voltage curves for a number of batteries shows that, over the range of discharge rates and periods of discharge at these rates that are likely to be used in EVs, the formulation given in Eq. 1 is a reasonable approximation, provided that the parameters V_o and R are properly defined.

The effective no-load voltage, V_o , is the y-intercept of an extrapolated plot of voltage versus current for the cell over the rates and periods of discharge that are of interest for EV applications. Similarly, the effective resistance, R in Eq. 1, is the slope of the voltage/current plot just described.

In the present version of DIANE, empirical values of V_o and R , obtained from laboratory test data, are input as functions of the depth-of-discharge (DOD); thus,

$$V_o = f_1 (\text{DOD}) \quad (2)$$

and

$$R = f_2 (\text{DOD}) \quad (3)$$

For the case of regenerative braking, the values of V_o and R can be different, and therefore the following functional relationships are used:

$$V_{or} = f_3 (\text{DOD}) \quad (4)$$

and

$$R_r = f_4 (\text{DOD}) \quad (5)$$

The parameter DOD in Eqs. 2-5 is defined as:

$$\text{DOD} = \frac{\int_0^T I \left[1 + g_1 \left(\frac{I}{I_3} - 1 \right) \right] dt}{C_3} \quad (6)$$

where:

t = time (h),

T = discharge time to reach DOD (h),

I_3 = the battery current corresponding to a three-hour rate (A),

C_3 = battery capacity corresponding to I_3 (Ah),

g_1 = a user-input, dimensionless parameter simulating the effect of discharge rate on capacity. The value of g_1 can be derived from battery test data (e.g., the Peukert curve). For most types of batteries, g_1 can be assumed to be zero.

For a battery that is discharged at a three-hour rate or for a battery that has a capacity unaffected by its discharge rate (i.e., $g_1 = 0$), Eq. 6 may be simplified to:

$$\text{DOD} = \frac{\int_0^T I dt}{C_3} \quad (7)$$

An assumption made in the DIANE formulation is that the characteristics of an EV battery pack can be represented by a typical cell. The capacity of a cell (in ampere-hours) is determined from the discharge time that the cell can sustain at a given discharge current before the terminal voltage falls below a cutoff point.

1.3 Procedure for Calculation of Power Requirement

For a vehicle with specified characteristics, the power requirement at the wheels corresponding to the driving profile is calculated from the required force, which overcomes the drag force, the rolling resistance, the grade, and acceleration and, at the same time, maintains the vehicle at the specified speed. The equations used in the calculation are described in App. A. The battery current and voltage corresponding to the power/time profile are then calculated on a second-by-second basis. Battery power, P_B , at any time, is the product of current, I , and voltage, V (i.e., $P_B = IV$). For a known battery power requirement P_B (see Eq. A.9), and with the aid of Eq. 1, we have the following quadratic equation that can be solved for I :

$$RI^2 - V_o I + P_B = 0 \quad (8)$$

The values of R and V_o can be obtained from Eqs. 2 and 3 or Eqs. 4 and 5.

After the instantaneous battery current is calculated, the battery voltage can be computed from Eq. 1. The effective capacity discharged is then updated to include the time increment according to Eq. 6. The calculation continues for the driving cycles until the battery voltage falls below a cutoff point or the battery current reaches the limit set by the user. The range is obtained by multiplying the number of times the driving profile is repeated by the range of the profile.

1.4 Organization of the Program

DIANE 2.1 consists of one main program and several subprograms. The names and functions of these subprograms are listed in Table 1.1. Within each subprogram, there could be more than one subroutine.

In linking compiled object files to produce the execution file DIANE21.EXE with graphics capability, a library named GRAFEX33.LIB (provided by the GRAFMATIC software package*) was used, in addition to the Microsoft FORTRAN and MATH libraries. An EGA or VGA graphics board is needed for plotting. A version of DIANE 2.1 without the graphics capability, DIANENP.EXE, was produced by omitting the last four statements about plotting in DIANE21.FOR. The plotting subprogram GRAPH was not included in DIANENP.EXE.

*GRAFATIC: Scientific/Engineering Graphics, MICROCOMPATIBLES, 301 Prelude Drive, Silver Springs, Md. 20901

TABLE 1.1 Program Organization of DIANE Version 2.1

Names	Function	Subroutines
		Included
DIANE21	Main program control; s-by-s EV simulation	RUNEV
INPUT1	Read and write vehicle and driving profile input data	PINPUT, PPRINT
INPUT2	Read and write battery input data	DINPUT, DPRINT
SIL	Set up output device; problem initialization; table look-up	SETPRINT, INIT, BETWEEN
INTER	Interactive modification of preselected parameters	INTERACT
POWER	Compute power profile	POWER
SPEEDUP	Compute vehicle speed for maximum-power acceleration	SPEEDUP
GRAPH	Plot maximum currents and minimum voltages during battery discharge	DPLOT, PLOTMENU, PLOTCL, PLOTCLV, PLOTBIKM, BITM, PLOTBVKM, BVTM

2 Description of Input Variables

Input data are divided into three categories: vehicle, driving profile, and battery. Respective default data files are included in Apps. B through D. Input data to DIANE can be changed in either of two ways: (1) by modifying an existing (default) data file through the use of an on-line interactive text editor or (2) by changing the values of the preselected parameters interactively prior to a simulation run.

2.1 Input Data for Vehicles

The input data that are needed for vehicle simulation are listed in Table 2.1.

Default data files (shown in App. B for eight types of vehicles) are available in the current version of the DIANE software package. These include the Eaton Dual-Shaft Electric Propulsion Van (DSEP), the Improved Dual-Shaft Electric Propulsion Van (IDSEP), the General Motors (GM) Griffon electric van, the Ford's Second-Generation Single-Shaft Electric Propulsion System (ETX-II), the Electric Power Research Institute's (EPRI) G-Van and TEVan, the Improved Electric Test Vehicle (IETV-1), and GM's two-passenger prototype electric car, the Impact.

2.2 Input Data for Driving Profiles

The power requirement of a vehicle depends on the driving profile that the vehicle must negotiate. A driving cycle is assumed to comprise two parts: a driving period followed by a rest period. Currently, the second-by-second velocity data in the driving period are limited to 400 entries. Table 2.2 shows the input data required for the driving profile data file.

Three default driving profiles, shown in App. C, are available in the software package. These profiles include the JPL-Standardized Version of SAE J227a Schedule C, the JPL-Standardized Version of SAE J227a Schedule D (Hewitt and Bryant 1982), and the Simplified Federal Urban Driving Schedule (SFUDS). SFUDS is a modification of the Federal Urban Driving Schedule (FUDS) with the power requirement at the battery terminals limited to 79 W/kg (DOE 1988).

For the case where power profile instead of velocity profile is specified, the second-by-second power requirement (based on battery weight) at the battery terminals should be entered as input. Table 2.3 shows the input for a power profile data file.

Two default power data files, J227AD.POW (for the IETV-1 with SAE J227aD driving profile) and SFUDS.POW (for the IDSEP vehicle with a battery weight of 695 kg), are also included in the software package and are shown in App. C.

TABLE 2.1 Input Data for Vehicle Simulation

input Variable	Unit	Comment
Title	-	Limited to 75 characters
Curb weight, without batteries, CWNB	kg	Vehicle test weight is $TW = CWNB + BW + PLW$
Battery weight, BW	kg	Including accessories
Drivetrain efficiency, EFFD	-	η_D in Eq. A9
Motor efficiency, EFFM	-	η_M in Eq. A9
Rolling resistance coefficient, K0	-	See Eq. A5
Rolling resistance coefficient, K1	s/m	See Eq. A5
Rolling resistance coefficient, K2	s ² /m ²	See Eq. A5
Frontal area, FAREA	m ²	A_F in Eq. A4
Drag coefficient, CD	-	C_D in Eq. A4
Grade, GRADE	%	$100 \times \tan \theta$; see Fig. A1
Payload, PI W	kg	Usually half of the maximum payload
Maximum vehicle weight, GVW	kg	Vehicle design weight
Controller current limit, DCOI	A	Voltage limit is set at cell level in BATTERY input data below

2.3 Input Data for Batteries

Input variables for a battery data file are listed in Table 2.4.

Five default battery data files are included in the DIANE software package (see App. D). Battery characteristics are based on test data from the Analysis and Diagnostic Laboratory (ADL) at Argonne National Laboratory (DeLuca et al. 1989; Miller 1989). The Na/S 1988 data file represents the 1988 CSPL Na/S cell technology (as demonstrated in the 24-cell, 8-V module), and the Na/S 1989 data file represents the 1989 cell technology (as demonstrated in the 960-cell,

TABLE 2.2 Input Data for Driving Profile Data File

Input Variable	Unit	Comment
Title	-	Limited to 75 characters
Cycle time, TC	s	Including rest time
Rest time, TREST	s	
Second-by-second velocity, VELO(N)	km/h	N=1 to TC-TREST; 400 maximum entries

TABLE 2.3 Input Data for Power Profile Data File

Input Variable	Unit	Comment
Title	-	Limited to 75 characters
Cycle time, TC	s	Including rest time
Rest time, TREST	s	
Cycle range, RC	km	Distance per profile
Second-by-second power demand, DP0(N)	W/kg	N=1 to TC-TREST; 400 maximum entries

64-V one-third battery). Also included in the software package are data files based on 220-A•h Ni/Fe modules (NIF220) made by Eagle-Picher Industries (EPI), 6-V tubular lead-acid modules (3ET205) made by Chloride EV Systems Ltd., and 5-kWh, 48-V zinc/bromine module made by S.E.A., Austria.

TABLE 2.4 Input Data for Battery Data File

Input Variable	Unit	Comment
Title	-	Limited to 75 characters
Net cell weight, WC	kg	With no burden
Accessory weight/cell, WY	kg	
Number of parallel strings in battery, NPS	-	
Cell capacity @ C/3 rate, C3	A·h	
Coefficient, DCOV1	V	Cell cutoff voltage $COV = DCOV1 + DCOV2 \cdot I_{max}$
Coefficient, DCOV2	V/A	I_{max} is cell maximum current
Number of (DOD,Vo) data pairs, MV	-	Cell no-load voltages
Cell (DOD,Vo) data pairs	-,V	see Eq. 2
Number of (DOD,R) data pairs, MR	-	Cell resistances
Cell (DOD,R) data pairs	-, Ω	See Eq. 3
Number of (DOD,Vor) pairs, MVRG	-	Regenerative braking ^a
Cell (DOD,Vor) data pairs	-,V	See Eq. 4
No. of (DOD,Rr) pairs, MRRG	-	Regenerative braking ^a
Cell (DOD,Rr) data pairs	-, Ω	See Eq. 5
Parameter g_1	-	See Eq. 6

^aDummy data must be input even if the data are not used in the case where the braking is not regenerative.

3 Program Operation and Output Information

DIANE 2.1 runs interactively on an IBM-compatible microcomputer. The following describes the step-by-step operation of DIANE 2.1 with graphics capability (DIANE21.EXE). Similar procedures are followed for the version without the graphics capability (DIANENP.EXE).

3.1 Step-by-Step Operation of DIANE Version 2.1

1. Copy the contents of the diskette into a subdirectory on your hard disk and run DIANE 2.1 from the hard disk. If you do not have a hard disk, insert the diskette into drive A and set the default drive to A.
2. Enter DIANE21 to call up the program and for graphics output. If graphics output is not desired, enter DIANENP.
3. You will be asked to specify the output device on which the calculational results are to be displayed or stored. Enter p (for printer), c (for console), or d (for disk). If you choose the disk, you will be asked to provide a name for the output file (the default name DOUT will be used if no file name is given).
4. Upon completion of Step 3, the names of the default data files included in the software package for various vehicles, driving profiles, and battery technologies will be displayed on the screen, as shown below:

*** Select System for Analysis ***		
<u>Vehicle</u>	<u>Driving Profile</u>	<u>Battery</u>
1: DSEP	1: J227aC	1: Na/S 1988
2: IDSEP	2: J227aD	2: Na/S 1989
3: Griffon	3: SFUDS	3: Ni/Fe EPI
4: ETX-II	4: User Input	4: 3ET205 L/A
5: G-Van		5: Zn/Br
6: TEVan		6: User Input
7: IETV-1		
8: Impact		
9: User Input		

You can select a default data file by entering the corresponding number for vehicle, driving profile, and battery technology, respectively. Or, you can use your own data file by entering the number signifying user input, followed by the name of the data file.

5. After you have selected the system for study, you can specify power profile at the battery terminals (W/kg_battery) corresponding to the selected vehicle and driving profile as input instead of being calculated from the velocity profile.
6. Upon completion of Step 5, you can supply a title for identifying the run.
7. Prior to the initiation of a simulation run, certain parameters can be changed interactively. These parameters are shown in the following screen display for sample problem 1 (IETV-1, J227aD, 3ET205):

INDEX	PARAMETER	COMMENT	UNITS	VALUE
*	GVW	Maximum vehicle wt.	kg	1837.600
**	TW	Vehicle test wt.	kg	1678.800
1	BW	Battery wt. w/accessories	kg	488.000
2	WC	Net cell weight	kg	10.930
3	WY	Accessory wt./cell	kg	.000
4	NC	No. of cells in battery	-	44.648
5	NPS	Parallel strings in batt.	-	1.000
6	C3	Cell Ah @ C/3	Ah	186.000
7	PLW	Vehicle payload	kg	158.800
8	DCOV1	cell cutoff voltage comp.1	V	1.300
9	DCOV2	cell cutoff voltage comp.2	V/A	.00000
10	RF	Resist. factor for aging	-	1.000
11	VF	NLV factor for aging	-	1.000
12	IRG	>0: regenerative braking	-	1
13	IPIN	>0: print input data	-	0
14	IPTST	>0: print profile results	-	1
15	IIV	>0: print S-by-S I & V	-	0
16	IACC	>0: accelerate @ max power	-	0

* Input value; TW must not exceed GVW
 ** Value computed from other input data

To change the value of a particular parameter, enter the corresponding index number. Enter 99 to see the updated display. Enter 0 to indicate that no more changes will be made and to instruct the program to start computing. The following statements are applicable to specific parameters:

- Note that the program only checks the test weight (TW) against the maximum vehicle design weight (GVW). You should make sure that the battery does not exceed its volume limitation.
- The cell cutoff voltage is assumed to be of the form $(DCOV1 + DCOV2 \cdot I_{max})$, where I_{max} is the maximum cell current in amperes. When the cell cutoff voltage falls below a user-specified limit, calculation stops.
- The resistance factor, RF, can be used to simulate changes in cell resistance due to battery aging. For a fresh battery, $RF = 1$. This factor applies to both the charging (during regenerative braking) and discharging processes.

- The no-load voltage factor, VF, can similarly be used to account for changes in cell no-load voltage due to aging. For a fresh battery, VF = 1. This factor applies to both the charging (during regenerative braking) and discharging processes.
- If IRG is a nonzero number (any one-digit integer), regenerative braking is considered in the calculation.
- If IPIN is a nonzero number (any one-digit integer), input data for vehicle, driving profile, and battery will be displayed. A second-by-second power profile at the battery terminals, computed on the basis of the input velocity profile and vehicle characteristics, will also be displayed. No velocity profile is displayed if power profile is specified as input.
- If IPTTEST is a nonzero number (any one-digit integer), profile-by-profile calculational data (such as maximum current, minimum voltage, ampere-hours, and kilowatt-hours) will be displayed. Otherwise, an asterisk (*) will be displayed on the screen to signify the completion of a driving profile.
- If IIV is a nonzero number (any one-digit integer), second-by-second currents and voltages of the first and the last driving profiles will be displayed.
- If IACC is a nonzero number (any one-digit integer), the acceleration of a vehicle under the hypothetical case of maximum battery power will be simulated. Second-by-second vehicle speed (up to 80 mph) and distance will be displayed.

To change parameters not on the preceding list, you can modify any default data file included in the software package by using a full-screen text editor. Unless you intend to permanently replace the default data file, be sure to assign a different name to your modified data file.

8. At the beginning of the calculation, a summary output similar to the following will be displayed on the screen:

Vehicle type	IETV-1
Drive cycle	J227aD
Battery type	3ET205
Test wt. of EV, (kg), TW	1678.800
Battery wt., (kg), BW	488.000
Net cell wt., (kg), WC	10.930
Accessory wt./cell, (kg), WY	.000
No. of cells in battery, NC	44.648
No. of parallel strings in batt., NPS	1.000
Cell amp-hours @ C/3, C3	186.000
Peak power demand, (W/kg)	52.586
(kW)	25.662
Battery peak power at 100% SOC (W/kg)	85.438
and 2/3-NLV, (kW)	41.694
Resistance factor for aging, RF	1.000
No-load voltage factor, VF	1.000

- To temporarily halt display on the screen, simultaneously press the Ctrl and S keys; press any key to resume.
 - To interrupt computation and terminate program execution, simultaneously press the Ctrl and Break keys.
9. Computational results similar to the following will be displayed on the screen at the conclusion of a case:

Projected maximum range is 69.912 km (43.451 miles)
Capacity removed is 11.475 kWh or 138.786 Ah
Regeneration capacity is 2.545 kWh or 25.378 Ah

10. If you are using the version with graphics capability (DIANE2.1.EXE), the program will ask if you want to see the profile-by-profile data (maximum current as well as minimum voltage in each driving profile) plotted. If you enter y, the following plotting menu will appear on the screen, which allows you to select the desired plot:

*** Select Variables for Plotting ***

- 0: No plotting; return
- 1: Maximum cell current vs. driving profile #
- 2: Maximum battery current vs. range (km)
- 3: Maximum battery current vs. time (h)
- 4: Minimum cell voltage vs. driving profile #
- 5: Minimum battery voltage vs. range (km)
- 6: Minimum battery voltage vs. time (h)

11. If $IACC = 1$, vehicle speed (up to 80 mph) and distance travelled as a function of time will be computed for the hypothetical case of maximum-power acceleration. No degradation of battery power capability due to depth-of-discharge effect is considered for the calculation.
12. Upon completion of a run, you will be asked if you want to run another case for the same combination of vehicle, driving profile, and battery system. If you enter y (for yes), the interactive screen display shown in Step 7 will reappear, which allows you to change the values of the parameters before another run is made. You can also change the output device and title at this time.
13. If you do not want to make another run for the same system, press any key. You will then be asked if you want to choose another system for study. If you enter y, the program will go to Step 3 to let you select an output device and a new combination (vehicle, driving profile, battery technology) for study.

3.2 Sample Problems

To demonstrate the use of DIANE 2.1, three sample problems (listed in Table 3.1), are included in the software package. Appendix E shows the output of the sample problems.

TABLE 3.1 Sample Problems

File Name	System Studied
SAMPLE-1	IETV-1/J227aD/3ET205
SAMPLE-2	Same as SAMPLE-1, except power profile is input
SAMPLE-3	Same as SAMPLE-1, except RF = 1.1, IPIN = 0, and IACC = 0

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Appendix A:
Calculation of Power Requirement

Appendix A: Calculation of Power Requirement

Power requirement at the battery terminals can be calculated from a specified velocity profile, provided that the vehicle characteristics (test weight, frontal area, drag coefficient, rolling resistance coefficients, the drivetrain efficiency, and the grade of the road) are given.

The instantaneous road-load power is calculated from the required force, which overcomes the drag force, the rolling resistance, and the grading effects while, at the same time, maintaining the vehicle at the specified speed. The equations for velocity, force, and power are given below.

The instantaneous speed of the vehicle at time t in any linear driving period can be expressed as:

$$V = V_1 + a\Delta t \quad (A.1)$$

where:

- a = acceleration or deceleration
= $(V_2 - V_1)/(t_2 - t_1)$;
- V_1, V_2 = the speed at time t_1 and t_2 , respectively;
- Δt = $t - t_1$;
- t = time;
- t_1 = the time at the beginning of the period; and
- t_2 = the time at the end of the period.

The distance at time t is given by:

$$S = S_1 + v_1\Delta t + \frac{a}{2}(\Delta t)^2 \quad (A.2)$$

where S_1 is the distance at time t_1 .

As shown in Fig. A.1, the total required driving force, F_T , is given by:

$$F_T = F_D + F_R + F_G + F_A \quad (A.3)$$

with the air-drag force,

$$F_D = \frac{1}{2}\rho C_D A_F V^2 \quad (A.4)$$

the rolling resistance force,

$$F_R = W_T \cos \theta (K_0 + K_1 V + K_2 V^2) \quad (A.5)$$

the force due to grade,

$$F_G = W_T \sin \theta \quad (\text{A.6})$$

and the acceleration force,

$$F_A = \frac{W_T}{g} a \quad (\text{A.7})$$

where:

- W_T = vehicle weight;
- g = gravitational acceleration;
- θ = grading angle, $\tan^{-1}(\% \text{ grade}/100)$;
- K_0, K_1, K_2 = rolling resistance coefficients;
- A_F = vehicle frontal area;
- ρ = air density; and
- C_D = drag coefficient.

The power at the wheels, P_{wh} , is given by:

$$P_{wh} = VF_T \quad (\text{A.8})$$

and the power required at the battery terminals is:

$$P_B = \frac{P_{wh}}{\eta_D \eta_M} \quad (\text{A.9})$$

where η_D and η_M are efficiencies of the transmission and the motor, respectively.

FIGURE A.1 Schematic Diagram of Forces Acting on a Vehicle

Appendix B:
Default Vehicle Data Files

TABLE B.1 Default Vehicle Data Set for the Eaton Dual-Shaft Electric Propulsion Van (DSEP)

Default vehicle dataset for DSEP

curb wt. w/o battery (kg), cwnb =	.129300E+04
battery wt. w/accessories, (kg), bw =	.700000E+03
drivetrain eff. (fraction), effd =	.819000E+00
motor eff. (fraction), effm =	.900000E+00
rolling res. coeff., (--), k0 =	.100000E-01
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.346000E+01
drag coeff., (--), cd =	.370000E+00
grade, (%), grade =	.000000E+00
payload (kg), pLw =	.232000E+03
gross vehicle weight, (kg), GVW =	.245700E+04
controller current limit, (A), DCOI =	.400000E+03

TABLE B.2 Default Vehicle Data Set for the Improved Dual-Shaft Electric Propulsion Van (IDSEP)

Default vehicle dataset for IDSEP

curb wt. w/o battery (kg), cwnb =	.142900E+04
battery wt. w/accessories, (kg), bw =	.695000E+03
drivetrain eff. (fraction), effd =	.752600E+00
motor eff. (fraction), effm =	.900000E+00
rolling res. coeff., (--), k0 =	.800000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.297000E+01
drag coeff., (--), cd =	.370000E+00
grade, (%), grade =	.000000E+00
payload (kg), pLw =	.273000E+03
gross vehicle weight, (kg), GVW =	.267000E+04
controller current limit, (A), DCOI =	.600000E+04

TABLE B.3 Default Vehicle Data Set for the Griffon Electric Van

Default vehicle dataset for Griffon

curb wt. w/o battery (kg), cwnb =	.150200E+04
battery wt. w/accessories, (kg), bw =	.113600E+04
drivetrain eff. (fraction), effd =	.750000E+00
motor eff. (fraction), effm =	.900000E+00
rolling res. coeff., (--), k0 =	.830000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.246000E+01
drag coeff., (--), cd =	.370000E+00
grade, (%), grade =	.000000E+00
payload (kg), pLw =	.431000E+03
gross vehicle weight, (kg), GVW =	.350000E+04
controller current limit, (A), DCOI =	.300000E+03

TABLE B.4 Default Vehicle Data Set for the Second-Generation Single-Shaft Electric Propulsion System (ETX-II)

Default vehicle dataset for ETX-II

curb wt. w/o battery (kg), cwnb =	.129800E+04
battery wt. w/accessories, (kg), bw =	.500000E+03
drivetrain eff. (fraction), effd =	.819000E+00
motor eff. (fraction), effm =	.900000E+00
rolling res. coeff., (--), k0 =	.100000E-01
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.295000E+01
drag coeff., (--), cd =	.370000E+00
grade, (%), grade =	.000000E+00
payload (kg), pLw =	.258000E+03
gross vehicle weight, (kg), GVW =	.231400E+04
controller current limit, (A), DCOI =	.480000E+03

TABLE B.5 Default Vehicle Data Set for the G-Van

Default Vehicle Datafile for G-VAN

curb wt. w/o batt. (kg), cwnb =	.200900E+04
battery wt. w/accessories, (kg), bw =	.115500E+04
drivetrain eff. (fraction), effd =	.794000E+00
motor eff. (fraction), effm =	.900000E+00
rolling res. coeff., (--), k0 =	.100000E-01
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.437000E+01
drag coeff., (--), cd =	.370000E+00
grade, (%), grade =	.000000E+00
payload (kg), pLw =	.409000E+03
gross vehicle weight, (kg), GVW =	.398200E+04
controller current limit, (A), DCOI =	.300000E+03

TABLE B.6 Default Vehicle Data Set for the TEVan

Default vehicle dataset for TEVan

curb wt. w/o battery (kg), cwnb =	.124600E+04
battery wt. w/accessories, (kg), bw =	.700000E+03
drivetrain eff. (fraction), effd =	.950000E+00
motor eff. (fraction), effm =	.900000E+00
rolling res. coeff., (--), k0 =	.830000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.246000E+01
drag coeff., (--), cd =	.370000E+00
grade, (%), grade =	.000000E+00
payload (kg), pLw =	.273000E+03
gross vehicle weight, (kg), GVW =	.249200E+04
controller current limit, (A), DCOI =	.300000E+03

TABLE B.7 Default Vehicle Data Set for the Improved Electric Test Vehicle (IETV-1)

Default vehicle dataset for IETV-1

curb wt. w/o battery (kg), cwnb =	.103200E+04
battery wt. w/accessories, (kg), bw =	.488000E+03
drivetrain eff. (fraction), effd =	.870000E+00
motor eff. (fraction), effm =	.900000E+00
rolling res. coeff., (--), k0 =	.900000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.174000E+01
drag coeff., (--), cd =	.310000E+00
grade, (%), grade =	.000000E+00
payload (kg), pLw =	.158800E+03
gross vehicle weight, (kg), GVW =	.183760E+04
controller current limit, (A), DCOI =	.600000E+03

TABLE B.8 Default Vehicle Data Set for the Impact

Default Vehicle Data File for IMPACT

curb wt. w/o batt. (kg), cwnb =	.603000E+03
battery wt. w/accessories, (kg), bw =	.397000E+03
drivetrain eff. (fraction), effd =	.840000E+00
motor eff. (fraction), effm =	.900000E+00
rolling res. coeff., (--), k0 =	.480000E-02
rolling res. coeff., (s/m), k1 =	.000000E+00
rolling res. coeff., (s**2/m**2), k2 =	.000000E+00
frontal area, (m**2), farea =	.290000E+01
drag coeff., (--), cd =	.190000E+00
grade, (%), grade =	.000000E+00
payload (kg), pLw =	.780000E+02
gross vehicle weight, (kg), GVW =	.115650E+04
controller current limit, (A), DCOI =	.300000E+03

Appendix C:

Default Driving Profile Data Files

TABLE C.3 Simplified Federal Urban Driving Schedule (SFUDS), Velocity Slightly Changed

Simplified FUDS (SFUDS) with velocity slightly changed
 cycle time including rest, (s), TC= 360
 rest time at end of cycle, (s), TREST = 0
 s-by-s velocity, (km/h), for TC-TREST s

.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.240000E+01	.480000E+01	.720000E+01	.970000E+01
.111000E+02	.122000E+02	.134000E+02	.146000E+02	.158000E+02
.169000E+02	.179000E+02	.187000E+02	.195000E+02	.201000E+02
.208000E+02	.214000E+02	.220000E+02	.227000E+02	.233000E+02
.240000E+02	.245000E+02	.249000E+02	.256000E+02	.261000E+02
.275000E+02	.290000E+02	.303000E+02	.315000E+02	.328000E+02
.340000E+02	.351000E+02	.360000E+02	.370000E+02	.378000E+02
.388000E+02	.396000E+02	.378000E+02	.359000E+02	.341000E+02
.320000E+02	.301000E+02	.277000E+02	.253000E+02	.227000E+02
.171000E+02	.114000E+02	.580000E+01	.200000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.240000E+01	.480000E+01	.720000E+01	.970000E+01
.111000E+02	.122000E+02	.134000E+02	.146000E+02	.158000E+02
.169000E+02	.179000E+02	.187000E+02	.195000E+02	.201000E+02
.208000E+02	.214000E+02	.220000E+02	.227000E+02	.233000E+02
.240000E+02	.245000E+02	.249000E+02	.256000E+02	.261000E+02
.275000E+02	.290000E+02	.303000E+02	.315000E+02	.328000E+02
.340000E+02	.351000E+02	.360000E+02	.370000E+02	.378000E+02
.388000E+02	.396000E+02	.378000E+02	.359000E+02	.341000E+02
.320000E+02	.301000E+02	.277000E+02	.253000E+02	.227000E+02
.171000E+02	.114000E+02	.580000E+01	.200000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.240000E+01	.480000E+01	.720000E+01	.970000E+01
.111000E+02	.122000E+02	.134000E+02	.146000E+02	.158000E+02
.169000E+02	.179000E+02	.187000E+02	.195000E+02	.201000E+02
.208000E+02	.214000E+02	.220000E+02	.227000E+02	.233000E+02
.240000E+02	.245000E+02	.249000E+02	.256000E+02	.261000E+02
.275000E+02	.290000E+02	.303000E+02	.315000E+02	.328000E+02
.340000E+02	.351000E+02	.360000E+02	.370000E+02	.378000E+02
.388000E+02	.396000E+02	.378000E+02	.359000E+02	.341000E+02
.320000E+02	.301000E+02	.277000E+02	.253000E+02	.227000E+02
.171000E+02	.114000E+02	.580000E+01	.200000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.240000E+01	.480000E+01	.720000E+01	.970000E+01
.111000E+02	.122000E+02	.134000E+02	.146000E+02	.158000E+02
.169000E+02	.179000E+02	.187000E+02	.195000E+02	.201000E+02
.208000E+02	.214000E+02	.220000E+02	.227000E+02	.233000E+02
.240000E+02	.245000E+02	.249000E+02	.256000E+02	.261000E+02

TABLE C.3 (Cont'd)

.266000E+02	.270000E+02	.274000E+02	.278000E+02	.283000E+02
.288000E+02	.293000E+02	.296000E+02	.301000E+02	.304000E+02
.309000E+02	.312000E+02	.362000E+02	.407000E+02	.447000E+02
.483000E+02	.513000E+02	.543000E+02	.571000E+02	.597000E+02
.621000E+02	.644000E+02	.666000E+02	.681000E+02	.695000E+02
.708000E+02	.721000E+02	.732000E+02	.744000E+02	.755000E+02
.766000E+02	.777000E+02	.787000E+02	.797000E+02	.806000E+02
.814000E+02	.824000E+02	.832000E+02	.840000E+02	.848000E+02
.855000E+02	.863000E+02	.869000E+02	.875000E+02	.861000E+02
.847000E+02	.832000E+02	.818000E+02	.803000E+02	.789000E+02
.774000E+02	.760000E+02	.745000E+02	.731000E+02	.718000E+02
.703000E+02	.689000E+02	.676000E+02	.663000E+02	.649000E+02
.650000E+02	.653000E+02	.655000E+02	.657000E+02	.660000E+02
.661000E+02	.663000E+02	.665000E+02	.668000E+02	.669000E+02
.671000E+02	.673000E+02	.674000E+02	.676000E+02	.678000E+02
.679000E+02	.681000E+02	.682000E+02	.684000E+02	.686000E+02
.687000E+02	.689000E+02	.689000E+02	.690000E+02	.692000E+02
.694000E+02	.695000E+02	.695000E+02	.697000E+02	.698000E+02
.698000E+02	.700000E+02	.687000E+02	.673000E+02	.660000E+02
.645000E+02	.632000E+02	.618000E+02	.604000E+02	.591000E+02
.576000E+02	.562000E+02	.547000E+02	.533000E+02	.518000E+02
.502000E+02	.488000E+02	.472000E+02	.457000E+02	.441000E+02
.423000E+02	.406000E+02	.388000E+02	.370000E+02	.352000E+02
.333000E+02	.312000E+02	.291000E+02	.267000E+02	.243000E+02
.216000E+02	.182000E+02	.142000E+02	.930000E+01	.450000E+01
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00

TABLE C.4 Power Profile (W/kg-batt) at Battery Terminals for J227aD and the Improved Electric Test Vehicle (IETV-1/J227aD)

```
Power profile (W/kg_batt) at battery terminals for IETV-1/J227aD
cycle time including rest (s), TC=                122
rest time at end of cycle (s), TREST =             25
driving distance in a cycle (km), RC =          .159000E+01
s-by-s power, (W/kg), for TC-TREST s
.620000E+01    .124000E+02    .186200E+02    .248700E+02    .311500E+02
.373700E+02    .414600E+02    .445400E+02    .468300E+02    .489500E+02
.501700E+02    .511200E+02    .518900E+02    .525900E+02    .521600E+02
.518800E+02    .514500E+02    .509300E+02    .499100E+02    .488300E+02
.470500E+02    .459200E+02    .446100E+02    .421600E+02    .409500E+02
.383800E+02    .368700E+02    .355000E+02    .153800E+02    .153800E+02
.153800E+02    .153800E+02    .153800E+02    .153800E+02    .153800E+02
.153800E+02    .153800E+02    .153800E+02    .153800E+02    .153800E+02
.153800E+02    .153800E+02    .153800E+02    .153800E+02    .153800E+02
.153800E+02    .153800E+02    .153800E+02    .153800E+02    .153800E+02
.153800E+02    .153800E+02    .153800E+02    .153800E+02    .153800E+02
.153800E+02    .153800E+02    .153800E+02    .153800E+02    .153800E+02
.153800E+02    .153800E+02    .153800E+02    .153800E+02    .153800E+02
.153800E+02    .153800E+02    .153800E+02    .153800E+02    .153800E+02
.153800E+02    .153800E+02    .153800E+02    .153800E+02    .153800E+02
.153800E+02    .153800E+02    .153800E+02    .153800E+02    .153800E+02
.153800E+02    .153800E+02    .153800E+02    .153800E+02    .153800E+02
-.142400E+02   -.125900E+02   -.111400E+02   -.949000E+01   -.815000E+01
-.535000E+02   -.487800E+02   -.443700E+02   -.396500E+02   -.348000E+02
-.300100E+02   -.250900E+02   -.200600E+02   -.151400E+02   -.101200E+02
-.504000E+01    .000000E+00
```

TABLE C.5 Power Profile at Battery Terminals for the Simplified Federal Urban Driving Schedule and the Improved Dual-Shaft Electric Propulsion Van (BW=695 kg)

Power profile at battery terminals for SFUDS/IDSEP(BW=695 kg)				
cycle time including rest, (s), TC=			360	
rest time at end of cycle, (s), TREST =			0	
driving distance in a cycle (km), RC =			.310000E+01	
s-by-s power, (W/kg_batt), for TC-TREST s				
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.200000E+02	.200000E+02	.200000E+02	.200000E+02	.200000E+02
.200000E+02	.200000E+02	.200000E+02	.200000E+02	.200000E+02
.200000E+02	.200000E+02	-.100000E+02	-.100000E+02	-.100000E+02
-.100000E+02	-.100000E+02	-.100000E+02	-.100000E+02	-.100000E+02
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.200000E+02	.200000E+02	.200000E+02	.200000E+02	.200000E+02
.200000E+02	.200000E+02	.200000E+02	.200000E+02	.200000E+02
.200000E+02	.200000E+02	-.100000E+02	-.100000E+02	-.100000E+02
-.100000E+02	-.100000E+02	-.100000E+02	-.100000E+02	-.100000E+02
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.200000E+02	.200000E+02	.200000E+02	.200000E+02	.200000E+02
.200000E+02	.200000E+02	.200000E+02	.200000E+02	.200000E+02
.200000E+02	.200000E+02	-.100000E+02	-.100000E+02	-.100000E+02
-.100000E+02	-.100000E+02	-.100000E+02	-.100000E+02	-.100000E+02
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.200000E+02	.200000E+02	.200000E+02	.200000E+02	.200000E+02
.200000E+02	.200000E+02	.200000E+02	.200000E+02	.200000E+02
.200000E+02	.200000E+02	-.100000E+02	-.100000E+02	-.100000E+02
-.100000E+02	-.100000E+02	-.100000E+02	-.100000E+02	-.100000E+02
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
.000000E+00	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02
.100000E+02	.100000E+02	.100000E+02	.100000E+02	.100000E+02

TABLE C.5 (Cont'd)

[illegible]

Appendix D:
Default Battery Data Files

TABLE D.1 Default Data Set for Sodium/Sulfur Batteries, 1988 Technology

Na/S battery - 1988 Technology: CSPL 24-cell module		
wt. of a battery cell, (kg), WC=		.120000E+00
accessory wt./cell, (kg), WY=		.600000E-01
no. of parallell strings, NPS=		.300000E+02
cell amp-hours @ C/3, C3=		.833000E+01
cell cutoff voltage comp.1, DCOV1=		.190000E+01
cell cutoff voltage comp.2, DCOV2=	-	.397500E-01
no. of (DOD,NLV) data pairs=		9
.000	2.050	
.050	2.070	
.100	2.080	
.400	2.080	
.500	2.070	
.600	2.068	
.700	2.055	
.800	2.035	
1.000	1.935	
no. of (DOD,R) data pairs=		8
.000	.495E-01	
.050	.383E-01	
.100	.371E-01	
.200	.371E-01	
.400	.383E-01	
.600	.404E-01	
.900	.457E-01	
1.000	.468E-01	
Regen (DOD,NLV) data pairs=		5
.000	2.080	
.250	2.070	
.500	2.060	
.750	2.050	
1.000	1.950	
Regen (DOD,R) data pairs=		5
.000	.360E-01	
.250	.370E-01	
.500	.370E-01	
.750	.380E-01	
1.000	.780E-01	
battery parameter, G1=		.000000E-00

TABLE D.2 Default Data Set for Sodium/Sulfur Batteries, 1989 Technology

Na/S batteries - 1989 Technology: CSPL 960-cell, 1/3-battery		
wt. of a battery cell, (kg), WC=		.126000E+00
accessory wt./cell, (kg), WY=		.116000E+00
no. of parallel strings, NPS=		.300000E+02
cell amp-hours @ C/3, C3=		.103000E+02
cell cutoff voltage comp.1, DCOV1=		.190000E+01
cell cutoff voltage comp.2, DCOV2=	-	.397500E-01
no. of (DOD,NLV) data pairs=		9
.000	2.053	
.050	2.069	
.100	2.075	
.400	2.075	
.500	2.072	
.600	2.066	
.700	2.056	
.800	2.038	
1.000	1.944	
no. of (DOD,R) data pairs=		8
.000	.491E-01	
.050	.431E-01	
.100	.413E-01	
.200	.408E-01	
.400	.408E-01	
.600	.422E-01	
.900	.422E-01	
1.000	.422E-01	
Regen (DOD,NLV) data pairs=		5
.000	2.080	
.250	2.070	
.500	2.060	
.750	2.050	
1.000	1.950	
Regen (DOD,R) data pairs=		5
.000	.360E-01	
.250	.370E-01	
.500	.370E-01	
.750	.380E-01	
1.000	.780E-01	
battery parameter, G1=		.000000E-00

TABLE D.3 Default Data Set for Nickel/Iron NIF220 Batteries

Default battery dataset for Ni/Fe NIF220 Batteries		
wt. of a battery cell, (kg), WC=		.500000E+01
accessory wt./cell, (kg), WY=		.000000E+00
no. of paralell strings, NPS=		.100000E+01
cell amp-hours @ C/3, C3=		.220000E+03
cell cutoff voltage comp.1, DCOV1=		.900000E+00
cell cutoff voltage comp.2, DCOV2=		.000000E+00
no. of (DOD,NLV) data pairs=		9
	.000	1.380
	.050	1.352
	.100	1.340
	.200	1.326
	.500	1.296
	.800	1.240
	.900	1.216
	.950	1.200
	1.000	1.164
no. of (DOD,R) data pairs=		7
	.000	.800E-03
	.100	.840E-03
	.500	.860E-03
	.700	.890E-03
	.800	.940E-03
	.900	.110E-02
	1.000	.150E-02
Regen (DOD,NLV) data pairs=		9
	.000	1.480
	.125	1.430
	.250	1.410
	.375	1.396
	.500	1.384
	.625	1.360
	.750	1.336
	.875	1.300
	1.000	1.260
Regen (DOD,R) data pairs=		9
	.000	.480E-03
	.125	.750E-03
	.250	.800E-03
	.375	.760E-03
	.500	.710E-03
	.625	.770E-03
	.750	.860E-03
	.875	.102E-02
	1.000	.125E-02
battery parameter, G1=		.000000E-00

TABLE D.4 Default Data Set for Tubular L/A 3ET205 Batteries

Default battery dataset for Tubular L/A 3ET205 Batteries

wt. of a battery cell, (kg), WC=	.109300E+02	
accessory wt./cell, (kg), WY=	.000000E+00	
no. of parallell strings, NPS=	.100000E+01	
cell amp-hours @ C/3, C3=	.186000E+03	
cell cutoff voltage comp.1, DCOV1=	.130000E+01	
cell cutoff voltage comp.2, DCOV2=	.000000E+00	
no. of (DOD,NLV) data pairs=		7
.000	2.150	
.050	2.150	
.400	2.090	
.700	2.020	
.800	2.000	
.900	1.960	
1.000	1.890	
no. of (DOD,R) data pairs=		8
.000	.110E-02	
.050	.933E-03	
.300	.917E-03	
.400	.933E-03	
.600	.103E-02	
.800	.123E-02	
.900	.143E-02	
1.000	.233E-02	
Regen (DOD,NLV) data pairs=		6
.000	2.450	
.125	2.150	
.250	2.133	
.500	2.083	
.750	2.033	
1.000	1.983	
Regen (DOD,R) data pairs=		6
.000	.100E-02	
.125	.940E-03	
.250	.910E-03	
.500	.880E-03	
.750	.860E-03	
1.000	.102E-02	
battery parameter, G1=		.140000E-00

TABLE D.5 Default Data Set for Zinc/Bromine Batteries

DIANE21 dataset for 48-V, 5-kWh S.E.A. Zn/Br Battery

wt. of a battery cell, (kg), WC=	.253100E+01	
battery accessory wt. (kg), WY=	.000000E+00	
no. of parallell strings, NPS=	.100000E+01	
modular amp-hours @ C/3, C3=	.121000E+03	
cell cutoff voltage comp.1, DCOV1=	.844000E+00	
cell cutoff voltage comp.2, DCOV2=	.000000E+00	
no. of (DOD,OCV) data pairs=		9
.000	1.828	
.080	1.800	
.170	1.778	
.250	1.759	
.330	1.747	
.410	1.734	
.500	1.725	
.580	1.716	
.660	1.706	
no. of (DOD,R) data pairs=		9
.000	.469E-02	
.080	.444E-02	
.170	.438E-02	
.250	.431E-02	
.330	.444E-02	
.410	.456E-02	
.500	.481E-02	
.580	.506E-02	
.660	.547E-02	
no. of (DOD,NLV) data pairs=		2
.000	1.900	
.900	1.900	
no. of (DOD,R) data pairs=		2
.000	.469E-02	
.900	.469E-03	
battery parameter, G1=		.000000E-00

Appendix E:
Sample Problems

SAMPLE 1: IETV-1/J227aD/3ET205 System with Regenerative Braking

SAMPLE-1: IETV-1/J227aD/3ET205 System with Regenerative Braking

Default vehicle dataset for IETV-1

curb wt. w/o battery (kg), cwnb =	1032.000
battery wt. w/accessories, (kg), bw =	488.000
drivetrain eff. (fraction), effd =	.870
motor eff. (fraction), effm =	.900
rolling res. coeff., (--), k0 =	.009
rolling res. coeff., (s/m), k1 =	.000
rolling res. coeff., (s**2/m**2), k2 =	.000
frontal area, (m**2), farea =	1.740
drag coeff., (--), cd =	.310
grade, (%), grade =	.000
payload (kg), pLw =	158.800
gross vehicle weight, (kg), GVW =	1837.600
controller current limit, (A), DCOI =	600.000

SAE J227AD (JPL-Standardized) DRIVING PROFILE

cycle time including rest, (s), TC=	122
rest time at end of cycle, (s), TREST =	25
s-by-s velocity, (km/h), for TC-TREST s	
4.12 8.24 12.36 16.48 20.60 24.71 28.62 32.31	
35.78 39.07 42.16 45.07 47.82 50.43 52.86 55.14	
57.28 59.29 61.16 62.90 64.49 65.97 67.34 68.56	
69.69 70.68 71.58 72.40 72.40 72.40 72.40 72.40	
72.40 72.40 72.40 72.40 72.40 72.40 72.40 72.40	
72.40 72.40 72.40 72.40 72.40 72.40 72.40 72.40	
72.40 72.40 72.40 72.40 72.40 72.40 72.40 72.40	
72.40 72.40 72.40 72.40 72.40 72.40 72.40 72.40	
72.40 72.40 72.40 72.40 72.40 72.40 70.04 68.11	
66.50 65.00 63.60 62.32 61.14 56.04 50.96 45.86	
40.76 35.67 30.57 25.47 20.39 15.29 10.18 5.10	
.00	

Power profile (W/kg) at battery terminals:

6.20 12.40 18.62 24.87 31.15 37.37 41.46 44.54
46.83 48.95 50.17 51.12 51.89 52.59 52.16 51.88
51.45 50.93 49.91 48.83 47.05 45.92 44.61 42.16
40.95 38.38 36.87 35.50 15.38 15.38 15.38 15.38
15.38 15.38 15.38 15.38 15.38 15.38 15.38 15.38
15.38 15.38 15.38 15.38 15.38 15.38 15.38 15.38
15.38 15.38 15.38 15.38 15.38 15.38 15.38 15.38
15.38 15.38 15.38 15.38 15.38 15.38 15.38 15.38
15.38 15.38 15.38 15.38 15.38 15.38 -25.50 -18.93
-14.24 -12.59 -11.14 -9.49 -8.15 -53.50 -48.78 -44.37
-39.65 -34.80 -30.01 -25.09 -20.06 -15.14 -10.12 -5.04
.00
km/cycle = 1.59

SAMPLE 1: IETV-1/J227aD/E3T205 System with Regenerative Braking (Cont'd)

Default battery dataset for Tubular L/A 3ET205 Batteries

wt. of a battery cell, (kg), WC=	10.930
accessory wt./cell, (kg), WY=	.000
no. of paralell strings, NFS=	1.000
cell amp-hours @ C/3, C3=	186.000
cell cutoff voltage comp.1,DCOV1=	1.300
cell cutoff voltage comp.2,DCOV2=	.000
no. of (DOD,NLV) data pairs=	7
.000	2.150
.050	2.150
.400	2.090
.700	2.020
.800	2.000
.900	1.960
1.000	1.890
no. of (DOD,R) data pairs=	8
.000	.00110
.050	.00093
.300	.00092
.400	.00093
.600	.00103
.800	.00123
.900	.00143
1.000	.00233
Regen (DOD,NLV) data pairs=	6
.000	2.450
.125	2.150
.250	2.133
.500	2.083
.750	2.033
1.000	1.983
Regen (DOD,R) data pairs=	6
.000	.00100
.125	.00094
.250	.00091
.500	.00088
.750	.00086
1.000	.00102
battery parameter, G1=	.140

SAMPLE 1: IETV-1/J227aD/E3T205 System with Regenerative Braking (Cont'd)

Vehicle type	IETV-1
Drive cycle	J227aD
Battery type	3ET205
Test wt. of EV, (kg), TW	1678.800
Battery wt., (kg), BW	488.000
Net cell wt., (kg), WC	10.930
Accessory wt./cell, (kg), WY	.000
No. of cells in battery, NC	44.648
No. of parallel strings in batt., NPS	1.000
Cell amp-hours @ C/3, C3	186.000
Peak power demand, (W/kg)	52.586
(kW)	25.662
Battery peak power at 100% SOC (W/kg) ...	85.438
and 2/3-NLV, (kW)	41.694
Resistance factor for aging, RF	1.000
No-load voltage factor, VF	1.000

Driving Profile	Time h	Range km	Maximum I		Minimum V		Amp-Hour		kWh Batt
			Cell	Batt	Cell	Batt	Cell	Batt	
1	.03	1.6	318.2	318.2	1.806	80.6	3.0	3.0	.3
2	.07	3.2	313.9	313.9	1.831	81.8	6.0	6.0	.5
3	.10	4.8	309.8	309.8	1.855	82.8	9.0	9.0	.8
4	.14	6.4	309.1	309.1	1.860	83.0	11.9	11.9	1.0
5	.17	7.9	309.7	309.7	1.856	82.9	14.9	14.9	1.3
6	.20	9.5	310.2	310.2	1.853	82.7	17.9	17.9	1.6
7	.24	11.1	310.8	310.8	1.849	82.6	20.9	20.9	1.8
8	.27	12.7	311.4	311.4	1.846	82.4	23.9	23.9	2.1
9	.31	14.3	312.0	312.0	1.842	82.3	26.9	26.9	2.3
10	.34	15.9	312.6	312.6	1.839	82.1	29.9	29.9	2.6
11	.37	17.5	313.2	313.2	1.835	81.9	32.9	32.9	2.9
12	.41	19.1	313.8	313.8	1.832	81.8	35.9	35.9	3.1
13	.44	20.7	314.4	314.4	1.828	81.6	38.9	38.9	3.4
14	.47	22.2	315.0	315.0	1.825	81.5	41.9	41.9	3.7
15	.51	23.8	315.6	315.6	1.821	81.3	44.9	44.9	3.9
16	.54	25.4	316.2	316.2	1.818	81.2	48.0	48.0	4.2
17	.58	27.0	317.0	317.0	1.813	80.9	51.0	51.0	4.4
18	.61	28.6	318.0	318.0	1.808	80.7	54.0	54.0	4.7
19	.64	30.2	318.9	318.9	1.802	80.5	57.1	57.1	5.0
20	.68	31.8	319.8	319.8	1.797	80.2	60.2	60.2	5.2
21	.71	33.4	320.8	320.8	1.792	80.0	63.2	63.2	5.5
22	.75	35.0	322.3	322.3	1.783	79.6	66.3	66.3	5.7
23	.78	36.5	324.0	324.0	1.774	79.2	69.4	69.4	6.0
24	.81	38.1	325.8	325.8	1.764	78.8	72.5	72.5	6.3
25	.85	39.7	327.6	327.6	1.755	78.3	75.6	75.6	6.5
26	.88	41.3	329.4	329.4	1.745	77.9	78.8	78.8	6.8
27	.92	42.9	331.3	331.3	1.735	77.4	81.9	81.9	7.0
28	.95	44.5	333.3	333.3	1.724	77.0	85.1	85.1	7.3
29	.98	46.1	335.3	335.3	1.714	76.5	88.2	88.2	7.6
30	1.02	47.7	337.4	337.4	1.704	76.1	91.4	91.4	7.8
31	1.05	49.3	339.5	339.5	1.693	75.6	94.6	94.6	8.1

SAMPLE 1: IETV-1/J227aD/E3T205 System with Regenerative Braking (Cont'd)

32	1.08	50.8	342.7	342.7	1.677	74.9	97.8	97.8	8.3
33	1.12	52.4	346.0	346.0	1.661	74.2	101.1	101.1	8.6
34	1.15	54.0	349.5	349.5	1.645	73.4	104.3	104.3	8.9
35	1.19	55.6	353.1	353.1	1.628	72.7	107.6	107.6	9.1
36	1.22	57.2	356.8	356.8	1.611	71.9	110.9	110.9	9.4
37	1.25	58.8	360.7	360.7	1.594	71.2	114.3	114.3	9.6
38	1.29	60.4	364.7	364.7	1.576	70.4	117.6	117.6	9.9
39	1.32	62.0	369.0	369.0	1.558	69.6	121.0	121.0	10.2
40	1.36	63.6	374.1	374.1	1.536	68.6	124.4	124.4	10.4
41	1.39	65.1	384.2	384.2	1.496	66.8	127.9	127.9	10.7
42	1.42	66.7	396.0	396.0	1.452	64.8	131.4	131.4	11.0
43	1.46	68.3	410.0	410.0	1.402	62.6	135.0	135.0	11.2
44	1.49	69.9	433.8	433.8	1.320	58.9	138.8	138.8	11.5
Driving Profile	Time h	Range km	Maximum I		Minimum V		Amp-Hour		kWh
			Cell	Batt	Cell	Batt	Cell	Batt	Batt

Cell voltage of first driving profile:

2.115	2.078	2.040	2.001	1.959	1.916	1.887	1.864
1.847	1.832	1.823	1.816	1.811	1.806	1.810	1.814
1.818	1.823	1.832	1.841	1.855	1.864	1.874	1.892
1.901	1.920	1.930	1.940	2.064	2.064	2.064	2.065
2.065	2.065	2.065	2.065	2.065	2.065	2.065	2.065
2.065	2.065	2.065	2.065	2.065	2.065	2.065	2.065
2.065	2.065	2.065	2.065	2.065	2.065	2.065	2.065
2.065	2.065	2.066	2.066	2.066	2.066	2.066	2.066
2.066	2.066	2.066	2.066	2.066	2.066	2.066	2.066
2.066	2.066	2.066	2.066	2.066	2.066	2.509	2.482
2.462	2.455	2.449	2.442	2.436	2.621	2.603	2.587
2.568	2.549	2.530	2.510	2.490	2.469	2.447	2.425
2.150							

Cell current of first driving profile:

32.022	65.213	99.751	135.849	173.761	213.157	240.179	261.157
277.070	292.088	300.867	307.650	313.201	318.240	314.906	312.659
309.344	305.322	297.776	289.903	277.190	269.263	260.160	243.531
235.410	218.519	208.765	200.030	81.449	81.448	81.447	81.445
81.444	81.442	81.441	81.440	81.438	81.437	81.435	81.434
81.432	81.431	81.430	81.428	81.427	81.425	81.424	81.422
81.421	81.420	81.418	81.417	81.415	81.414	81.413	81.411
81.410	81.408	81.407	81.405	81.404	81.403	81.401	81.400
81.398	81.397	81.395	81.394	81.393	81.391	81.390	81.388
81.387	81.386	81.384	81.383	81.381	81.380	-111.057	-83.371
-63.218	-56.055	-49.716	-42.456	-36.543	-223.094	-204.796	-187.478
-168.751	-149.194	-129.647	-109.263	-88.083	-67.035	-45.190	-22.725
.000							

SAMPLE 1: IETV-1/J227aD/E3T205 System with Regenerative Braking (Cont'd)

Cell voltage of last driving profile:

1.912	1.858	1.801	1.740	1.672	1.598	1.543	1.498
1.461	1.424	1.400	1.374	1.350	1.325	1.324	1.320
1.320	1.323	1.337	1.353	1.383	1.400	1.420	1.459
1.477	1.515	1.536	1.555	1.800	1.800	1.800	1.800
1.799	1.799	1.799	1.799	1.798	1.798	1.798	1.798
1.797	1.797	1.797	1.796	1.796	1.796	1.796	1.795
1.795	1.795	1.795	1.794	1.794	1.794	1.794	1.793
1.793	1.793	1.793	1.792	1.792	1.792	1.792	1.791
1.791	1.791	1.791	1.790	1.790	1.790	1.790	1.789
1.789	1.789	1.789	1.788	1.788	1.788	2.125	2.094
2.071	2.063	2.056	2.047	2.041	2.251	2.230	2.211
2.190	2.169	2.147	2.124	2.100	2.076	2.051	2.025
1.944							

Cell current of last driving profile:

35.425	72.931	112.982	156.218	203.566	255.594	293.631	325.020
350.335	375.739	391.756	406.512	420.097	433.820	430.532	429.437
425.946	420.776	407.950	394.490	371.724	358.593	343.491	315.756
303.129	276.780	262.275	249.558	93.401	93.414	93.427	93.440
93.453	93.466	93.479	93.492	93.505	93.518	93.531	93.545
93.558	93.571	93.584	93.597	93.610	93.623	93.636	93.650
93.663	93.676	93.689	93.702	93.716	93.729	93.742	93.755
93.768	93.782	93.795	93.808	93.821	93.835	93.848	93.861
93.875	93.888	93.901	93.915	93.928	93.941	93.955	93.968
93.981	93.995	94.008	94.021	94.035	94.048	-131.107	-98.816
-75.158	-66.718	-59.234	-50.643	-43.633	-259.839	-239.049	-219.304
-197.868	-175.385	-152.810	-129.152	-104.436	-79.732	-53.932	-27.220
.000							

Projected maximum range is	69.912 km (	43.451 miles)
Capacity removed is	11.475 kWh	or 138.786 Ah
Regeneration capacity is	2.545 kWh	or 25.378 Ah

SAMPLE 1: IETV-1/J227aD/E3T205 System with Regenerative Braking (Cont'd)

***** Vehicle velocity with maximum-power acceleration *****

Time(s)	km/h	mph	km	mile
-----	-----	-----	-----	-----
1	20.11	12.50	.00	.00
2	32.49	20.20	.01	.01
3	41.93	26.06	.02	.01
4	49.77	30.93	.03	.02
5	56.57	35.16	.05	.03
6	62.65	38.94	.06	.04
7	68.15	42.35	.08	.05
8	73.18	45.48	.10	.06
9	77.82	48.37	.12	.08
10	82.15	51.06	.15	.09
11	86.19	53.67	.17	.10
12	90.02	55.95	.19	.12
13	93.62	58.19	.22	.14
14	97.03	60.31	.25	.15
15	100.26	62.31	.27	.17
16	103.33	64.22	.30	.19
17	106.25	66.04	.33	.21
18	109.03	67.77	.36	.22
19	111.69	69.42	.39	.24
20	114.23	71.00	.42	.26
21	116.66	72.51	.45	.28
22	119.01	73.97	.49	.30
23	121.26	75.37	.52	.32
24	123.42	76.71	.55	.34
25	125.50	78.00	.59	.37
26	127.48	79.23	.62	.39
27	129.39	80.42	.66	.41

This is the end of the case.

SAMPLE 2: Same as SAMPLe-1 Except Power Profile Is Input

SAMPLE-2: Same As SAMPLe-1 Except Power Profile is Input

Default vehicle dataset for IETV-1

curb wt. w/o battery (kg), cwnb =	1032.000
battery wt. w/accessories, (kg), bw =	488.000
drivetrain eff. (fraction), effd =	.870
motor eff. (fraction), effm =	.900
rolling res. coeff., (--), k0 =	.009
rolling res. coeff., (s/m), k1 =	.000
rolling res. coeff., (s**2/m**2), k2 =	.000
frontal area, (m**2), farea =	1.740
drag coeff., (--), cd =	.310
grade, (%), grade =	.000
payload (kg), plw =	158.800
gross vehicle weight, (kg), GVW =	1837.600
controller current limit, (A), DCOI =	600.000

Power profile (W/kg) at battery terminals:

6.20	12.40	18.62	24.87	31.15	37.37	41.46	44.54
46.83	48.95	50.17	51.12	51.89	52.59	52.16	51.88
51.45	50.93	49.91	48.83	47.05	45.92	44.61	42.16
40.95	38.38	36.87	35.50	15.38	15.38	15.38	15.38
15.38	15.38	15.38	15.38	15.38	15.38	15.38	15.38
15.38	15.38	15.38	15.38	15.38	15.38	15.38	15.38
15.38	15.38	15.38	15.38	15.38	15.38	15.38	15.38
15.38	15.38	15.38	15.38	15.38	15.38	15.38	15.38
15.38	15.38	15.38	15.38	15.38	15.38	15.38	15.38
15.38	15.38	15.38	15.38	15.38	15.38	15.38	15.38
15.38	15.38	15.38	15.38	15.38	15.38	-25.50	-18.93
-14.24	-12.59	-11.14	-9.49	-8.15	-53.50	-48.78	-44.37
-39.65	-34.80	-30.01	-25.09	-20.06	-15.14	-10.12	-5.04
.00							
km/cycle =	1.59						

SAMPLE 2: Same as SAMPLE-1 Except Power Profile is Input (Cont'd)

Default battery dataset for Tubular L/A 3ET205 Batteries

wt. of a battery cell, (kg), WC=	10.930	
accessory wt./cell, (kg), WY=	.000	
no. of paralell strings, NPS=	1.000	
cell amp-hours @ C/3, C3=	186.000	
cell cutoff voltage comp.1, DCOV1=	1.300	
cell cutoff voltage comp.2, DCOV2=	.000	
no. of (DOD,NLV) data pairs=		7
.000	2.150	
.050	2.150	
.400	2.090	
.700	2.020	
.800	2.000	
.900	1.960	
1.000	1.890	
no. of (DOD,R) data pairs=		8
.000	.00110	
.050	.00093	
.300	.00092	
.400	.00093	
.600	.00103	
.800	.00123	
.900	.00143	
1.000	.00233	
Regen (DOD,NLV) data pairs=		6
.000	2.450	
.125	2.150	
.250	2.133	
.500	2.083	
.750	2.033	
1.000	1.983	
Regen (DOD,R) data pairs=		6
.000	.00100	
.125	.00094	
.250	.00091	
.500	.00088	
.750	.00086	
1.000	.00102	
battery parameter, G1=		.140

SAMPLE 2: Same as SAMPLE-1 Except Power Profile Is Input (Cont'd)

Vehicle type	IETV-1
Drive cycle	J227aD
Battery type	3ET205
Test wt. of EV, (kg), TW	1678.800
Battery wt., (kg), BW	488.000
Net cell wt., (kg), WC	10.930
Accessory wt./cell, (kg), WY	.000
No. of cells in battery, NC	44.648
No. of parallel strings in batt., NPS	1.000
Cell amp-hours @ C/3, C3	186.000
Peak power demand, (W/kg)	52.590
(kW)	25.664
Battery peak power at 100% SOC (W/kg) ...	85.438
and 2/3-NLV, (kW)	41.694
Resistance factor for aging, RF	1.000
No-load voltage factor, VF	1.000

Driving Profile	Time h	Range km	Maximum I		Minimum V		Amp-Hour		kWh Batt
			Cell	Batt	Cell	Batt	Cell	Batt	
1	.03	1.6	318.3	318.3	1.806	80.6	3.0	3.0	.3
2	.07	3.2	313.9	313.9	1.831	81.8	6.0	6.0	.5
3	.10	4.8	309.8	309.8	1.855	82.8	9.0	9.0	.8
4	.14	6.4	309.1	309.1	1.860	83.0	11.9	11.9	1.0
5	.17	8.0	309.7	309.7	1.856	82.9	14.9	14.9	1.3
6	.20	9.5	310.3	310.3	1.853	82.7	17.9	17.9	1.6
7	.24	11.1	310.8	310.8	1.849	82.6	20.9	20.9	1.8
8	.27	12.7	311.4	311.4	1.846	82.4	23.9	23.9	2.1
9	.31	14.3	312.0	312.0	1.842	82.3	26.9	26.9	2.3
10	.34	15.9	312.6	312.6	1.839	82.1	29.9	29.9	2.6
11	.37	17.5	313.2	313.2	1.835	81.9	32.9	32.9	2.9
12	.41	19.1	313.8	313.8	1.832	81.8	35.9	35.9	3.1
13	.44	20.7	314.4	314.4	1.828	81.6	38.9	38.9	3.4
14	.47	22.3	315.0	315.0	1.825	81.5	41.9	41.9	3.7
15	.51	23.9	315.6	315.6	1.821	81.3	44.9	44.9	3.9
16	.54	25.4	316.2	316.2	1.818	81.2	48.0	48.0	4.2
17	.58	27.0	317.1	317.1	1.813	80.9	51.0	51.0	4.4
18	.61	28.6	318.0	318.0	1.808	80.7	54.0	54.0	4.7
19	.64	30.2	318.9	318.9	1.802	80.5	57.1	57.1	5.0
20	.68	31.8	319.8	319.8	1.797	80.2	60.2	60.2	5.2
21	.71	33.4	320.8	320.8	1.792	80.0	63.2	63.2	5.5
22	.75	35.0	322.3	322.3	1.783	79.6	66.3	66.3	5.7
23	.78	36.6	324.0	324.0	1.774	79.2	69.4	69.4	6.0
24	.81	38.2	325.8	325.8	1.764	78.8	72.5	72.5	6.3
25	.85	39.8	327.6	327.6	1.755	78.3	75.6	75.6	6.5
26	.88	41.3	329.5	329.5	1.745	77.9	78.7	78.7	6.8
27	.92	42.9	331.4	331.4	1.735	77.4	81.9	81.9	7.0
28	.95	44.5	333.3	333.3	1.724	77.0	85.0	85.0	7.3
29	.98	46.1	335.3	335.3	1.714	76.5	88.2	88.2	7.6
30	1.02	47.7	337.4	337.4	1.704	76.1	91.4	91.4	7.8

SAMPLE 2: Same as SAMPLE-1 Except Power Profile Is Input (Cont'd)

31	1.05	49.3	339.6	339.6	1.693	75.6	94.6	94.6	8.1
32	1.08	50.9	342.7	342.7	1.677	74.9	97.8	97.8	8.3
33	1.12	52.5	346.0	346.0	1.661	74.2	101.1	101.1	8.6
34	1.15	54.1	349.5	349.5	1.645	73.4	104.3	104.3	8.9
35	1.19	55.7	353.1	353.1	1.628	72.7	107.6	107.6	9.1
36	1.22	57.2	356.9	356.9	1.611	71.9	110.9	110.9	9.4
37	1.25	58.8	360.7	360.7	1.594	71.2	114.3	114.3	9.6
38	1.29	60.4	364.7	364.7	1.576	70.4	117.6	117.6	9.9
39	1.32	62.0	369.0	369.0	1.558	69.6	121.0	121.0	10.2
40	1.36	63.6	374.1	374.1	1.536	68.6	124.4	124.4	10.4
41	1.39	65.2	384.2	384.2	1.496	66.8	127.9	127.9	10.7
42	1.42	66.8	396.0	396.0	1.452	64.8	131.4	131.4	11.0
43	1.46	68.4	410.0	410.0	1.402	62.6	135.0	135.0	11.2
44	1.49	70.0	433.7	433.7	1.321	59.0	138.8	138.8	11.5
Driving Profile	Time h	Range km	Maximum I Cell Batt		Minimum V Cell Batt		Amp-Hour Cell Batt		kWh Batt

Cell voltage of first driving profile:

2.115	2.078	2.040	2.001	1.959	1.916	1.887	1.864
1.847	1.832	1.823	1.816	1.811	1.806	1.810	1.814
1.818	1.823	1.832	1.841	1.855	1.864	1.874	1.892
1.901	1.919	1.930	1.940	2.064	2.064	2.065	2.065
2.065	2.065	2.065	2.065	2.065	2.065	2.065	2.065
2.065	2.065	2.065	2.065	2.065	2.065	2.065	2.065
2.065	2.065	2.065	2.065	2.065	2.065	2.065	2.065
2.065	2.065	2.066	2.066	2.066	2.066	2.066	2.066
2.066	2.066	2.066	2.066	2.066	2.066	2.066	2.066
2.066	2.066	2.066	2.066	2.066	2.066	2.509	2.482
2.462	2.455	2.449	2.442	2.436	2.621	2.603	2.587
2.568	2.549	2.530	2.510	2.490	2.469	2.447	2.425
2.150							

Cell current of first driving profile:

32.044	65.214	99.747	135.868	173.784	213.166	240.166	261.125
277.064	292.110	300.845	307.676	313.219	318.269	314.893	312.652
309.321	305.357	297.805	289.924	277.224	269.255	260.153	243.515
235.408	218.546	208.795	200.054	81.428	81.426	81.425	81.423
81.422	81.421	81.419	81.418	81.416	81.415	81.414	81.412
81.411	81.409	81.408	81.406	81.405	81.404	81.402	81.401
81.399	81.398	81.396	81.395	81.394	81.392	81.391	81.389
81.388	81.387	81.385	81.384	81.382	81.381	81.379	81.378
81.377	81.375	81.374	81.372	81.371	81.370	81.368	81.367
81.365	81.364	81.362	81.361	81.360	81.358	-111.075	-83.360
-63.210	-56.044	-49.713	-42.472	-36.560	-223.081	-204.791	-187.489
-168.736	-149.202	-129.636	-109.243	-88.069	-67.025	-45.194	-22.713
.000							

SAMPLE 2: Same as SAMPLE-1 Except Power Profile is Input (Cont'd)

Cell voltage of last driving profile:

1.912	1.858	1.801	1.740	1.672	1.598	1.543	1.498
1.461	1.424	1.400	1.375	1.351	1.326	1.325	1.321
1.321	1.323	1.338	1.353	1.384	1.400	1.420	1.460
1.477	1.516	1.537	1.555	1.800	1.800	1.800	1.800
1.799	1.799	1.799	1.799	1.798	1.798	1.798	1.798
1.797	1.797	1.797	1.797	1.796	1.796	1.796	1.796
1.795	1.795	1.795	1.795	1.794	1.794	1.794	1.794
1.793	1.793	1.793	1.793	1.792	1.792	1.792	1.792
1.791	1.791	1.791	1.791	1.790	1.790	1.790	1.790
1.789	1.789	1.789	1.789	1.788	1.788	2.126	2.094
2.071	2.063	2.056	2.047	2.041	2.251	2.230	2.211
2.190	2.169	2.147	2.124	2.100	2.076	2.051	2.025
1.944							

Cell current of last driving profile:

35.449	72.930	112.974	156.236	203.586	255.591	293.592	324.944
350.294	375.739	391.674	406.386	419.935	433.654	430.279	429.191
425.664	420.625	407.804	394.344	371.632	358.438	343.354	315.628
303.036	276.750	262.259	249.538	93.367	93.380	93.393	93.406
93.419	93.432	93.445	93.459	93.472	93.485	93.498	93.511
93.524	93.537	93.550	93.563	93.576	93.589	93.603	93.616
93.629	93.642	93.655	93.668	93.682	93.695	93.708	93.721
93.734	93.748	93.761	93.774	93.787	93.801	93.814	93.827
93.840	93.854	93.867	93.880	93.894	93.907	93.920	93.934
93.947	93.960	93.974	93.987	94.000	94.014	-131.128	-98.802
-75.148	-66.704	-59.230	-50.662	-43.653	-259.823	-239.044	-219.316
-197.850	-175.394	-152.797	-129.129	-104.420	-79.719	-53.937	-27.206
.000							

Projected maximum range is 69.960 km (43.480 miles)
 Capacity removed is 11.474 kWh or 138.772 Ah
 Regeneration capacity is 2.544 kWh or 25.377 Ah

SAMPLE 2: Same as SAMPLE-1 Except Power Profile is Input (Cont'd)

***** Vehicle velocity with maximum-power acceleration *****

Time(s)	km/h	mph	km	mile
-----	-----	-----	-----	-----
1	20.11	12.50	.00	.00
2	32.49	20.20	.01	.01
3	41.93	26.06	.02	.01
4	49.77	30.93	.03	.02
5	56.57	35.16	.05	.03
6	62.65	38.94	.06	.04
7	68.15	42.35	.08	.05
8	73.18	45.48	.10	.06
9	77.82	48.37	.12	.08
10	82.15	51.06	.15	.09
11	86.19	53.57	.17	.10
12	90.02	55.95	.19	.12
13	93.62	58.19	.22	.14
14	97.03	60.31	.25	.15
15	100.26	62.31	.27	.17
16	103.33	64.22	.30	.19
17	106.25	66.04	.33	.21
18	109.03	67.77	.36	.22
19	111.69	69.42	.39	.24
20	114.23	71.00	.42	.26
21	116.66	72.51	.45	.28
22	119.01	73.97	.49	.30
23	121.26	75.37	.52	.32
24	123.42	76.71	.55	.34
25	125.50	78.00	.59	.37
26	127.48	79.23	.62	.39
27	129.39	80.42	.66	.41

This is the end of the case.

SAMPLE 3: Same as SAMPLe-1 Except RF = 1.1, IPIN = 0, and IACC = 0

SAMPLE-3: Same As SAMPLe-1 Except RF = 1.1, IPIN = 0, and IACC = 0

Vehicle type	IETV-1
Drive cycle	J227aD
Battery type	3ET205
Test wt. of EV, (kg), TW	1678.800
Battery wt., (kg), BW	488.000
Net cell wt., (kg), WC	10.930
Accessory wt./cell, (kg), WY	.000
No. of cells in battery, NC	44.648
No. of parallel strings in batt., NPS	1.000
Cell amp-hours @ C/3, C3	186.000
Peak power demand, (W/kg)	52.586
(kW)	25.662
Battery peak power at 100% SOC (W/kg) ...	85.438
and 2/3-NLV, (kW)	41.694
Resistance factor for aging, RF	1.100
No-load voltage factor, VF	1.000

Driving Profile	Time h	Range km	Maximum I		Minimum V		Amp-Hour		kWh Batt
			Cell	Batt	Cell	Batt	Cell	Batt	
1	.03	1.6	326.1	326.1	1.763	78.7	3.1	3.1	.3
2	.07	3.2	320.6	320.6	1.793	80.0	6.1	6.1	.5
3	.10	4.8	315.7	315.7	1.821	81.3	9.1	9.1	.8
4	.14	6.4	315.0	315.0	1.824	81.5	12.1	12.1	1.0
5	.17	7.9	315.6	315.6	1.821	81.3	15.1	15.1	1.3
6	.20	9.5	316.3	316.3	1.817	81.1	18.1	18.1	1.6
7	.24	11.1	316.9	316.9	1.814	81.0	21.1	21.1	1.8
8	.27	12.7	317.5	317.5	1.810	80.8	24.1	24.1	2.1
9	.31	14.3	318.1	318.1	1.807	80.7	27.2	27.2	2.3
10	.34	15.9	318.8	318.8	1.803	80.5	30.2	30.2	2.6
11	.37	17.5	319.4	319.4	1.800	80.3	33.2	33.2	2.9
12	.41	19.1	320.0	320.0	1.796	80.2	36.3	36.3	3.1
13	.44	20.7	320.7	320.7	1.792	80.0	39.3	39.3	3.4
14	.47	22.2	321.3	321.3	1.789	79.9	42.4	42.4	3.7
15	.51	23.8	322.0	322.0	1.785	79.7	45.5	45.5	3.9
16	.54	25.4	322.7	322.7	1.781	79.5	48.5	48.5	4.2
17	.58	27.0	323.7	323.7	1.776	79.3	51.6	51.6	4.4
18	.61	28.6	324.7	324.7	1.770	79.0	54.7	54.7	4.7
19	.64	30.2	325.8	325.8	1.764	78.8	57.8	57.8	5.0
20	.68	31.8	326.8	326.8	1.759	78.5	60.9	60.9	5.2
21	.71	33.4	328.0	328.0	1.752	78.2	64.0	64.0	5.5
22	.75	35.0	330.0	330.0	1.742	77.8	67.1	67.1	5.7
23	.78	36.5	332.0	332.0	1.731	77.3	70.2	70.2	6.0
24	.81	38.1	334.1	334.1	1.720	76.8	73.4	73.4	6.3
25	.85	39.7	336.2	336.2	1.710	76.3	76.6	76.6	6.5
26	.88	41.3	338.4	338.4	1.699	75.8	79.7	79.7	6.8
27	.92	42.9	340.7	340.7	1.687	75.3	82.9	82.9	7.0
28	.95	44.5	343.0	343.0	1.676	74.8	86.1	86.1	7.3
29	.98	46.1	345.4	345.4	1.664	74.3	89.4	89.4	7.6
30	1.02	47.7	347.9	347.9	1.652	73.8	92.6	92.6	7.8

SAMPLE 3: Same as SAMPLE-1 Except RF = 1.1, IPIN = 0, and IACC = 0 (Cont'd)

31	1.05	49.3	351.3	351.3	1.636	73.1	95.9	95.9	8.1
32	1.08	50.8	355.3	355.3	1.618	72.2	99.2	99.2	8.3
33	1.12	52.4	359.5	359.5	1.599	71.4	102.5	102.5	8.6
34	1.15	54.0	364.0	364.0	1.579	70.5	105.8	105.8	8.9
35	1.19	55.6	368.8	368.8	1.559	69.6	109.2	109.2	9.1
36	1.22	57.2	373.7	373.7	1.538	68.7	112.6	112.6	9.4
37	1.25	58.8	378.9	378.9	1.517	67.7	116.0	116.0	9.6
38	1.29	60.4	384.5	384.5	1.495	66.7	119.5	119.5	9.9
39	1.32	62.0	390.8	390.8	1.471	65.7	123.0	123.0	10.2
40	1.36	63.6	404.9	404.9	1.420	63.4	126.5	126.5	10.4
41	1.39	65.1	422.5	422.5	1.360	60.7	130.2	130.2	10.7
Driving Profile	Time h	Range km	Maximum I		Minimum V		Amp-Hour		kWh
			Cell	Batt	Cell	Batt	Cell	Batt	Batt

Cell voltage of first driving profile:

2.111	2.071	2.029	1.984	1.938	1.889	1.856	1.830
1.810	1.792	1.782	1.774	1.768	1.763	1.768	1.771
1.777	1.782	1.793	1.803	1.820	1.830	1.842	1.862
1.873	1.893	1.905	1.916	2.056	2.056	2.056	2.056
2.056	2.056	2.056	2.056	2.056	2.056	2.056	2.056
2.056	2.056	2.056	2.056	2.056	2.056	2.056	2.056
2.056	2.056	2.056	2.057	2.057	2.057	2.057	2.057
2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057
2.057	2.057	2.057	2.057	2.057	2.057	2.057	2.057
2.057	2.057	2.057	2.057	2.058	2.058	2.519	2.489
2.467	2.460	2.453	2.445	2.439	2.640	2.621	2.603
2.583	2.562	2.541	2.520	2.497	2.474	2.451	2.427
2.150							

Cell current of first driving profile:

32.076	65.448	100.325	136.963	175.680	216.211	244.212	266.076
282.736	298.524	307.773	314.927	320.784	326.104	322.525	320.108
316.562	312.274	304.278	295.962	282.596	274.283	264.765	247.454
239.022	221.548	211.486	202.492	81.800	81.798	81.796	81.795
81.793	81.792	81.790	81.788	81.787	81.785	81.784	81.782
81.780	81.779	81.777	81.776	81.774	81.772	81.771	81.769
81.768	81.766	81.764	81.763	81.761	81.760	81.758	81.756
81.755	81.753	81.752	81.750	81.748	81.747	81.745	81.744
81.742	81.741	81.739	81.737	81.736	81.734	81.733	81.731
81.729	81.728	81.726	81.725	81.723	81.721	-110.641	-83.140
-63.089	-55.956	-49.640	-42.403	-36.506	-221.472	-203.416	-186.312
-167.800	-148.445	-129.080	-108.861	-87.824	-66.889	-45.129	-22.714
.000							

SAMPLE 3: Same as SAMPLE-1 Except RF = 1.1, IPIN = 0, and IACC = 0 (Cont'd)

Cell voltage of last driving profile:

1.932	1.878	1.821	1.759	1.691	1.616	1.561	1.515
1.478	1.440	1.416	1.396	1.378	1.360	1.367	1.370
1.376	1.385	1.403	1.421	1.452	1.469	1.489	1.526
1.543	1.579	1.599	1.616	1.838	1.838	1.837	1.837
1.837	1.837	1.837	1.837	1.837	1.837	1.837	1.837
1.837	1.836	1.836	1.836	1.836	1.836	1.836	1.836
1.836	1.836	1.836	1.835	1.835	1.835	1.835	1.835
1.835	1.835	1.835	1.835	1.835	1.835	1.834	1.834
1.834	1.834	1.834	1.834	1.834	1.834	1.834	1.834
1.833	1.833	1.833	1.833	1.833	1.833	2.143	2.110
2.086	2.077	2.069	2.061	2.054	2.274	2.253	2.233
2.211	2.188	2.165	2.141	2.116	2.091	2.064	2.037
1.972							

Cell current of last driving profile:

35.052	72.160	111.781	154.546	201.367	252.801	290.391	321.403
346.409	371.497	387.317	400.329	411.654	422.521	417.168	413.928
408.614	401.972	388.873	375.513	354.244	341.613	327.362	301.894
289.987	265.625	252.021	240.058	91.501	91.505	91.510	91.515
91.519	91.524	91.529	91.534	91.538	91.543	91.548	91.552
91.557	91.562	91.567	91.571	91.576	91.581	91.586	91.590
91.595	91.600	91.605	91.609	91.614	91.619	91.623	91.628
91.633	91.638	91.642	91.647	91.652	91.657	91.661	91.666
91.671	91.676	91.680	91.685	91.690	91.695	91.699	91.704
91.709	91.714	91.718	91.723	91.728	91.733	130.045	-98.078
-74.633	-66.264	-58.841	-50.316	-43.358	-257.166	-236.668	-217.188
-196.030	-173.823	-151.511	-128.111	-103.644	-79.168	-53.580	-27.058
.000							

Projected maximum range is 65.145 km (40.488 miles)
 Capacity removed is 10.693 kWh or 130.169 Ah
 Regeneration capacity is 2.429 kWh or 24.061 Ah

This is the end of the case.

-END-

DATE FILMED

01 / 28 / 91