ECU System Product Definition Specification	*HEV ePark Controller*	Doc Number:
ECU Program Engineering Manager **Approved:** **Date:** **ECU Program Engineer** **Approved:** **Date:**	Preliminary **As a preliminary document, information contained within this specification is FOR REFERENCE ONLY!** This document is unchecked is to be used for internal BWA use only. Recipient is responsible for maintaining up to date copies of this document from the document author.	**Release Number:** **Release Date:**

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1 Document Scope

This document is intended to provide an overview definition of the ECU product and the system it is intended to control.

2 Reference Documents

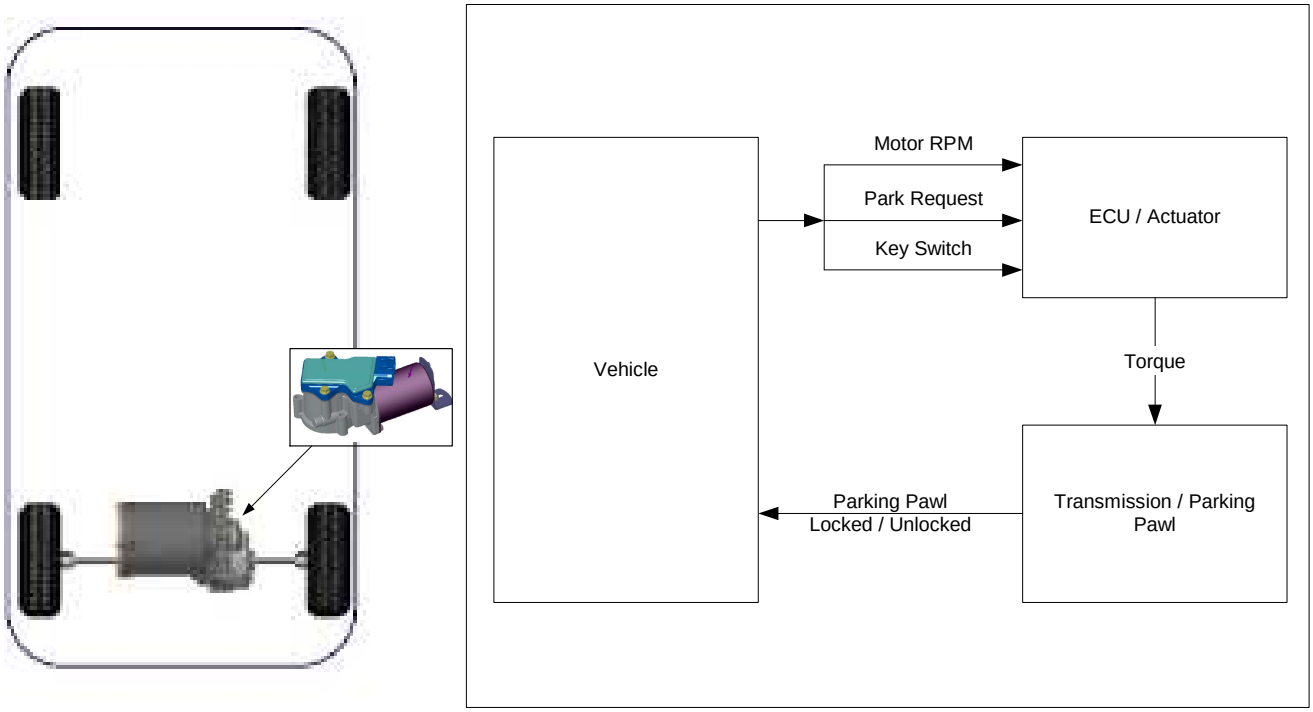
Document Name	Version	Source
HEV CAN Database	1.0	BW

3 Document Acronyms

Acronym	Description
BW	Borg Warner
DMC	Digital Motor Controller
DTC	Diagnostic Trouble Code
ECU	Electronic Control Unit
ePark	Electric Park
HEV	Hybrid Electric Vehicle
IGN	Ignition
PMDC	Permanent Magnet Direct Current
TCM	Transaxle Control Module

4 System Overview

The ePark controller is part of the transmission park system. The ePark controller is comprised of an ECU, a geared PMDC motor, non-contacting rotary position sensor, and a temperature sensor. The ePark controller interfaces and receives information with other vehicle systems over a vehicle CAN bus. The ECU directly controls the ePark shift motor providing torque to the transmission park system that engages or dis-engages a parking pawl mechanism allowing the transmission/vehicle to move or not. Shifting into or out of park is only attempted if the system meets defined shift criteria and a request for a shift is made by the operator.



5 Interfaces

5.1 Vehicle Package Interface

The ECU will have a mechanical design to allow ease of physical packaging onto a single speed transmission for electric vehicles. 2D drawings and 3D model data will be provided to allow development of packaging the ECU into the vehicle.

5.2 Electrical Interface

The ECU will be designed to allow the end customer connector the ePark system with a single connection. The connection will be a single multi-cavity electrical connection. This connection shall provide the ECU with power, ground and serial communication.

5.3 Vehicle Networking Interface

The ECU will be designed to operate as a node on the Vehicle CAN bus infrastructure. It is expected that most of the Input data will come as CAN signal inputs to our system. The required signal inputs for the ECU to function are defined within this document.

5.4 Tools Interface

The ECU will be designed to allow Vector CAN tools interfacing to the system for vehicle development purposes.

5.5 Diagnostics Support Interface

The ECU will be designed to provide diagnostic mode support features to allow for system debug, EOL testing and for after market serviceability.

6 ECU Functional Definition

6.1 Module Initialization

When the power is turned on, as detected by the IGN line into the ECU reading greater than or equal to 7.5 Vdc, the module will be ready to receive CAN messages within 120 ms and send out the first CAN message between 120-500ms. All fault conditions will be re-diagnosed at ignition on and if a fault condition exists, the appropriate DTC will be considered active. The module will be ready to initiate the first shift request within 2.0 seconds of ignition on providing all shift conditions are met.

When the module powers up, it will receive park request - {0-off, 1-park, 2-unpark, 3-Invalid} from DMC through CAN, and respond with park, unpark, or no-action.

Actual Motor Position	Received CAN Request	Shift Motor Response
Park	Park	No Action
Park	UnPark	Unpark
Park	Off	No Action
Unpark	Park	Park
Unpark	Unpark	No Action
Unpark	Off	No Action
Unknown[1]	Park	Park
Unknown[1]	Unpark	Unpark
Unknown[1]	Off	No Action

6.2 Park / Unpark Shifting

Shifts are only allowed when vehicle conditions specified are satisfied. Once the motor starts moving the shift conditions are no longer checked. The shift conditions are:

6.2.1 Park to UnPark Shift Criteria

- No general encoder fault
- No motor open/shorted ground fault
- No motor open/short to battery fault
- No thermal protection fault

[1] Only at cycle IGN

6.2.2 Unpark to Park Shift Criteria

- No general encoder fault
- No motor open/shorted ground fault
- No motor open/short to battery fault
- *ENGINE_RPM_LOW_LIMIT* < electric motor speed < *ENGINE_RPM_HIGH_LIMIT*
- No thermal protection fault

Once a shift is initiated, the shift to the requested destination will be completed. Shift requests during a shift will be ignored until the current shift is completed.

If, during a shift attempt, the destination is not detected in *MOTOR_ON_TIME* seconds, and there are no detected system faults, the shift motor will be considered stalled. If the shift motor is stalled, it will be stopped. A shift system timeout fault will be set as defined in DTC section 6.5.

The maximum amount of time the shift motor is energized is *MOTOR_ON_TIME* seconds.

6.3 Thermal Management

The ECU is equipped with a thermistor mounted to the PCB to determine the modules board temperature. This temperature is used for thermal compensation of the motor position sensor and for protection of the PCB from thermal damage. If the thermistor reads a PCB temperature greater than 126C the ECU will enter a thermal protection event. During a thermal protection event, a TCM_ECU_OVERTEMP CAN signal will be set and motor shift is disabled.

Once the board temperature is equal to or less than 126C after a thermal protection event the ECU will return to normal operation and allow shift requests.

6.4 Bus Signal Interfacing

Two-wire communications line used to communicate system parameters as required at a 500 Kbaud rate. Hardware and protocol per ISO/DIS 11898 and SAE2284.

Reference CAN database HEV CAN database.dbc

HEV CAN database.dbc

6.4.1 CAN Message Received

The following is a summary list of CAN messages that is required to be on the vehicle for proper functioning of the ePark controller.

Message	ID
DBG_TCM_CCP_CRO_ID	$71A
MS_308h	$308
VMS_TCM_VCMD_VERSION	$0A
VMS_DMC_BOOLEANS	$8C
InvokeBootloaderCmd	$52A

6.4.1.1 Message $71A (DBG_TCM_CCP_CRO_ID)

Name	Start Bit	Length (Bit)	Value Type	Init value	Factor	Min.	Max.	Unit	Comments
CCP_CRO_DATA	0	64	Unsigned	0	1	0	0	-	CANape use only. CCP CRO message Byte order Intel
Tx method:	NoMsgSendType								
Cycle Time:	0								

6.4.1.2 Message $308 (DMC_TCM_SHIFT)

Name	Start Bit	Length (Bit)	Value Type	Init value	Factor	Min.	Max.	Unit	Comments
MotorSpd	8	16	Unsigned	-16064	0.5	-16064	16064	rpm	Used for vehicle speed qualification of parking pawl engage speed allow engage if abs(motorRPM) < 200 RPM. Offset: -16064 Byte order Intel
parkrequest	5	2	Unsigned	0	1	0	2	-	0-off, 1-park, 2-unpark, 3-Invalid Byte order Intel
Tx method:	Cyclic								
Cycle Time:	10 ms, Also when driver press the button, a message will be sent out immediately.								

6.4.1.3 Message $0A (VMS_TCM_VCMD_Version)

Name	Start Bit	Length (Bit)	Value Type	Init value	Factor	Min.	Max.	Unit	Comments
VMS_TCM_VCMD_Version	0	8	Unsigned	0	1	0	0	-	A message that is used to request the TCM version. When the received value of the message is zero the TCM will transmit the version information. All other received message values will be ignored and no response transmitted. Byte order Intel
Tx method:	NoMsgSendType								
Cycle Time:	0								

6.4.1.4 Message $8C (VMS_DMS_BOOLEANS)

Name	Start Bit	Length (Bit)	Value Type	Init value	Factor	Min.	Max.	Unit	Comments
ClearFaults	2	1	Unsigned	0	1	0	1	-	Set to one for one message cycle for each event of key on, key off, charge port door open, etc.. Cleared otherwise. Meant to clear outstanding errors or faults. Byte order Motorola
Tx method:	NoMsgSendType								
Cycle Time:	0 ms								

6.4.1.5 Message $52A (InvokeBootloaderCmd)

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Name	Start Bit	Length (Bit)	Value Type	Init value	Factor	Min.	Max.	Unit	Comments
InvokeBootloaderCms	0	64	Unsigned	0	1	0	0	-	Request for transmission id. Only 0x09 command is supported. Byte order Intel
Tx method:	NoMsgSendType								
Cycle Time:	0								

6.4.2 CAN message Transmitted

The following is a summary list of CAN messages that is will be transmitted by the ePark ECU.

Message	ID
TCM_DBG_CCP_DTO_ID	$51E
TCM_DMC_STATE[2]	$55C
TCM_VMS_ALERT_FAULT	$580
TCM_VMS_ALERT_LOG	$590
TCM_VMS_VCMD_VERSION	$500
InvokeBootloaderRsp	$53A

6.4.2.1 Message $51E (TCM_DBG_CCP_DTO_ID)

Name	Start Bit	Length (Bit)	Value Type	Init value	Factor	Min.	Max.	Unit	Comments
CCP_DTO_DATA	0	64	Unsigned	0	1	0	0	-	CANape use only Byte order Intel
Tx method:	NoMsgSendType								
Cycle Time:	0								

[2] Message monitoring required for basic functionality

6.4.2.2 Message $55C

Name	Start Bit	Length (Bit)	Value Type	Init value	Factor	Min.	Max.	Unit	Comments
driveSensor	7	1	Unsigned	0	1	0	1	Logic	active when the parking pawl is fully disengaged and ready for drive. • 1 - ready to drive • 0 - not ready to drive Byte order Motorola
parkSensor	6	1	Unsigned	0	1	0	1	Logic	active when the actuator is fully extended against the park pawl spring, meaning the pawl will "definitely" engage when the gear aligns with the pawl, it will to drop in, • 1 - park "active" • 0 - not "parked" The sensor does NOT sense whether the pawl is in the slot, just whether it is cocked and ready to drop. Byte order Motorola
parkLock	0	3	Unsigned	0	1	0	7	-	The signal may take values of : • 0x0- Off • 0x1 – Parking • 0x2 – Parked • 0x3 – Park Stalled • 0x4 – Unparking • 0x5 – Unparked • 0x6 – Unparked Stalled • 0x7 – Unknown The parkLock status is what the DMC looks for. If it gets 2 - Parked, that is good enough for it; it doesn't need to know that the pawl and slot are lined up and engaged as long as the pawl is cocked or armed so that with no additional action on the part of the TCM module the pawl "will" engage when the car is moved. Byte order Motorola
Tx method:	Cyclic								
Cycle Time:	100ms								

6.4.2.3 Message $580 (TCM_VMS_ALERT_FAULT)

Name	Start Bit	Length (Bit)	Value Type	Init value	Factor	Min.	Max.	Unit	Comments
TCM_CAN_ERR	17	1	Unsigned	0	1	0	0	Logic	TCM CAN bus was in error state Byte order Motorola
TCM_HALL_SENSOR_INVALID	10	1	Unsigned	0	1	0	0	Logic	the shift motor angle sensor is at fault Byte order Motorola
TCM_LOST_COMM_DMC	14	1	Unsigned	0	1	0	0	Logic	CAN message from DMC is lost Byte order Motorola
TCM_PARK_MOTOR_JAMMED_MIDDLE	7	1	Unsigned	0	1	0	0	Logic	Bit will be set if motor is stalled between Park and Upark as well as outside of Park and Unpark Positions Byte order Motorola
TCM_PARK_MOTOR_JAMMED_PARK	5	1	Unsigned	0	1	0	0	Logic	Bit will be set if motor is stalled in park Byte order Motorola
TCM_PARK_MOTOR_JAMMED_UNPARK	6	1	Unsigned	0	1	0	0	Logic	Bit will be set if motor is stalled in unpark Byte order Motorola
TCM_PARK_MOTOR_OPEN_CKT	4	1	Unsigned	0	1	0	0	Logic	Park pawl motor seems to be unplugged, open circuit. Byte order Motorola
TCM_ECU_OVERTEMP	19	1	Unsigned	0	1	0	0	Logic	ECU board temperature is over threshold Byte order Motorola
Tx method:	Cyclic								
Cycle Time:	1000ms								

6.4.2.4 Message $590 (TCM_VMS_ALERT_LOG)

Name	Start Bit	Length (Bit)	Value Type	Init value	Factor	Min.	Max.	Unit	Comments
alertID	0	8	Unsigned	0	1	0	17	-	A TCM_VMS_ALERT_LOG message is sent whenever a TCM_VMS_ALERT_FAULT signal becomes active. The alert ID value in TCM_VMS_ALERT_LOG message matches the alert fault bit position, 0 through N, in the TCM_VMS_ALERT_FAULT message. Once a fault is logged subsequent occurances of the same fault do not need to be logged unless it has been set again after having been cleared. Byte order Motorola

Tx method: IfActive

Cycle Time: 0

Example:

Alert Fault message	Alert_Fault Bit	AlertID Value
TCM_PARK_MOTOR_OPEN_CKT	Bit 4	0x04
TCM_PARK_MOTOR_JAMMED_PARK	Bit 5	0x05

6.4.2.5 Message $500 (TCM_VMS_VCMD_VERSION)

Name	Start Bit	Length (Bit)	Value Type	Init value	Factor	Min.	Max.	Unit	Comments
TCM_AppVersionMajor	0	8	Unsigned	0	1	0	255	-	Application major version, binary value. Byte order Motorola
TCM_AppVersionMinor	8	8	Unsigned	0	1	0	255	-	Application minor version, binary value Byte order Motorola
TCM_AppVersionSubMinor	16	8	Unsigned	0	1	0	255	-	Application sub minor version, binary value Byte order Motorola
TCM_BootVersionMajor	24	8	Unsigned	0	1	0	255	-	Bootloader major version, binary value. Byte order Motorola
TCM_BootVersionMinor	32	8	Unsigned	0	1	0	255	-	Bootloader minor version, binary value Byte order Motorola
TCM_BootVersionSubMinor	40	8	Unsigned	0	1	0	255	-	Bootloader sub minor version, binary value Byte order Motorola
TCM_BuildFlagsH	48	8	Unsigned	0	1	0	255	-	Arbitrary build flags; note MSB first, LSB second. Byte order Motorola
TCM_BuildFlagsL	56	8	Unsigned	0	1	0	255	-	Arbitrary build flags; note MSB first, LSB second. Byte order Motorola
Tx method:	NoMsgSendType								
Cycle Time:	0								

6.4.2.6 Message $53A (InvokeBootloaderRsp)

Name	Start Bit	Length (Bit)	Value Type	Init value	Factor	Min.	Max.	Unit	Comments
BootResponse	0	64	Unsigned	0	1	0	0	-	Only respond with transmission id when InvokeBootloaderCmd (0x52A) first byte is 0x09, and ignore other commands. Message 0x53A contents: 09 54 43 4D 2D 52 34 00 --> TCM-R4 Byte order Intel
Tx method:	NoMsgSendType								
Cycle Time:	0								

6.5 Service Diagnostic Mode Support

While the module is active it periodically monitors its inputs and outputs. If a fault is detected, the ECU will report faults in CAN message TCM_VMS_ALERT_FAULT (0x580) and store a diagnostic Trouble Code (DTC) in the module's non-volatile memory. The DTC codes are retrievable through the use of a Vector tool. The DTC's will remain in memory until the module is instructed to erase the DTC's by the diagnostic tester. When battery power is turned off, the ECU stops monitoring any inputs and outputs.

Diagnostic Trouble Codes to be supported are:

DTC	Description
U0100	DLCM message ($308) is missing
U0001	High Speed CAN Communication Bus Fault
P1736	Motor open / short to ground / short to battery
P1738	Shift system timeout
P1739	General Position encoder error
P1746	ECU thermal threshold exceeded

Diagnostic will be performed between *SHIFT_BATT_UNDER_VOLTAGE – SHIFT_BATT_OVER_VOLTAGE* Vdc, except CAN related faults which will be performed between *SYSTEM_VOLTAGE_LOW – SYSTEM_VOLTAGE_HIGH* Vdc

6.6 In-Field Flashing Capability

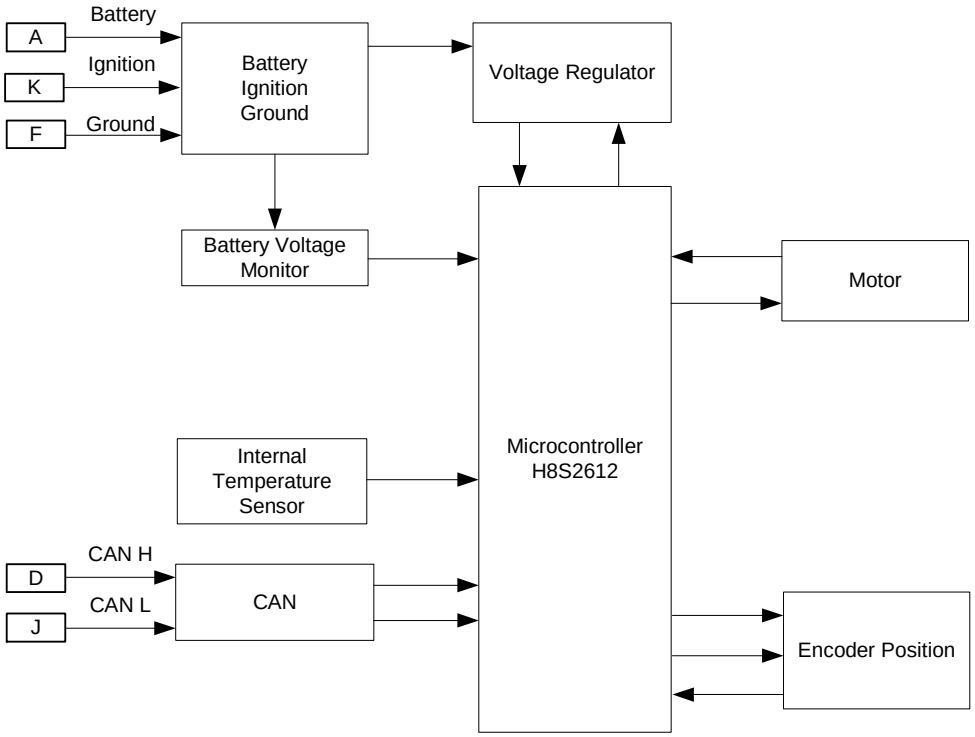
The ECU will have the capability to be reflashed over the CAN using CANape.

6.7 Power Management

Power will be supplied and managed by a power management module on the vehicle network. Power is required to be supplied during the entire time the system is to be functional. At a vehicle key off, power is expected to be continued to be supplied to the ePark controller for a customer defined period of time sufficient to allow any request for park or unpark to be performed. During this time period the ePark controller will require all CAN messages to have full functional capability. Once power is removed or drops below the minimum normal operating voltage the ePark controller will shut down.

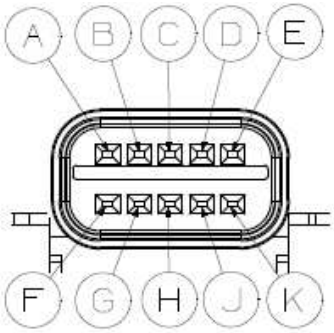
7 ECU Hardware Definition

7.1 Electrical Block Diagram



7.2 Electrical Interface

Pin Number	Name	Comments
A	Battery	Voltage range: 0 – 26.5 Vdc 25 Amp max
B	Not Used	
C	Not Used	
D	CAN High	Class 2B, 500kbaud High Speed CAN bus input
E	Not Used	
F	Ground	Provides ground path for the ECU
G	Not Used	
H	Not Used	
J	CAN Low	Class 2B, 500kbaud High Speed CAN bus input
K	Ignition	Voltage Range: 0 to 26.5 Vdc 250 mA Max



Vehicle mating connector: Delphi p/n 15326842

7.3 Environmental Requirements

7.3.1 Storage Temperature

Storage Temperature: -40℃ to 140℃ (non-operation al)

7.3.2 Operating Temperature

The ECU assembly will meet all requirements of this specification over an ambient temperature of -40℃ to 125℃.

7.3.3 ECU Mounting Location/ Sealing

The ePark Controller will be mounted directly to the transmission on the under body of the vehicle. The ePark controller will be exposed to heavy spray and full water immersion. As such the ePark controller will be a fully sealed unit.

7.4 Electrical Requirements

7.4.1 Vehicle Operating Voltage

Normal operation voltage: *SHIFT_BATT_UNDER_VOLTAGE* – *SHIFT_BATT_OVER_VOLTAGE* Vdc

CAN Operational Votlage range: *SYSTEM_VOLTAGE_LOW* – *SYSTEM_VOLTAGE_HIGH* Vdc

Diagnostic operating range: *SYSTEM_VOLTAGE_LOW* – *SYSTEM_VOLTAGE_HIGH* Vdc, except motor related faults which will be performed between *SHIFT_BATT_UNDER_VOLTAGE* – *SHIFT_BATT_OVER_VOLTAGE* Vdc.

7.4.2 Max Current Draw

The maximum current draw for the ePark controller is 25A for max operating time of 1.5 sec.

7.4.3 Parasitic Current

The maximum parasitic current draw is 1 mA.

8 Validation

Mechanical, Environmental, and environmental testing per BW specification 44-00-430-043-H

9 Calibration

Text in this document that is all cap and in Italics are calibratable values and defined in the calibration specification. For reference the calibration values are listed in the below table.

Calibration name	Units	Range	Minimum Resolution	Released Calibration
ENGINE_RPM_HIGH_LIMIT	RPM	-	-	200
ENGINE_RPM_LOW_LIMIT	RPM	-	-	-200
MOTOR_ON_TIME	Sec	-	-	1.5
SHIFT_BATT_UNDER_VOLTAGE	Volts	-	-	9.0
SHIFT_BATT_OVER_VOLTAGE	Volts	-	-	16.0
SYSTEM_VOLTAGE_LOW	Volts	-	-	8.0
SYSTEM_VOLTAGE_HIGH	Volts	-	-	16.0

10 Change Log

Rev.	Page/ Section	Description	By	Date	CHKD
1	All	Initial release	SLR	6/11/09	
2	6.4.1.2 6.4.1.3 6.4.2.2 6.4.2.3	Message $308 cycle time 10ms was 0ms Message $0A bit length 0 was 8 Message $55C cycletime 100ms was 0ms Message $580 cycletime 1000ms was 0ms	SLR	6/17/09	
3	 2 5.3 Multiple 6.4 6.4.1 6.4.1.2 6.4.2.4 6.5 9	- Updates after peer review - Updated reference doc to just specifiy “HEV CAN database ver 1.0” - “inputs” was “input” - replaced actual values with calibration variable name - Updated CAN database to “HEV CAN database” - Tx method “NoMsgSendType” was “cyclic” for message $71A, $8C. - Byte order “Intel” was “Motorola” for signal “parkrequest” - “alertID” was “alerted” - DTC description for U0100 was “DMC message (0x65A) is missing” - Added calibration section	SLR	6/19/09	
4	6.4.1.2	Removed signal MotorSpdPar & MotorSpdTog. Updated HEV CAN database.dbc	SLR	7/13/09	
5	6.4.1.3	Changed message bit length from 0 to 8 and removed bit length comment for message VMS_TCM_VCMD_Version. Removed zero length comment from	SLR	7/17/09	
6	6.4.1.3	Added comment that message value must be zero to TCM version to be sent. All other message values will be ignored.	SLR	7/22/09	
7	6.4	Updated the HEV CAN database.dbc	RWG	8/7/09	
8	Header	Update the revision date	RWG	8/7/09	
9	6.1	Off was Unpark, No Action was Unpark – tracker 2213	SLR	8/21/09	
10	6.1 6.4.1.2 6.4.2.5	Added “3-Invalid” Added “3-Invalid” to parkrequest MSB was LSB, LSB was MSB	SLR	1/26/10	