Diagnostic Service Tool Functional Specification
VIA ISO9141 / K-Line
For STC-1xx

Table of Contents

1. Introduction

1.1 Purpose and Scope

The purpose of the document is to describe the Diagnostic Service Tool requirements for STC-1xx ECU Modules.

1.2 Service Tool Description

A Diagnostic Tool is needed to diagnose car subsystem issues using the On Board Diagnostics capabilities embedded within the STC-1xx ECU module. Error codes within these ECU modules are known as DTC (Diagnostic Test Codes). These DTC's are specific error codes that are assigned to known issues that vehicles may have. ECU modules detect errors within the system and flags errors along with the DTC. This diagnostic tool will be used to record errors with the module, which can then be shared with other engineers in discussing issues.

1.3 Acronyms & Abbreviations

OBD	On-Board Diagnostics
NVM	Non Volatile Memory
TID	Test Identification
PID	Parameter Identification
CVN	Calibration Verification Number
VIN	Vehicle Identification Number

1.4 Diagram Clarification

Because the message length sent between PC and ECU is 7 bytes long, the document will use the following diagram to describe 7-bit specific messages being sent and received between PC and STC-1xx:

Diagram 1:

Msg Disc.	Byte #1	Byte #2	Byte #3	Byte #4	Byte #5	Byte #6	Byte #7
Request	Mode	PID					
Response	Mode	PID	Data A	Data B	Data C	Data D	

2. Requirements

The following list outlines the key requirements requested by the customer to produce the Diagnostic Tool for the STC-1xx module.

1. Able to Read DTC from ECU board
2. Ability to Clear DTC from ECU board
3. Able to store DTC's along with User Comments
4. Read Various Engine Parameters
5. Able to read Freeze Frame Data parameters
6. Ability to run self-tests (including key-off and key-on tests)
7. Display System Status (Air Conditioning, Idle Control, …)
8. Ability to run Input/Output tests (Air Conditioning control, MIL, …)
9. Displays Vehicle Information

3. Software Layout

3.1 Features

3.1.1 Self Diagnostic Tool

- ***Read DTC*** – Reads the DTC's on the ECU board and displays each DTC on the screen along with a description.
- ***Store DTC*** - The user is able to add comments next to each DTC in the same window as the DTC Read window and store the DTC's along with comments in an Excel Worksheet File.
- ***Clear DTC*** – Clears all existing DTC's on the NVM (Non-Volatile Memory)
- ***Keep Alive Memory Reset*** – Resets the KAM in the vehicle, which is useful when loading new calibration files, fuel pump or throttle body. This allows the vehicle to better adjust to newly installed car components.

3.1.2 Read Engine Parameter

- ***Main Parameters*** – Display various parameters including monitored statuses, number of DTCs, Engine Coolant Temperatures, etc… *(See Section 4.2.1 for more details).*
- ***Store Main Parameters*** – Allows the user to store Main Parameter data into an excel file. To store the data into a file there is the option of selecting the file path to where the data is saved. Data is recorded into the excel file where specified, when the user presses the "Start Reading" button, and stops recording data

when the user presses the “Stop Reading” button. Parameter data in the Excel File will include the dates the data is read next to each parameter for reference.

- ***Main Parameter Waveform*** – Reads the data from the excel file specified and displays parameter data in a waveform.
- ***HEGO Sensor Voltage*** – Displays the waveform of voltage read from the HEGO Sensor Voltage.
- ***Distance Travelled with MIL On*** – Displays the distance travelled with MIL on.

3.1.3 Freeze Frame Data

- ***Freeze Frame Data*** - Displays the engine conditions when a malfunction is detected. This is useful for determining the different car components that might have been a factor during malfunction. *(See Section 4.3 for more details).*
- ***Store Freeze Frame Data*** – The freeze frame data read through the program will be stored into an excel file specified by the user. If the excel file specified already contains data, the newly added data will append existing data. Each Freeze Frame parameter in the excel file will include the dates read for reference.

3.1.4 Self-Test

- ***Engine-Off Test*** – Runs the Engine-Off test when the engine is not running and notifies the user if the system runs correctly without the engine on.
- ***Engine-On Test*** – Runs the Engine-On test when then engine is running and notifies the user if the system runs correctly with the engine on.

3.1.5 System Status

Reads the live status of specific car components such as Air Conditioning, or Idle Control. *(See section 4.5 for more details).*

3.1.6 Input/Output Test

Allows the user to control specific car components like Air Conditioning and MIL. *(See Section 4.6 for more details).*

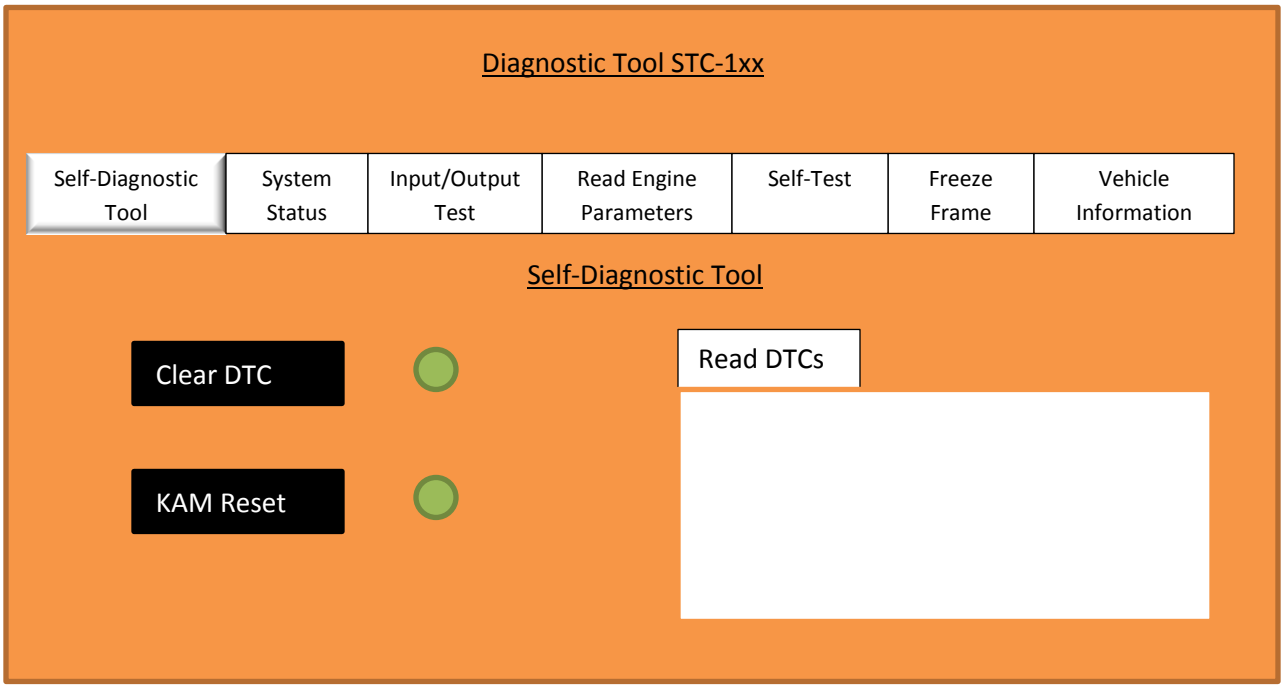
3.1.7 Vehicle Information

Displays 3 types of vehicle information:

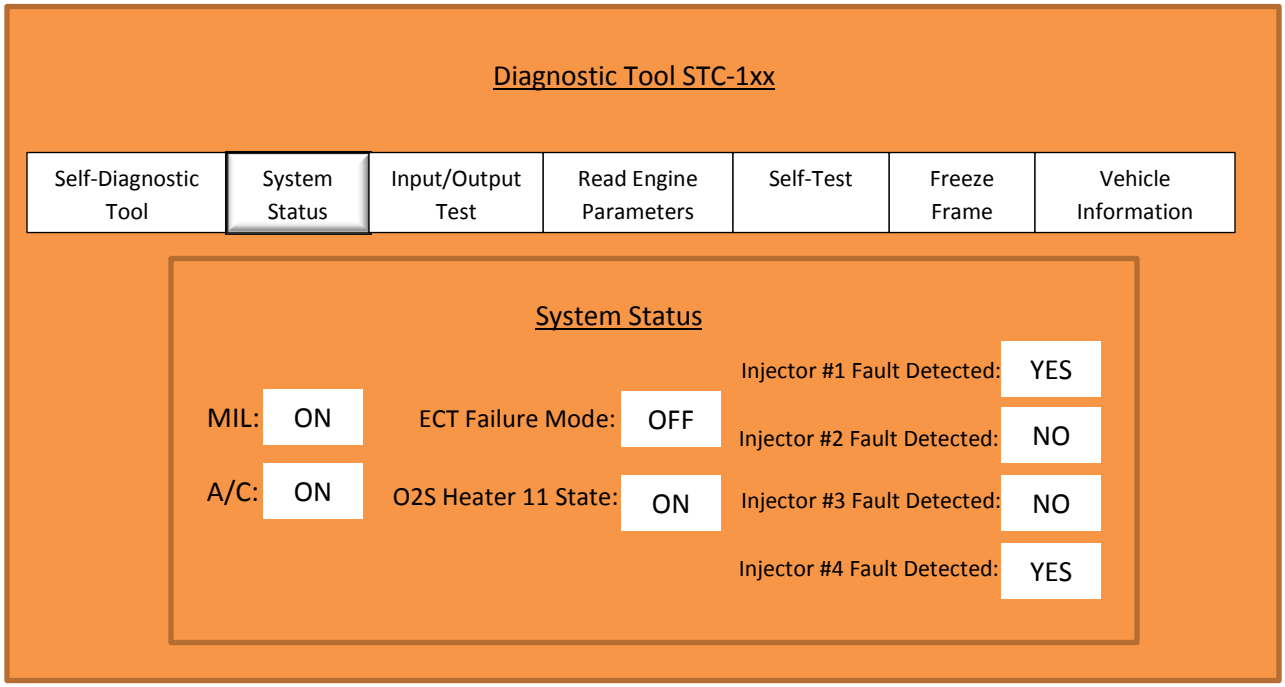
1. VIN (Vehicle Identification Number)
2. Calibration ID
3. CVN (Calibration Verification Number)

3.2 User Interface

The Main Menu of the user interface will include a 7 tabbed window which corresponds to the 7 main features of the Diagnostic Tool Software. These include: Self Diagnostic Tool, Read Engine Parameters, Freeze Frame Data, Self-Test, System Status, Input/Output Test and Vehicle Information.



Selecting any of the 7 main feature buttons will lead the user to the select feature's tabbed window. For example, selecting the System Status button will lead the user to a window displaying various car component statuses like MIL, and Air Conditioning status.



4. Diagnostic Test Modes

4.1 Self Diagnostic Tool

4.1.1 DTC Read

The DTC function uses mode $03 “Request Powertrain Diagnostic Trouble Codes/ Request MIL Codes.” Using mode $03 allows for 3 DTC codes to be read in one frame due to the 7 Data Bytes constraint. To request DTC codes, only the first byte is sent containing $03. The response from the ECU will contain a $43 in the first byte, followed by 3 DTC codes encoded in pairs of hex bytes. For clarification, DTC #1 is contained in bytes 2 and 3, DTC #2 is contained in bytes 4 and 5 and DTC #3 is contained in bytes 6 and 7. Below is an example of how to request DTC codes:

Mode $03 Request and Response

Request	03						
Response	43	DTC #1		DTC #2		DTC #3	

4.1.2 DTC Clear

The DTC Clear function uses mode $04, which is “Clear/Reset Emission Related Diagnostic Info.” This mode is used to clear all DTCs that exist is the NVM. To request for a DTC Clear, only the first byte must be sent containing $04. If all DTCs have been successfully cleared, the ECU should respond with a $44 in the first byte. Below is an example of how to clear DTC codes, as well as if there is an Invalid Format ($12), Conditions are Not Correct ($22) or Response Pending ($78).

Mode $04 Request and Response

Request	04						
Response	44						

Invalid Format ($12)

Request	04						
Response	7F	04	12				

Conditions are Not Correct ($22)

Request	04						
Response	7F	04	22				

Response Pending ($78)

Request	04						
Response	7F	04	78				

4.1.3 Keep Alive Memory Reset

The Keep Alive Memory Reset function requires the use of Mode $B1. In order to reset the Keep Alive Memory, the software must send $B1 in the first byte.

4.2 Read Engine Parameter

4.2.1 Main Parameters

The Main Parameters include all parameters capable in mode $01 on the STC-1xx. The following is a list of PID parameters that will be included in the Diagnostic Tool. Use *Diagram 1* to verify where the Data Bytes are located.

Main Parameters

PID	Description	Data Bytes
$00	Displays the PIDs support from $01 – 20	A, B, C, D
$01	Number of DTCs & MIL Status	A, B, C, D
$03	Fuels System 1 Status	A
$04	Calculated Load Value	A
$05	Engine Coolant Temperature	A
$06	Short Term Fuel Trim, Bank 1	A
$07	Long Term Fuel Trim, Bank 1	A
$0B	Intake Manifold Absolute Pressure	A
$0C	Engine RPM	A, B
$0D	Vehicle Speed Sensor	A
$0E	Ignition Timing Advance for #1 Cylinder	A
$0F	Intake Air Temperature	A
$11	Absolute Throttle Position	A
$13	Location of Oxygen Sensors	A
$14	Oxygen Sensor 11 Voltage/Fuel Trim.	A, B
$15	Oxygen Sensor 12 Voltage/Fuel Trim.	A,B
$1C	OBD Requirement Supported	A
$20	PIDs supported $21-40	A,B, C, D
$21	Distance Traveled with MIL on	A, B
$40	PIDs Supported $41-60	A, B, C, D
$46	Ambient Air Temperature (Calc)	A

4.2.2 HEGO Sensor Voltage

The HEGO Sensor Voltage is produced using Mode $01. PID $13 is used to find the location of the Oxygen Sensor, while PIDs $14 and $15 are used to find Oxygen Sensor 11 and Oxygen Sensor 12's Voltage/Fuel Trim Values respectively. The Oxygen Sensor Output Voltage is located in Byte A of the 7-bit data, and The Fuel trim Value is located in Byte B of the 7-bit data. The software will include a waveform diagram to illustrate the HEGO Sensor Voltage over time.

4.2.3 Distance Traveled with MIL On

Finding the Distance Traveled with MIL On also requires the use of Mode $01 along with PID $21. The units for distance traveled is in kilometers. The 7-bit data should return hex values in bytes A and B, which represent the distance traveled. The Minimum value possible is 0 kilometers while the Maximum value possible is 65,535 kilometers with a scaling/bit of 1 km per count.

4.3 Freeze Frame Data

The Freeze Frame Data function uses Mode $02. This mode differs from Mode $01, in which Mode $02 allows for specifying a frame number. The 1st bit contains the mode $02, the 2nd bit contains a PID, and the 3rd bit contain the frame number. Below shows a diagram of a 7-byte data request and response as well as a list of PIDs supported in Mode $02.

Mode $02 Request and Response

Request	02	PID	Frame #				
Response	42	PID	Frame #	Data A	Data B	Data C	Data D

Freeze Frame Data Functions

PID	Description	Data Bytes
$00	PIDs supported $01-20	A, B, C, D
$02	DTC which stored freeze Frame	A, B
$03	Fuel System Status 1	A
$04	Calculated Load Value	A
$05	Engine Coolant Temperature	A
$06	Short Term Fuel Trim, Bank 1	A
$07	Long Term Fuel Trim, Bank 1	A
$0B	Intake Manifold Absolute Pressure	A
$0C	Engine RPM	A,B
$0D	Vehicle Speed Sensor	A

4.4 Self Test

Both Engine On and Engine Off Tests require the use of Mode $31.

4.4.1 Engine Off

The Engine Off self-test is known as the KOEO Self-Test. The KOEO Self-Test takes around less than 25 seconds to execute. To request a KOEO Self-Test from the ECU $31, $02, $00 must be sent to the ECU. A positive response should appear as $71, $02. If the conditions are not met to run the test a

negative response will appear as $7F, $31, $22. Below are examples for running these tests along with diagrams of Abnormal and Routine exits.

KOEO Self-Test Entry

Request	31	02	00				
Positive Response	71	02					
Negative Response	7F	31	22				

KOEO Self-Test Abnormal Exit

Request	32	02	00				
Positive Response (test still was running)	72	02	64				
Negative Response (test was completed)	7F	32	22				
Negative Response (no routine had been started)	7F	32	22				

KOEO Self-Test Routine Exit

Request	33	02					
Negative Response (test is still running)	7F	33	21				
Positive Response (test completed with no failures)	73	02	00	Result #1 (P1xxx)	Result #2 (P1xxx)	Result #3 (P1xxx)	Result #4 (P1xxx)
Positive Response (test completed with failures)	73	02	01	Result #1 (DTC)	Result #2 (DTC)	Result #3 (DTC)	Result #4 (DTC)
Positive Response (test was aborted)	73	02	02	Result #1 (DTC)	Result #2 (DTC)	Result #3 (DTC)	Result #4 (DTC)

4.4.2 Engine On

The Engine On self-test is known as the KOER Self-Test. The KOER Self-Test takes around less than 70 seconds to execute. To request a KOER Self-Test from the ECU $31, $82, $00 must be sent to the ECU. A positive response should appear as $71, $82. If the conditions are not met to run the test a negative response will appear as $7F, $31, $22. Below are examples for running these tests along with diagrams of Abnormal and Routine exits.

KOER Self-Test Entry

Request	31	82	00				
Positive Response	71	82					
Negative Response	7F	31	22				

KOER Self-Test Abnormal Exit

Request	32	82	00				
Positive Response (test still was running)	72	82	64				
Negative Response (test was completed)	7F	32	22				
Negative Response (no routine had been started)	7F	32	22				

KOER Self-Test Routine Exit

Request	33	02					
Negative Response (test is still running)	7F	33	21				
Positive Response (test completed with no failures)	73	82	00	Result #1 (P1xxx)	Result #2 (P1xxx)	Result #3 (P1xxx)	Result #4 (P1xxx)
Positive Response (test completed with failures)	73	82	01	Result #1 (DTC)	Result #2 (DTC)	Result #3 (DTC)	Result #4 (DTC)
Positive Response (test was aborted)	73	82	02	Result #1 (DTC)	Result #2 (DTC)	Result #3 (DTC)	Result #4 (DTC)

4.5 System Status

The System Status function requires the use of Mode $22 “Read Data by Common ID.” To request for “Read Data”, the first byte must contain the mode $22, along with a 4 digit PID in bytes #2 and #3. Data byte #2 represents the high byte and Data byte #3 represents the low byte of the PID #.

The ECU should respond with $62, PID #(high byte), PID #(Low byte), followed by the next 4 bytes containing the recorded value of the specific request. Below shows an example of a system status request:

Mode $22 Request and Response

Request	22	PID #(high byte)	PID #(Low Byte)				
Positive Response	62	PID #(high byte)	PID #(Low Byte)	Record Value #1	Record Value #2	Record Value #3	Record Value #n
Negative Response	7F	22	12, 31, 33				

System Status Functions

Common ID #	Description	Byte/Bit
0906	Control state of the hardwired AC input pin to the PCM	1/7
095D	Idle Air Monitor Completed	1/7
095D	Misfire Monitor Completed	2/7

095D	EGR monitor Completed	2/6
095D	HEGO Monitor Completed	2/5
095D	Fuel Monitor Completed	2/4
095D	Secondary Air Monitor Completed	2/3
095d	Purge Monitor Completed	2/2
095D	CCM Monitor Completed	2/1
095D	Catalyst Monitor Completed	2/0
09CD	CMP and CKP are in sync	1/0
09CD	PIP state is high	1/2
09CD	Dechoke mode flag	1/3
1101	Power Steering Pressure Switch load present	1/7
1101	A/C requested by driver	1/0
1102	A/C pressure sensor high	1/0
1103	OBDII trip completed	1/7
1103	Open Loop Fuel conditions met	1/6
1103	MIL requested on	1/5
1103	High Speed Fan requested on	1/3
1104	A/C clutch commanded on	1/0
1106	IAT failure mode	1/7
1106	ECT failure mode	1/6
1106	Throttle Sensor Failure Mode	1/5
1107	1 = OSS is in FMEM	1/1
1107	1=CID is not currently reliable	1/0
162D	Injector #4 Output fault detected	1/3
162D	Injector #3 Output fault detected	½
162D	Injector #2 Output fault detected	1/1
162D	Injector #1 Output fault detected	1/0
162E	A/C Clutch output fault detected	1/5
162F	High Speed Fan Output fault detected	1/1
1631	O2S Heater 11 State	1/0
A430	Coolant temperature has reached OBDII warm threshold	1/1
A430	On/Run	1/0

4.6 Input/Output Test

The Input/Output Test requires the use of Mode $2F. To send a Input/Output Test request, $2F must be sent in the first byte followed by the PID (high byte), PID (low byte), Control Parameter, and 2 data bytes for substitute value in that order. Below is a diagram of an Input/Output Test request and response along with a table describing the different Input/Output Test Functions.

Mode $2F Request and Response

Request	2F	PID #(high byte)	PID #(Low Byte)	Control Param.	Subst. Value #1	Subst. Value #2	
Positive Response	6F	PID #(high byte)	PID #(Low Byte)	Control Param.	Subst. Value #1	Subst. Value #2	

Negative Response	7F	2F	11,12, 22, 31, 33				

I/O Test Functions

Common ID #	Hex Channel #	Description
E900	00	Idle speed control duty cycle
E904	04	Target lambda value, bank 1
E906	06	Fuel pump commanded on/off
E909	09	Purge Canister Solenoid
E911	11	Spark angle final
E919	19	HEGO sensor bank 1 upstream heater state
E91D	1D	Command Specified Fuel injectors on for INJON_TM
E91E	1E	Command specified fuel injectors off for INJOFF_TM
E941	41	A/C Relay
E942	42	MIL Output
E952	52	High Speed Fan Commanded On

4.7 Vehicle Information

The Vehicle Information function requires the use of Mode $09. Below is a diagram show where each data byte is located as well as table of TIDs supported in Mode $09:

Mode $09 Request and Response

Request	09	TID					
Response	02	TID	Data A	Data B	Data C	Data D	

List of Vehicle Information

TID	Description	Data Bytes
$00	Vehicle Information Types supported ($01-20)	A, B, C, D
$02	VIN – 17 characters	A, B, C, D
$04	Calibration IDs	A, B, C, D
$06	Calibration Verification Numbers (CVN)	A, B, C, D

5. Diagnostic Trouble Codes (DTCs)

5.1 Diagnostic Trouble Code Table

Below is a table containing all DTCs known in the STC-1xx:

	DTCs	MIL	Continuous	KOEO	KOER
	Fuel and Air Metering and Auxiliary Emission Controls				
P0068	MAP - Throttle Position Correlation	x	x		
	Fuel and Air Metering				
P0106	Manifold Absolute Pressure/BARO Sensor Range/Performance	x	x		x
P0107	Manifold Absolute Pressure/BARO Sensor Low	x	x	x	x
P0108	Manifold Absolute Pressure/BARO Sensor High	x	x	x	x
P0109	Manifold Absolute Pressure/BARO Sensor Intermittent		x		
P0112	Intake Air Temperature Sensor 1 Circuit Low (Bank 1)	x	x	x	x
P0113	Intake Air Temperature Sensor 1 Circuit High (Bank 1)	x	x	x	x
P0114	Intake Air Temperature Sensor 1 Intermittent/Erratic (Bank 1)		x		
P0116	Engine Coolant Temperature Sensor 1 Circuit Range/Performance		x		
P0117	Engine Coolant Temperature Sensor 1 Circuit Low	x	x	x	x
P0118	Engine Coolant Temperature Sensor 1 Circuit High	x	x	x	x
P0119	Engine Coolant Temperature Sensor 1 Circuit Intermittent/Erratic		x		
P0121	Throttle/Pedal Position Sensor A Circuit Range/Performance		x		x
P0122	Throttle/Pedal Position Sensor A Circuit Low		x	x	x
P0123	Throttle/Pedal Position Sensor A Circuit High		x	x	x
P0124	Throttle/Pedal Position Sensor A Intermittent		x	x	x
P0125	Insufficient Coolant Temp For Closed Loop Fuel Control		x		
P0131	O2 Circuit Low Voltage (Bank 1, Sensor 1)	x	x		x
P0132	O2 Circuit High Voltage (Bank 1, Sensor 1)	x	x		x
P0133	O2 Circuit Slow Response (Bank 1, Sensor 1)	x	x		
P0135	O2 Heater Circuit (Bank 1, Sensor 1)	x	x	x	x
P0136	O2 Circuit (Bank 1, Sensor 2)	x	x		
P0138	O2 Circuit High Voltage (Bank 1, Sensor 2)	x	x		x
P0141	O2 Heater Circuit (Bank 1, Sensor 2)	x	x	x	x
P0171	System Too Lean (Bank 1)	x	x		
P0172	System Too Rich (Bank 1)	x	x		
	Fuel and Air Metering				
P0201	Cylinder 1 Injector Circuit / Open	x	x	x	x

P0202	Cylinder 2 Injector Circuit / Open	**x**	x	x	x
P0203	Cylinder 3 Injector Circuit / Open	**x**	x	x	x
P0204	Cylinder 4 Injector Circuit / Open	**x**	x	x	x
P0219	Engine Overspeed Condition		x		
P0230	Fuel Pump Primary Circuit		x	x	
P0231	Fuel Pump Secondary Circuit Low		x		x
P0232	Fuel Pump Secondary Circuit High		x	x	
P0297	Vehicle Overspeed Condition		x		
	Ignition System or Misfire				
P0300	Random Misfire Detected	**x**	x		
P0301	Cylinder 1 Misfire Detected	**x**	x		
P0302	Cylinder 2 Misfire Detected	**x**	x		
P0303	Cylinder 3 Misfire Detected	**x**	x		
P0304	Cylinder 4 Misfire Detected	**x**	x		
P0315	Crankshaft Position System Variation Not Learned	**x**	x		
P0320	Ignition/Distributor Engine Speed Input Circuit	**x**	x		
P0325	Knock Sensor 1 Circuit (Bank 1)	**x**	x		x
P0340	Camshaft Position Sensor A Circuit (Bank 1 or single sensor)	**x**	x		
P0351	Ignition Coil A Primary/Secondary Circuit	**x**	x		
P0352	Ignition Coil B Primary/Secondary Circuit	**x**	x		
	Auxiliary Emission Controls				
P0420	Catalyst System Efficiency Below Threshold (Bank 1)	**x**	x		
P0443	Evaporative Emission System Purge Control Valve Circuit	**x**	x	x	x
P0460	Fuel Level Sensor A Circuit, Open/Short & Stuck FLI test	**x**	x	x	x
P0461	Fuel Level Sensor A Circuit Range/Performance, Noisy FLI test		x		
P0481	Fan 1 Control Circuit		x	x	x
	Vehicle Speed, Idle Control and Auxiliary Inputs				
P0505	Idle Air Control System, KOER				x
P0506	Idle Air Control System RPM Lower Than Expected	**x**	x		
P0507	Idle Air Control System RPM Higher Than Expected	**x**	x		
P0511	Idle Air Control Circuit		x		x
P0537	A/C Evaporator Temperature Sensor Circuit Low		x		x
P0538	A/C Evaporator Temperature Sensor Circuit High		x		x
P0562	System Voltage Low	**x**	x	x	x
P0563	System Voltage High		x	x	x
	Computer and Auxiliary Outputs				
P0602	Powertrain Control Module Programming Error (checksum)		x	x	x
P0610	Control Module Vehicle Options Error	**x**	x		
P0720	Output Shaft Speed Sensor Circuit	**x**	x		
	Manufacturer Specific DTCs				

P1000	OBD Systems Readiness Test Not Complete		x	x	x
P1001	KOER Not Able to Complete, KOER Aborted				x
P1116	Engine Coolant Temperature Sensor Out Of Self Test Range			x	x
P1120	Throttle Position Sensor A Out Of Range Low (Ratch too low)	**x**	x	x	x
P1124	Throttle Position Sensor A Out Of Self Test Range			x	x
P1127	Exhaust Temperature Out of Range, O2 Sensor Tests Not Completed				x
P1460	A/C Clutch Relay Control Circuit		x	x	x
P1464	A/C Demand Out Of Self Test Range			x	x
P1501	Vehicle Speed Sensor Out Of Self Test Range			x	x
P1607	MIL Output Circuit	**x**	x		
P1608	PCM Internal Circuit (KAM, RAM, ROM, or Engine off Timer)	**x**	x		
P1635	Tire/Axle Out of Acceptable Range		x		
P1639	Vehicle ID Block Corrupted, Not Programmed	**x**	x		
	Fuel and Air Metering and Auxiliary Emission Controls				
P2195	O2 Sensor Signal Biased/Stuck Lean - Bank 1, Sensor 1	**x**	x		x
P2196	O2 Sensor Signal Biased/Stuck Rich - Bank 1, Sensor 1	**x**	x		x
P2270	O2 Sensor Signal Biased/Stuck Lean - Bank 1, Sensor 2				x
P2271	O2 Sensor Signal Biased/Stuck Rich - Bank 1, Sensor 2				x

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6. Revision History

Version	Date	Section	Change	Author
0.1	13 Jun 2012	All	Creation of the document. Information was obtained from ChangAn CB series ECM Diagnostic Specification, Part No. VP9DUU-12A650-AC	E. Hsu

7. Originators of Document

1) Evan Hsu