Indmar

MARINE ENGINES

Service and Diagnostic Manual

For Electronic Fuel Injection Systems With Indmar Electronic Control Module Includes 80 Pin and 120 Pin ECM Diagnostics

Version 1.3

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SPN Codes and Page Numbers Sorted by SPN

SPN Codes and Page Numbers Sorted by SPN

SPN Codes and Page Numbers Sorted by SPN

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1 Abbreviations

AL	Adaptive Learn
BP	Barometric Pressure
CAN	Controller Area Network
CCP	CAN Calibration Protocol
CHT	Cylinder Head Temperature
CL	Closed Loop
CNG	Compressed Natural Gas
DBW	Drive-By-Wire
DM	Diagnostic Message
DMM	Digital Multi-Meter (high impedance)
DST	Diagnostic Scan Tool
DTC	Diagnostic Trouble Code
DVOM	Digital Voltage and Ohm Meter (high impedance)
ECI	EControls Inc.
ECIPP	EControls Inc. Proprietary Protocol
ECM	Engine Control Module
ECT	Engine Coolant Temperature
ECU	Engine Control Unit
EDIS	EControls Display and Interface Software
EGO	Exhaust Gas Oxygen Sensor, typically heated
EMWT	Exhaust Manifold Water Temperature
EPR	Electronic Pressure Regulator
ERWT	Exhaust Manifold Riser Temperature
ETB	Electronic Throttle Body
ETC	Electronic Throttle Control
FDR	Flight Data Recorder
FMI	Failure Mode Indicator
FO	Firing Order
FP	Fuel Pressure
FPP	Foot Pedal Position
FRP	Fuel Rail Pressure
FRT	Fuel Rail Temperature
FSS	Fault Snapshot
FT	Fuel Temperature
GCP	Global Control Platform
HDGCP	Heavy-Duty Global Control Platform (On-Road Heavy-Duty)
HEGO	Heated Exhaust Gas Oxygen Sensor (same as HO2S)
HO2S	Heated Oxygen Sensor (same as HEGO)
IAC	Idle Air Control
IAT	Intake Air Temperature
ICAV	Instant Crank Angle Velocity
IVS	Idle Validation Switch
LDGCP	Light-Duty Global Control Platform

	(Industrial, Smart/Logic Coil)
LED	Light Emitting Diode
LPG	Liquefied Propane Gas
MAP	Manifold Absolute Pressure
MDGCP	Medium-Duty Global Control Platform (Industrial, Dumb Coil)
MGCP	Marine Global Control Platform
μP	Microprocessor
Mfg	Manufacture
MIL	Malfunction Indicator Lamp
NG	Natural Gas
OBD	On-Board Diagnostics
OEM	Original Equipment Manufacture
PC	Personal Computer
PCU	Powertrain Control Unit
PFI	Port Fuel Injection
PGN	Parameter Group Number
PWM	Pulse Width Modulated
RAM	Random Access Memory
RPM	Revolutions Per Minute
Rx	Receive
SAE	Society of Automotive Engineering
SA	Source Address
SPFI	Sequential Port Fuel Injection
SPN	Suspect Parameter Number
Tach	Tachometer
TBI	Throttle Body Injection
TDC	Top Dead Center
TIP	Throttle Inlet Pressure
TPS	Throttle Position Sensor
TSC	Torque/Speed Control
Tx	Transmit
UEGO	Universal Exhaust Gas Oxygen Sensor (also called wide-range EGO)
VDC	Voltage, Direct Current
VR	Variable Reluctance
Vsw	Switched, Ignition Voltage
WGP	Waste-Gate Pressure

2 Overview

This manual is intended to be used as an aid for Indmar Products customers as a technical and training publication to understand the fault detection system. This manual defines the diagnostics and recommended troubleshooting procedures associated with an Indmar Global Control Platform (GCP) engine control module (ECM) for use on marine engines.

This manual is organized in the following manner:

1st Page of Diagnostic Information for a Given Fault

DTC XXXX- Diagnostic Condition

Block Diagram of Circuit

- *External Hardware Input/Output*- This identifies the hardware that either sends an input to the ECM or is driven by an ECM output.
- *Check Condition*- This defines what condition to troubleshoot the fault condition.
- *Fault Condition(s)*- This identifies the condition(s) that set the fault.
- *Corrective Action(s)*- This identifies the *RECOMMENED* corrective action(s) that the ECM is generally programmed to perform. In some instances, the calibration engineer(s) may choose to perform a different action.
- Emissions or Non-emissions related fault

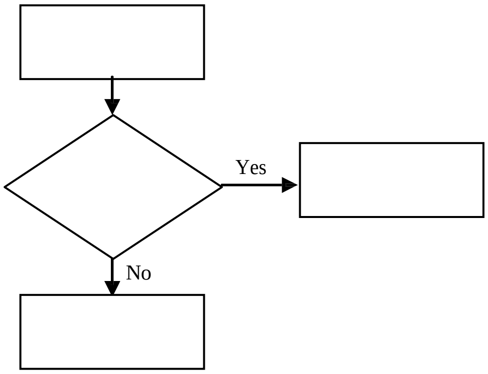
Text to identify the circuit of interest and its use for control.

Text to describe the conditions that cause the fault to set.

2nd Page of Diagnostic Information for a Given Fault

<u>DTC XXXX- Diagnostic Condition</u>

Note: Helpful tips used to aid troubleshooting



Troubleshooting flow chart

Diagnostic Aids

- Tip #1
- Tip #2 …

3 Fault Code Broadcast

All diagnostic trouble codes are broadcast for display on a PC or service tool. They can acquire the data from the ECU through CAN protocol. Faults may be acquired over the CAN1 network through CAN J1939-based scan tools or multi-function display units.

3.1 Diagnostic Trouble Codes

The numeric diagnostic trouble codes assigned to the faults in this manual are cross-referenced to SAE's "Recommended Practice for Diagnostic Trouble Code Definitions" (SAE J2012). This will assign both the DTC as displayed on the PC as well as the flash code output on the MIL output pin.

3.2 CAN

The GCP supports SAE J1939 CAN based diagnostic support. This includes:

- DM1: Active Diagnostic Trouble Codes
- DM2: Previously Active Diagnostic Trouble Codes
- DM3: Diagnostic Data Clear/Reset of Previously Active DTCs
- DM4: Freeze Frame Parameters
- DM5: Diagnostic Readiness (bytes 1, 2, and 3 are supported)
- DM11: Diagnostic Data Clear/Reset For Active DTCs
- DM12: Emissions-Related Active Diagnostic Trouble Codes
- DM19: Calibration Information

All diagnostic trouble codes broadcast over CAN1 will be according to SAE J1939 DM1 and DM2. MY09 MGCP ECUs are compliant with J1939 OBD-M, supporting the Diagnostic Messages above as well as user indicators and CAN data defined in the OBD-M protocol. Faults available for broadcast and their respective SPN/FMI numbers are dependent on the application and engine calibration.

The data capture at the occurrence of a fault, known in the ECM as fault snapshot (FSS), is available upon DM4 request. The following bytes are supported for DM4 if configured in the ECM software:

- Byte 1: Freeze Frame Length
- Byte 2-6: SPN, FMI, SPN Conversion Method, and Occurrence
- Byte 7: Manifold Absolute Pressure
- Byte 8-9: Engine Speed
- Byte 10: Engine Load (MAP based estimate)
- Byte 11: Engine Coolant Temperature
- Byte 14: # of starts since fault was last active
- Byte 15: Index into FSS_storage table for Fault Snap Shot retrieval

Resetting active and previously active DTCs is handled through DM11 and DM3, respectively. DM1 and DM2 lamp indicators are assigned to each fault based on the fault's diagnostic action as defined in the calibration. The lamps are assigned based on the configuration outlined in Table 1.

Table 1: J1939 Diagnostic Lamp Configuration

ECI Diagnostic Action	J1939 Lamp
MIL	MIL
Soft Warning	Amber
Hard Warning, Low Rev Limit, Shutdown	Red Stop
Power Derate 1 & 2	Protect
Forced Idle	None (use in combination with other action)

Diagnostic Calibration Configuration and Corrective Actions

Each fault within the GCP is capable of being uniquely configured in the engine's diagnostic calibration to cause one or more corrective actions while a given fault is active. Table 2 identifies the configuration options and corrective actions available for configuration of each fault. The desired action is set by the OEM calibration engineers.

Table 2: Diagnostic Corrective Actions

Corrective Action	Description
Enable	Enables the fault for fault detection
Shutdown	Cause an engine shutdown when fault becomes active
Never Forget	Retain fault as historic/previously active until cleared by a technician and does not allow historic fault to be "auto-cleared"
Turn on MIL	Turn on MIL output when fault becomes active
CL Disable	Disable closed-loop while the fault is active
CL Disable Key- Cyc	Disable closed-loop while the fault is active and for the remainder of the key cycle
AL Disable	Disable adaptive learn while the fault is active
AL Disable Key-Cyc	Disable adaptive learn while the fault is active and for the remainder of the key cycle
Power Derate 1	Limit TPS to the Power Derate 1 percent set in the diagnostic calibration while the fault is active. The Power Derate 1 TPS percent should be set higher than Power Derate 2 as Power Derate 2 adds a higher level of protection.
Power Derate 2	Limit TPS to the Power Derate 2 percent set in the diagnostic calibration while the fault is active. If the calibration is set to "Latched for Key-Cycle" Power Derate 2 remains active until engine speed and FPP conditions are satisfied. The Power Derate 2 TPS percent should be set lower than Power Derate 1 as Power Derate 2 adds a higher level of protection.
Low Rev Limit	Limit RPM to the Low Rev Limit speed set in the diagnostic calibration while the fault is active. If the calibration is set to "Latched for Key-Cycle" Low Rev Limit remains active until engine speed and FPP conditions are satisfied.
Forced Idle	Limit RPM to the Forced Idle speed set in the diagnostic calibration while the fault is active and for the remainder of the key cycle
Soft Warning	Turn on the soft warning output when the fault becomes active
Hard Warning	Turn on the hard warning output when the fault becomes active
Stopped Check	Run fault detection/checking while the engine is in a key-on, engine-off condition. NOTE: It is recommended that this feature only be used for general sensor faults (high/low voltage) and some output drivers

4 Pinout Details 80 Pin ECM

Pin	ECM	Description
J1-01	CRK_POS	populated - internal CRK_NEG connection to ground renders this input single ended Hall-effect only
J1-02	CRK_NEG	tied to internal analog ground
J1-03	5V_rtn	analog ground
J1-04	5V_ext1	standard 5V sensor excitation - 200mA capacity
J1-05	FPUMP_LS	0.5A LS saturation fuel pump relay control
J1-06	MIL	0.5A LS saturation MIL
J1-07	BUZZ	0.5A LS saturation buzzer control
J1-08	RELAY_LS	0.5A LS saturation power relay control
J1-09	TACH	LS switch to ground for pulse output - internal 2.21K pullup to Vsw
J1-10	AUX_PWM8	0.5A LS saturation aux PWM 8 - unused
J1-11	Vrelay	relay switched Vbat - reverse battery protected
J1-12	DBW-	+/- 6.5A peak, 3.5A continuous DBW control H-bridge
J1-13	DBW+	+/- 6.5A peak, 3.5A continuous DBW control H-bridge
J1-14	AUX_PWM5_HS+Recirc	- 2A HS saturation aux PWM 5 WITH 2A recirc to ground – LY6 cam phaser
J1-15	AUX_PWM3	4A LS saturation - cruise or throttle-override indicator output
J1-16	AUX_PWM6+Recirc	4A LS saturation aux PWM6 WITH 2A recirc to Vrelay - unused
J1-17	EGOH_4	4A LS saturation EGO heater 4 PWM
J1-18	INJ5_LS	injector driver 5 - saturation
J1-19	INJ7_LS	injector driver 7 - saturation
J1-20	INJ2_LS	injector driver 2 - saturation
J1-21	Ground	power ground
J1-22	COIL1b	spark driver 5 - logic 5V output
J1-23	COIL2b	spark driver 6 - logic 5V output
J1-24	COIL3b	spark driver 7 - logic 5V output
J1-25	COIL4b	spark driver 8 - logic 5V output
J1-26	Vswitch	key-on/start/run +12V switched power
J1-27	TPS1	100K pulldown 0-5V TPS1
J1-28	TPS2	100K pulldown 0-5V TPS2
J1-29	AUX_ana_PU3	2.21K pullup 0-5V aux analog PU3 - Trans Temp
J1-30	AUX_ana_PU2	2.21K pullup 0-5V aux analog PU2 - Perfect Pass Request
J1-31	AUX_ana_PU1	2.21K pullup 0-5V aux analog PU1 - master/slave
J1-32	RS	populated – single ended Hall-effect input
J1-33	FPP1	100K pulldown 0-5V FPP1
J1-34	FPP2/IVS	22.1K pullup 0-5V FPP2
J1-35	MAP	100K pulldown 0-5V MAP
J1-36	IAT	2.21K pullup 0-5V IAT
J1-37	OILP	22.1K pullup 0-5V oil pressure switch/sender input
J1-38	ECT	2.21K pullup 0-5V ECT
J1-39	INJ6_LS	injector driver 6 - saturation
J1-40	Ground	power ground
J1-41	KNK1+	knock channel 1+ - high-gain (3x) for flat response sensors
J1-42	KNK1-	knock channel 1- - high-gain (3x) for flat response sensors
J1-43	GOV2/PD2	0-28.4V digital input open-circuit signal of 2.74V governor select 2 (cruise dec)
J1-44	COIL4a	spark driver 4 - logic 5V output

J1-45	COIL3a	spark driver 3 - logic 5V output
J1-46	COIL2a	spark driver 2 - logic 5V output
J1-47	COIL1a	spark driver 1 - logic 5V output
J1-48	CAM1	populated - single ended Hall-effect input
J1-49	AUX_ana_PUD5	2.21K pullup 0-5V aux analog PUD5 - unused
J1-50	AUX_ana_PUD4	1.00K pullup 0-5V aux analog PUD4 – fuel level (SC - resistance sender)
J1-51	AUX_ana_PUD3	22.1K pullup 0-5V aux analog PUD3 – Perfect Pass VGOV
J1-52	AUX_DIG3/PUD7	0-28.4V digital input with 4.99K pulldown aux digital 3 - START input trigger
J1-53	AUX_DIG2	0-28.4V digital input open-circuit signal of 2.74V aux digital 2 - cruise enable
J1-54	AUX_DIG1	0-28.4V digital input open-circuit signal of 2.74V aux digital 1 - oil level switch
J1-55	EGO4	EGO sensor 4
J1-56	EGO3	EGO sensor 3
J1-57	EGO2	EGO sensor 2
J1-58	EGO1	EGO sensor 1
J1-59	Vbat	battery +12V continuous power
J1-60	Ground	power ground
J1-61	KNK2+	knock channel 2+ - high-gain (3x) for flat response sensors
J1-62	KNK2-	knock channel 2- - high-gain (3x) for flat response sensors
J1-63	GOV1/PD3	0-28.4V digital input open-circuit signal of 2.74V governor select 1 (cruise inc)
J1-64	CAN1-	populated
J1-65	CAN1+	populated - with 120 ohm termination to CAN1-
J1-66	5V_rtn	analog ground
J1-67	5V_ext2	secondary 5V sensor excitation - 200mA capacity
J1-68	CAN2-	populated
J1-69	CAN2+	populated - with 120 ohm termination to CAN2-
J1-70	AUX_ana_PD1	100K pulldown 0-5V aux analog PD1 - Fuel Level (0-5V sensor - MC)
J1-71	AUX_PWM1	LS resistance sender gauge driver 1, 0-147mA range
J1-72	AUX_PWM2	LS resistance sender gauge driver 2, 0-147mA range
J1-73	AUX_PWM4	4A LS saturation aux PWM 4 – starter relay LS
J1-74	EGOH_1	4A LS saturation EGO heater 1 PWM
J1-75	EGOH_2	4A LS saturation EGO heater 2 PWM
J1-76	EGOH_3	4A LS saturation EGO heater 3 PWM
J1-77	INJ3_LS	injector driver 3 - saturation
J1-78	INJ4_LS	injector driver 4 - saturation
J1-79	INJ8_LS	injector driver 8 - saturation
J1-80	INJ1_LS	injector driver 1 - saturation

INDMAR ECM 120 Way

PIN	Function	Color	PIN	Function	Color	PIN	Function	Color	PIN	Function	Color
1	Coil 1	YW/BK	31	Coil 5	WE/OE	61	Coil 3	YW/RD	91	NA	
2	Coil 6	GN/YW	32	Coil 2	YW/TN	62	Coil 4	TN/YW	92	NA	
3	Coil 8	WE/RD	33	CamPhase2	BK/PE	63	Pre O2 1	LTBE/OE	93	Coil 7	YW/LTBE
4	Fuel Press	WE/LTGN	34	Start Out	YW/RD	64	Pre O2 2	LTBE/RD	94	Ground	BK
5	NA		35	Fuel Pump	OE/BE	65	Post O2 1	LTBE/WE	95	Injector 1	TN
6	NA		36	Power Relay	WE/LTBE	66	Post O2 2	GN/PE	96	Injector 5	WE
7	Fuel Level	PK	37	Air Temp	YW/GY	67	Buzzer	TN/RD	97	Injector 4	TN/RD
8	NA		38	Head Temp	TN/WE	68	MIL	TN/BK	98	Injector 8	GY/YW
9	Water Flow	WE/TN	39	TPS1	PE/LTBE	69	Master	YW	99	Injector 6	BN/YW
10	NA		40	TPS2	LTBE/BE	70	NA		100	Injector 3	BN/LTBE
11	NA		41	MAP	LTGN	71	Tran Temp	TN/BK	101	Injector 7	TN/BK
12	NA		42	PPS1	LTBE/BK	72	Cruise +	PK/BK	102	Injector 2	LTGN/OE
13	NA		43	PPS2	LTBE/YW	73	Cruise -	PK/WE	103	NA	
14	CAN +	BE/PK	44	Oil Press	GN/WE	74	NA		104	NA	
15	CAN -	BE/WE	45	Ignition	PE	75	NA		105	Temp Gauge	TN
16	NA		46	Pre O2 1	GY/LTBE	76	5V 2 Pos	LTGN/PE	106	Oil Gauge	LTBE
17	NA		47	Pre O2 2	OE/LTGN	77	5V 2 Gnd	LTGN/BK	107	CamPhase1	RD/WE
18	Paddle	GN/RD	48	Post O2 1	OE	78	NA		108	Ground	BK
19	5V Pos	LTGN/RD	49	Post O2 2	GN/WE	79	NA		109	NA	
20	5V Gnd	BK/LTGN	50	Pre O2 1	RD/BK	80	NA		110	NA	
21	Crank +	PE/WE	51	Pre O2 1	BK/RD	81	NA		111	NA	
22	Crank -	WE/PE	52	Pre O2 1	OE/RD	82	NA		112	NA	
23	CAM1 +	GY/BN	53	Pre O2 2	RD/YW	83	Oil Level	TN/RD	113	NA	
24	CAM1 -	PE/OE	54	Pre O2 2	TN/GN	84	Cruise	TN/WE	114	NA	
25	CAM2 +	GY/WE	55	Pre O2 2	TN/LTBE	85	NA		115	NA	
26	CAM2 -	GY/BK	56	NA		86	Start In	YW/RD	116	ETC -	TN/OE
27	Knock1 +	BK/YW	57	NA		87	NA		117	ETC +	PK/WE
28	Knock1 -	BK	58	Battery	RD/TN	88	Cruise Ind	LTGN/BK	118	NA	
29	Knock2 +	BK/WE	59	NA		89	Tach	GY	119	NA	
30	Knock2 -	BK	60	Relay Sense	PK/GN	90	NA		120	Ground	BK

Color Chart:

BE	Blue
BK	Black
BN	Brown
GN	Green
GY	Gray
OE	Orange

PE	Purple
PK	Pink
RD	Red
TN	Tan
WE	White
YW	Yellow

Modifier:

LT	Light

5 Diagnostic Tests

The GCP engine control module for spark-ignited engine applications incorporates a set of eleven (11) diagnostic tests that perform specific functions used as an aid for verifying proper engine control. This section describes the tests supported, test states, and operating criteria for each test.

Diagnostic tests are software selectable and can be initiated via CAN using CCP.

5.1 Spark Kill Test

"Coil X" disables individual cylinders at any operating condition for the duration defined in calibration or until released through software. 'Spark Kill' may be used in conjunction with 'Injector Kill' to disable two cylinders at any given time. Upon a state change from one cylinder to another, the test sequence will automatically re-enable the first coil prior to disabling the selected coil. This test reverts to normal operation if "Normal" state is selected, ignition voltage is cycled from high to low, or the calibrated timeout expires.

⚠ ***NOTE: This test should not be initiated prior to the "Injector Kill" test when the engine is equipped with a catalyst. If performed while the injector for the selected cylinder is firing, raw-unburned fuel and air will be present in the exhaust and will react in the catalyst resulting in extremely high catalyst substrate temperatures which can cause wash coat or substrate damage and failure.***

States

1) Normal: State of normal operation
2) Coil 1: Disables coil or spark for cylinder 1 in firing order or block order
3) Coil 2: Disables coil or spark for cylinder 2 in firing order or block order
4) Coil 3: Disables coil or spark for cylinder 3 in firing order or block order
5) Coil 4: Disables coil or spark for cylinder 4 in firing order or block order
6) Coil 5: Disables coil or spark for cylinder 5 in firing order or block order
7) Coil 6: Disables coil or spark for cylinder 6 in firing order or block order
8) Coil 7: Disables coil or spark for cylinder 7 in firing order or block order
9) Coil 8: Disables coil or spark for cylinder 8 in firing order or block order

Monitored Status

1) Test not started
2) Test is running
3) Test finished (timeout achieved)
4) ~~Error: Pre-condition 1 not fulfilled~~
5) ~~Error: Pre-condition 2 not fulfilled~~
6) ~~Error: Pre-condition 3 not fulfilled~~
7) ~~Error: Pre-condition 4 not fulfilled~~
8) Cannot start test

5.2 Injector Kill Test

"Inj X" disables individual cylinders at any operating condition for the duration defined in calibration or until released through software. 'Injector Kill' may be used in conjunction with 'Spark Kill' to disable two cylinders at any given time. Upon a state change from one cylinder to another, the test sequence will automatically re-enable the first injector prior to disabling the selected injector. Reverts to normal operation if "Normal" state is selected, ignition voltage is cycled from high to low, or the calibrated timeout expires.

NOTE: This test should not be initiated at high loads or for more than five (5) seconds if the engine is equipped with a catalyst. If done so, a large quantity of oxygen will fuel undesirable reactions in the catalyst resulting in extremely high catalyst substrate temperatures which can cause wash coat or substrate damage and failure.

States

1) Normal: State of normal operation
2) Inj 1: Disables injector 1 in firing order or block order
3) Inj 2: Disables injector 2 in firing order or block order
4) Inj 3: Disables injector 3 in firing order or block order
5) Inj 4: Disables injector 4 in firing order or block order
6) Inj 5: Disables injector 5 in firing order or block order
7) Inj 6: Disables injector 6 in firing order or block order
8) Inj 7: Disables injector 7 in firing order or block order
9) Inj 8: Disables injector 8 in firing order or block order

Monitored Status

1) Test not started
2) Test is running
3) Test finished (timeout achieved)
4) ~~Error: Pre-condition 1 not fulfilled~~
5) ~~Error: Pre-condition 2 not fulfilled~~
6) ~~Error: Pre-condition 3 not fulfilled~~
7) ~~Error: Pre-condition 4 not fulfilled~~
8) Cannot start test

5.3 Injector Fire Test

"Inj X" activates a selected injector for a finite duration with the engine in the "Stopped" state only. Upon initiation of the test, the fuel pump relay will remain disabled and the injector will fire. The injector on-time will be calibrated in software to allow a noticeable pressure drop at the fuel rail. The test reverts to normal operation if the "Normal" state is selected, ignition voltage is cycled from high to low, engine speed is sensed, or the calibrated timeout expires. Once an injector on test has been run, subsequent injectors may only be activated/tested after the engine has achieved *X* cranking revolutions (as defined in calibration) and the engine has stopped. This test may not be run in conjunction with a Spark Fire or Compression test.

States

1) Disabled: State of normal operation
2) Inj 1: Activates injector 1 in firing order or block order
3) Inj 2: Activates injector 2 in firing order or block order
4) Inj 3: Activates injector 3 in firing order or block order
5) Inj 4: Activates injector 4 in firing order or block order
6) Inj 5: Activates injector 5 in firing order or block order
7) Inj 6: Activates injector 6 in firing order or block order
8) Inj 7: Activates injector 7 in firing order or block order
9) Inj 8: Activates injector 8 in firing order or block order

Monitored Status

1) Test not started
2) Test is running
3) Test finished (timeout is reached)
~~4) Error: Pre-condition 1 not fulfilled~~
~~5) Error: Pre-condition 2 not fulfilled~~
~~6) Error: Pre-condition 3 not fulfilled~~
~~7) Error: Pre-condition 4 not fulfilled~~
8) Cannot start test (engine speed is sensed or engine needs to crank)

5.4 Spark Fire Test

"Coil X" activates a selected coil for X seconds (defined in calibration) with the engine in the "Stopped" state only. The coil will be fired at a rate equivalent to 1600 RPM/14.5 psi. The test reverts to normal operation if the "Normal" state is selected, ignition voltage is cycled from high to low, engine speed is sensed, or the calibrated timeout expires. This test will not run in conjunction with a Compression test or following an Injector Fire test.

States

1) Disabled: State of normal operation
2) Coil 1: Activates Coil 1 in firing order or block order
3) Coil 2: Activates Coil 2 in firing order or block order
4) Coil 3: Activates Coil 3 in firing order or block order
5) Coil 4: Activates Coil 4 in firing order or block order
6) Coil 5: Activates Coil 5 in firing order or block order
7) Coil 6: Activates Coil 6 in firing order or block order
8) Coil 7: Activates Coil 7 in firing order or block order
9) Coil 8: Activates Coil 8 in firing order or block order

Monitored Status

1) Test not started
2) Test is running
3) Test finished (timeout is reached)
~~4) Error: Pre-condition 1 not fulfilled~~
~~5) Error: Pre-condition 2 not fulfilled~~
~~6) Error: Pre-condition 3 not fulfilled~~

~~7)Error: Pre-condition 4 not fulfilled~~
~~8)~~ Cannot start test (speed is sensed)

NOTE: This test should not be initiated on gaseous fueled engines in which gaseous fuel may be present in the combustion chamber, intake, or exhaust. If using this test is desirable on gaseous fueled engines, remove the spark plug wires from all spark plugs, install a spark plug tester in the desired spark plug wire and initiate the test.

5.5 DBW Test

Permits full-authority operation of an electronic throttle via the throttle command input while the engine is in the “Stopped” state only. Reverts to normal operation if “Off” state is selected, ignition voltage is lost, or engine speed is sensed.

NOTE: Ensure that the foot pedal position sensor/electronic throttle control input is at 0% or idle prior to starting/operating the engine. While this test mode will revert to disabled when engine speed is sensed, the throttle command will follow the FPP % commanded by the sensor causing the engine to accelerate.

States
1) Off: State of normal operation
2) Enabled: Enables full authority control of an electronic throttle

Monitored Status
1) Test not started
2) Test is running
3) Test finished
4)~~Error: Pre-condition 1 not fulfilled~~
~~5) Error: Pre-condition 2 not fulfilled~~
~~6) Error: Pre-condition 3 not fulfilled~~
~~7) Error: Pre-condition 4 not fulfilled~~
8) Cannot start test (speed is sensed)

5.6 External Power Test

Manually activates relays (relay power, fuel pump, and drive-by wire power) controlled by the ECM while the engine is in the “Stopped” or “Running” states. Reverts to normal operation if “Automatic” state is selected or ignition voltage is cycled from high to low.

States
1) Automatic: State of normal operation
2) Relay On: Activates relay power (injector and coil high-side power)
3) All On: Activates fuel pump and relay power

Monitored Status

1) Test not started
2) Test is running
3) Test finished

4)~~Error: Pre-condition 1 not fulfilled~~
~~5) Error: Pre-condition 2 not fulfilled~~
~~6) Error: Pre-condition 3 not fulfilled~~
~~7) Error: Pre-condition 4 not fulfilled~~

8) Cannot start test (no ignition voltage)

5.7 Compression Test

Disables all coils and injectors permitting cylinder compression testing. To prevent against firing coils and injectors in the event of a microprocessor reboot during low voltage cranking, the test state will be burned into EEPROM. In addition, EControls Inc. requires that the relay power fuse be removed. This test may only be activated while the engine is in the “Stopped” state. Test reverts to normal operation only when the “Normal” state is selected. This test may be initiated by selecting “Enabled” in the software or through use of a switched hardware input. This test may not be run in conjunction with Spark Fire or Injector Fire tests.

NOTE: Due to the liability of initiating a compression test in software, EControls Inc. burns this test state into EEPROM. As a result, this test must manually be disabled by the operator through software. EControls Inc. recommends that this test only be performed while the vehicle is in an appropriate location in the event that the diagnostic PC has a low-battery condition that may not permit re-enabling normal operation.

States

1) Disabled: State of normal operation
2) Active: Enables compression test mode

Monitored Status

1) Test not started
2) Test is running
3) Test finished

4)~~Error: Pre-condition 1 not fulfilled~~
~~5) Error: Pre-condition 2 not fulfilled~~
~~6) Error: Pre-condition 3 not fulfilled~~
~~7) Error: Pre-condition 4 not fulfilled~~

8) Cannot start test (engine run speed is sensed > than crank speed)

NOTE: Due to the personal and property liability exposure with such a test, EControls requires that the diagnostic/service manual specifically identifies that removal of the coil and injector high-side relay and/or fuse(s) is required during a compression test. If procedures are not written that require removal of the relay power relay or fuse(s) and the test will only be

enable through software, EControls Inc. will require a written release-of-liability against human liability and property damage.

5.8 Spark Advance Test

Commands a calibrated base spark advance if engine speed and manifold pressure are below a calibrated limit. If engine is operated above the calibrated operating limit, base spark advance as set in the normal calibration will be used until the engine set point falls below the calibrated limit. This test may be initiated by selecting "Enabled" in the software or through use of a switched hardware input. The test reverts to normal operation when "Normal" state is selected or when ignition voltage is cycled from high to low.

States

1) Disabled: State of normal operation
2) Active: Sets spark timing to a calibrated default spark advance

Monitored Status

1) Test not started
2) Test is running
3) Test finished
4) ~~Error: Pre-condition 1 not fulfilled ("RPM/MAP too high)~~
~~5) Error: Pre-condition 2 not fulfilled~~
~~6) Error: Pre-condition 3 not fulfilled~~
~~7) Error: Pre-condition 4 not fulfilled~~
8) Cannot start test

5.9 Idle Speed Command

Commands a temporary idle speed, up to X RPM as defined in calibration through modulation of an electronic throttle. Reverts to normal operation when "Normal" state is selected, a throttle command input (for electronic throttle engines) above X% (defined in calibration) is detected or ignition voltage is cycled from high to low.

States

1) Disabled: State of Normal operation
2) Active: Enables manual entry of engine speed into a speed entry field
3)

Monitored Status

1) Test not started
2) Test is running
3) Test finished (TPS or TCP % above limit is detected during test)
~~4) Error: Pre-condition 1 not fulfilled~~
~~5) Error: Pre-condition 2 not fulfilled~~
~~6) Error: Pre-condition 3 not fulfilled~~
~~7) Error: Pre-condition 4 not fulfilled~~
8) Cannot start test (TPS or TCP % above limit is detected)

NOTE: ECI will not permit programmed idle speeds above 800 RPM without a written release-of-liability if the engine is not equipped with a transmission position sensor.

5.10 Fuel/Spark Inhibit Input

Disables triggering of spark and injection of fuel when the input (analog or digital) selected meets the calibrated state. This is often linked to the fuel select switch as a neutral mode.

States

1) Disabled
2) Aux PU1 = Gnd
3) Aux PU2 = Gnd
4) Aux PU3 = Gnd
5) Aux DIG1 = Gnd
6) Aux DIG1 = V+
7) Aux DIG2 = Gnd
8) Aux DIG2 = V+
9) Aux DIG3 = Gnd
10) Aux DIG3 = V+
11) Aux DIG4 = Gnd
12) Aux DIG4 = V+
13) Aux DIG1 = Open
14) Aux DIG2 = Open
15) Aux DIG3 = Open
16) Aux DIG4 = Open

Monitored Status

1) Inactive/Normal: Test is inactive, state of normal operation
2) Active/Shutdown: Test is active and system will not inject fuel or trigger spark

5.11 Closed-Loop Test

Tests the closed-loop fueling feedback system to verify that exhaust gas oxygen sensors are properly functioning and are providing reliable information. The test runs in the order defined below and aborts if at anytime an error/fault is identified, the throttle input is elevated, or the operator requests the test to STOP. Aborting the test due to identification of an error/fault requires that the service technician addresses the identified error and then repeats the test to fully validate the system.

1. **Enable Strategy and HEGO Sensors (*CL Test State*= Pre-cat init test)**

    a. The test mode is entered by selecting START from EDIS. Once initiated, the user must acknowledge two prompts prior to the test running. These prompts require that the vehicle be in neutral or park and notify the user that the engine speed will increase to run the test. Answering YES to both of these prompts will initiate the test.

NOTE: ECI requires that 3rd party diagnostic scan tools also use similar prompts to notify the operator to ensure idle or park is selected and to notify that an elevated speed will be commanded during the test.

a. Govern engine to X RPM as defined in the calibration. NOTE: Test disables if FPP% exceeds the % used in Idle Speed Command Test (Tidlspd_FPP_max)

b. Turn all configured EGO heaters on according to 'EGOZ Heater-Control Target Impedance / Voltage Limit Schedule'.

   NOTE: EGO heater control during this phase uses the run time and heater impedance target schedule, including the heater voltage limits, until the heaters are operating at the final impedance target.

c. *CL pre-cat test status* will indicate "Test Running" through steps 2-3.

2. Pre-Catalyst EGO Heater Diagnosis (*CL Test State*= Pre-cat heater & pre-cat power test)

- *The purpose of this portion of the test is:*

   1. *To validate that the pre-catalyst EGO heater element(s) are capable of heating the sense element(s) to a useable state.*

   2. *To validate that the pre-catalyst sense element(s) are operating at the desired temperature.*

a. Monitor EGO impedance feedback and verify impedance ≤ 'EGO impedance active threshold'; this stage runs up to the maximum run time in the 'EGOZ Heater-Control Target Impedance / Voltage Limit Schedule' + 'EGO Heater Additional Wait Time'. If this check fails for any of the pre-catalyst sensors the *CL pre-cat test status* will indicate "Pre or Post-cat EGO Lazy" and the appropriate EGO Lazy fault for the sensor(s) is set.

b. In addition, the system monitors EGO impedance feedback and verifies that impedance is equal to the fully warm ‘EGOZ Impedance Target’ + ‘EGO Heater Impedance Max Error’. If any EGO impedance fails to reach the final target plus the impedance error tolerance the heater power is deemed low , the *CL pre-cat test status* “Pre-cat EGO Power Low” is generated, and the appropriate EGO Lazy fault for the sensor(s) is set. Once all pre-catalyst EGOs have reached the active threshold ('Pre-cat EGO impedance active threshold) the closed-loop system is activated and fueling perturbation begins at the nominal fueling target defined in the test setup parameters.

3. Pre-Catalyst EGO Sensor Check (*CL Test State*= Pre-cat voltage test & Pre-cat BM test)

- *The purpose of this portion of the test is:*

  1. *To validate that the pre-catalyst EGO sensor feedback is perturbating and providing feedback that correlates to commanded fueling excursions.*

  2. *Attempt to identify leaks within the pre-catalyst sensor assembly and/or the exhaust system and/or identify significant fuel delivery problems.*

a. Once all pre-catalyst EGOs have reached the active threshold ('Pre-cat EGO impedance active threshold’) closed-loop is activated and fueling perturbation begins at the nominal fueling target defined in the test setup parameters. During this time, adaptive learn is disabled and the fueling error is monitored (CL_BM). Once the closed-loop system validates a certain number of EGO switches, the total fueling correction (CL_BM+A_BM) is compared to allowable fueling correction limit for the test (‘CL + adapt multiplier max value’).

b. If the fueling correction is within the limits defined in the calibration, the *CL pre-cat test status* will indicate “Test Finished: Passed.”

c. This portion of the test will fail if the EGO fails to generate the required number of switching cycles or if the fueling correction is outside of the acceptable limits. The *CL pre-cat test status* will indicate “Pre-cat EGO non-responsive” or “Pre-cat EGO fueling error” status, respectively. In addition, the appropriate “Closed-Loop High/Low” fault will be generated if this check fails.

4. Post-Catalyst EGO Heater Diagnosis (*CL Test State*= Post-cat heater test & post-cat power test)

- *The purpose of this portion of the test is:*

  1. *To validate that the post-catalyst EGO heater element(s) are capable of heating the sense element(s) to a useable state.*

  2. *To validate that the post-catalyst sense element(s) are operating at the desired temperature.*

a. Upon successful completion of the pre-catalyst EGO test checks, the system begins to monitor the post-catalyst sensor(s). The first check is to monitor EGO impedance feedback and verify impedance ≤ ‘EGO impedance active threshold’; this stage runs up to the maximum run time in the ‘EGOZ Heater-Control Target Impedance / Voltage Limit Schedule’ + ‘EGO Heater Additional Wait Time’. If this check fails for any of the post-catalyst sensors the *CL post-cat test status* will indicate “Post-cat EGO Lazy” and the appropriate EGO Lazy fault for the sensor(s) is set.

b. In addition, the system monitors EGO impedance feedback and verifies that impedance is equal to the fully warm ‘EGOZ Impedance Target’ + ‘EGO Heater Impedance Max Error’. If any EGO impedance fails to reach the final target plus the impedance error tolerance the heater power is deemed low , the *CL post-cat test status* “Post-cat EGO Power Low” is generated, and the appropriate EGO Lazy fault for the sensor(s) is set. Once all post-catalyst EGOs have reached the active threshold ('Post-cat EGO impedance active threshold) the rich/lean test is run on the post-catalyst sensors.

5. Post-Catalyst EGO Sensor Check (*CL Test State*= Post-cat rich test & Post-cat lean test)

- *The purpose of this portion of the test is:*

  1. *To validate that the post-catalyst EGO sensor feedback is changing as a result of significant changes in pre-catalyst fueling.*

a. Command nominal fueling while applying the fueling multiplier(s) generated during the ‘CL pre-cat voltage test’ mode (step 3a).

b. Command a rich open-loop fueling command as defined in the calibration and monitor the post-catalyst EGO voltage feedback to verify that the sensor’s rich feedback is within tolerance.

c. Command a lean open-loop fueling command as defined in the calibration and monitor the post-catalyst EGO voltage feedback to verify that the sensor’s lean feedback is within tolerance.

d. If the post-catalyst EGO voltage feedback is within the limits defined in the calibration, the *CL post-cat test status* will indicate “Test Finished: Passed” and the *CL Test State* will indicate “Finished.” If post-cat voltage(s) fall outside of the rich/lean limits, *CL post-cat test status* will indicate “Post-cat EGO Rich Failure” or “Post-cat EGO Lean Failure” and the EGO Lazy fault will be set for the appropriate sensor, respectively.

The engine will return to idle upon completion or abortion of the of the closed-loop diagnostic test.

NOTE: Be sure to check CL Test State, CL pre-cat test status, and CL post-cat test status to determine if the test was successful. If the test failed for ANY reason, faults will be displayed and configured system alarm(s) (soft warning, hard warning, or MIL) will be generated. Technicians should clear faults after running the Closed-Loop Test.

States (CL Test State)

1) Inactive
2) Pre-cat init test
3) Pre-cat heater test
4) Pre-cat power test

5) Pre-cat voltage test
6) Pre-cat BM test
7) Post-cat heater test
8) Post-cat power test
9) Post-cat rich test
10) Post-cat lean test
11) Finished
12) Invalid

Pre-Catalyst Monitored Status (CL Pre-Cat Test Status)

1) Test Not Started
2) Test Running
3) Test Finished: Passed
4) Pre-cat EGO Lazy (generates appropriate EGO Lazy fault)
5) Pre-cat EGO Power Low
6) Pre-cat EGO non-responsive
7) Pre-cat EGO fueling error
8) Cannot start test (FPP or TCP % above limit is detected)

Post-Catalyst Monitored Status (CL Post-Cat Test Status)

1) Test Not Started
2) Test Running
3) Test Finished: Passed
4) Post-cat EGO Lazy (generates appropriate EGO Lazy fault)
5) Post-cat EGO Power Low
6) Post-cat EGO Rich Failure
7) Post-cat EGO Lean Failure
8) Cannot start test (FPP or TCP % above limit is detected)

6 Diagnostic Trouble Code Fault Descriptions

LDGCP and MGCP header pins are in standard font, HDGCP and MDGCP header pins are in italicized parentheses *(##).*

6.1 SPN & FMI to DTC Conversion Table

Indmar	DTC Configurations

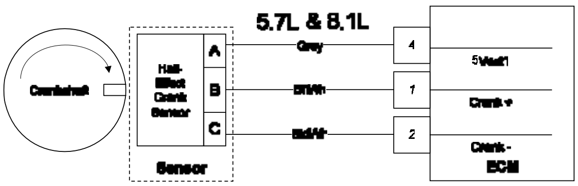
SPN	FMI	DTC Code	Description
29	3	DTC 2128	FPP2 voltage high
29	4	DTC 2127	FPP2 voltage low
51	3	DTC 123	TPS1 voltage high
51	4	DTC 122	TPS1 voltage low
51	0	DTC 221	TPS1-2 higher than expected
51	1	DTC 121	TPS1-2 lower than expected
51	7	DTC 2112	Unable to reach higher TPS
51	7	DTC 2111	Unable to reach lower TPS
51	31	DTC 2135	TPS1/2 simultaneous voltages out-of-range
84	8	DTC 502	Roadspeed input loss of signal
91	3	DTC 2122	FPP1 voltage high
91	4	DTC 2123	FPP1 voltage low
91	16	DTC 2126	FPP1-2 higher than expected
91	18	DTC 2121	FPP1-2 lower than expected
91	31	DTC 1121	FPP1/2 simultaneous voltages out-of-range (redundancy lost)
91	19	DTC 1630	J1939 ETC message receipt loss
100	1	DTC 524	Oil pressure low
100	1	DTC 524	Oil pressure sender low pressure
100	0	DTC 521	Oil pressure sender high pressure
100	3	DTC 523	Oil pressure sender high voltage
100	4	DTC 522	Oil pressure sender low voltage
102	3	DTC 238	TIP/TOP high voltage
102	4	DTC 237	TIP/TOP low voltage
102	0	DTC 234	Boost control overboost failure
102	1	DTC 299	Boost control underboost failure
102	2	DTC 236	TIP/TOP active
105	3	DTC 113	IAT voltage high
105	4	DTC 112	IAT voltage low
105	15	DTC 111	IAT higher than expected stage 1
105	0	DTC 127	IAT higher than expected stage 2
106	16	DTC 108	MAP pressure high
106	4	DTC 107	MAP voltage low
108	0	DTC 2229	BP pressure high
108	1	DTC 129	BP pressure low
110	3	DTC 118	ECT voltage high
110	4	DTC 117	ECT voltage low
110	15	DTC 116	ECT higher than expected stage 1
110	0	DTC 217	ECT higher than expected stage 2

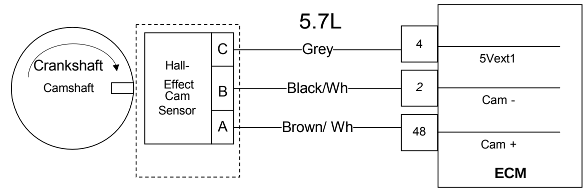
168	15	DTC 563	Vbat voltage high
168	17	DTC 562	Vbat voltage low
515	16	DTC 1111	RPM above fuel rev limit level
515	0	DTC 1112	RPM above spark rev limit level
628	13	DTC 601	Microprocessor failure - FLASH
629	31	DTC 606	Microprocessor failure - COP
629	31	DTC 1612	Microprocessor failure - RTI 1
629	31	DTC 1613	Microprocessor failure - RTI 2
629	31	DTC 1614	Microprocessor failure - RTI 3
629	31	DTC 1615	Microprocessor failure - A/D
629	31	DTC 1616	Microprocessor failure - Interrupt
630	12	DTC 604	Microprocessor failure - RAM
636	2	DTC 336	CRANK input signal noise
636	8	DTC 16	Crank and/or cam could not synchronize during start
636	4	DTC 337	Crank signal loss
639	12	DTC 1626	CAN-J1939 Tx fault
639	12	DTC 1627	CAN-J1939 Rx fault
645	4	DTC 2618	Tach output ground short
645	3	DTC 2619	Tach output short to power
651	5	DTC 261	Injector 1 open or short to ground
651	6	DTC 262	Injector 1 coil shorted
652	5	DTC 264	Injector 2 open or short to ground
652	6	DTC 265	Injector 2 coil shorted
653	5	DTC 267	Injector 3 open or short to ground
653	6	DTC 268	Injector 3 coil shorted
654	5	DTC 270	Injector 4 open or short to ground
654	6	DTC 271	Injector 4 coil shorted
655	5	DTC 273	Injector 5 open or short to ground
655	6	DTC 274	Injector 5 coil shorted
656	5	DTC 276	Injector 6 open or short to ground
656	6	DTC 277	Injector 6 coil shorted
657	5	DTC 279	Injector 7 open or short to ground
657	6	DTC 280	Injector 7 coil shorted
658	5	DTC 282	Injector 8 open or short to ground
658	6	DTC 283	Injector 8 coil shorted
695	9	DTC 1629	J1939 TSC1 message receipt loss
701	3	DTC 1511	AUX analog Pull-Up 1 high voltage
701	4	DTC 1512	AUX analog Pull-Up 1 low voltage
702	3	DTC 1513	AUX analog Pull-Up 2 high voltage
702	4	DTC 1514	AUX analog Pull-Up 2 low voltage
703	3	DTC 1517	AUX analog Pull-Up 3 high voltage
703	4	DTC 1518	AUX analog Pull-Up 3 low voltage
710	3	DTC 1515	AUX analog Pull-Down 1 high voltage
710	4	DTC 1516	AUX analog Pull-Down 1 low voltage
723	4	DTC 342	Loss of CAM input signal
723	2	DTC 341	CAM input signal noise
731	4	DTC 327	Knock1 sensor open or not present
731	2	DTC 326	Knock1 excessive or erratic signal
920	4	DTC 1641	Buzzer control ground short
920	5	DTC 1642	Buzzer open

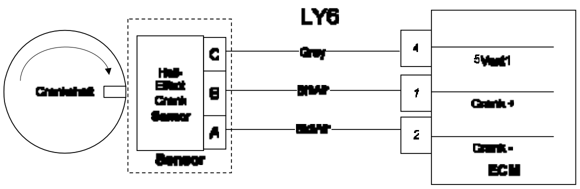
920	3	DTC 1643	Buzzer control short to power
1079	3	DTC 643	Sensor supply voltage 1 high
1079	4	DTC 642	Sensor supply voltage 1 low
1079	31	DTC 1611	Sensor supply voltage 1 and 2 out-of-range
1080	3	DTC 653	Sensor supply voltage 2 high
1080	4	DTC 652	Sensor supply voltage 2 low
1110	31	DTC 1625	J1939 shutdown request
1192	3	DTC 1131	WGP voltage high
1192	4	DTC 1132	WGP voltage low
1213	4	DTC 1644	MIL control ground short
1213	5	DTC 650	MIL open
1213	3	DTC 1645	MIL control short to power
1268	5	DTC 2300	Spark coil 1 primary open or short to ground
1268	6	DTC 2301	Spark coil 1 primary shorted
1269	5	DTC 2303	Spark coil 2 primary open or short to ground
1269	6	DTC 2304	Spark coil 2 primary shorted
1270	5	DTC 2306	Spark coil 3 primary open or short to ground
1270	6	DTC 2307	Spark coil 3 primary shorted
1271	5	DTC 2309	Spark coil 4 primary open or short to ground
1271	6	DTC 2310	Spark coil 4 primary shorted
1272	5	DTC 2312	Spark coil 5 primary open or short to ground
1272	6	DTC 2313	Spark coil 5 primary shorted
1273	5	DTC 2315	Spark coil 6 primary open or short to ground
1273	6	DTC 2316	Spark coil 6 primary shorted
1274	5	DTC 2318	Spark coil 7 primary open or short to ground
1274	6	DTC 2319	Spark coil 7 primary shorted
1275	5	DTC 2321	Spark coil 8 primary open or short to ground
1275	6	DTC 2322	Spark coil 8 primary shorted
1321	4	DTC 616	Start relay ground short
1321	5	DTC 615	Start relay coil open
1321	3	DTC 617	Start relay coil short to power
1323	11	DTC 1311	Cylinder 1 misfire detected
1323	31	DTC 301	Cylinder 1 emissions/catalyst damaging misfire
1324	11	DTC 1312	Cylinder 2 misfire detected
1324	31	DTC 302	Cylinder 2 emissions/catalyst damaging misfire
1325	11	DTC 1313	Cylinder 3 misfire detected
1325	31	DTC 303	Cylinder 3 emissions/catalyst damaging misfire
1326	11	DTC 1314	Cylinder 4 misfire detected
1326	31	DTC 304	Cylinder 4 emissions/catalyst damaging misfire
1327	11	DTC 1315	Cylinder 5 misfire detected
1327	31	DTC 305	Cylinder 5 emissions/catalyst damaging misfire
1328	11	DTC 1316	Cylinder 6 misfire detected
1328	31	DTC 306	Cylinder 6 emissions/catalyst damaging misfire
1329	11	DTC 1317	Cylinder 7 misfire detected
1329	31	DTC 307	Cylinder 7 emissions/catalyst damaging misfire
1330	11	DTC 1318	Cylinder 8 misfire detected
1330	31	DTC 308	Cylinder 8 emissions/catalyst damaging misfire
1347	5	DTC 628	Fuel-pump high-side open or short to ground
1347	6	DTC 629	Fuel-pump high-side short to power
1348	4	DTC 628	Fuel pump relay control ground short

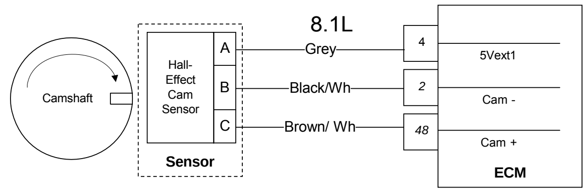
1348	5	DTC 627	Fuel pump relay coil open
1348	3	DTC 629	Fuel pump relay coil short to power
1485	4	DTC 686	Power relay ground short
1485	5	DTC 685	Power relay coil open
1485	3	DTC 687	Power relay coil short to power
3050	11	DTC 420	Catalyst inactive on gasoline (Bank 1)
3051	11	DTC 430	Catalyst inactive on gasoline (Bank 2)
3217	5	DTC 134	EGO1 open / lazy
3227	5	DTC 154	EGO2 open / lazy
3256	5	DTC 140	EGO3 open / lazy
3266	5	DTC 160	EGO4 open / lazy
3673	3	DTC 223	TPS2 voltage high
3673	4	DTC 222	TPS2 voltage low
4236	0	DTC 1155	[illegible]
4236	1	DTC 1156	Closed-loop gasoline bank1 low
4237	0	DTC 171	Adaptive-learn gasoline bank1 high
4237	1	DTC 172	Adaptive-learn gasoline bank1 low
4238	0	DTC 1157	Closed-loop gasoline bank2 high
4238	1	DTC 1158	Closed-loop gasoline bank2 low
4239	0	DTC 174	Adaptive-learn gasoline bank2 high
4239	1	DTC 175	Adaptive-learn gasoline bank2 low
520197	4	DTC 332	Knock2 sensor open or not present
520197	2	DTC 331	Knock2 excessive or erratic signal
520199	11	DTC 2120	FPP1 invalid voltage and FPP2 disagrees with IVS (redundancy lost)
520199	11	DTC 2125	FPP2 invalid voltage and FPP1 disagrees with IVS (redundancy lost)
520199	11	DTC 1122	FPP1/2 do not match each other or IVS (redundancy lost)

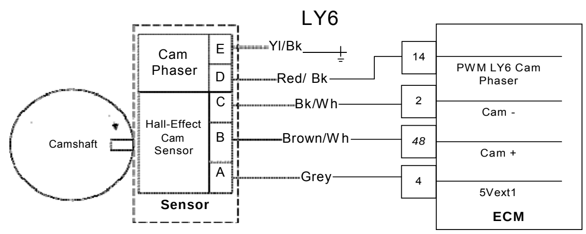
SPN 636, FMI 8- Crank and/or Cam Could Not Synchronize During Start











- Crankshaft Position Sensor/Camshaft Position Sensor
- Check Condition- Engine Cranking or Running
- Fault Condition- Engine rotates without crank and/or cam synchronization
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Emissions related fault

The crankshaft position sensor is a magnetic sensor (variable reluctant/magnetic pick-up or hall-effect) installed in the engine block adjacent to a “coded” trigger wheel located on the crankshaft. The sensor-trigger wheel combination is used to determine crankshaft position (with respect to TDC cylinder #1 compression) and the rotational engine speed. Determination of the crankshaft position and speed is necessary to properly activate the ignition, fuel injection, and throttle governing systems for precise engine control.

The camshaft position sensor is a magnetic sensor (variable reluctant/magnetic pick-up or hall-effect) installed in the engine block or valve train adjacent to a “coded” trigger wheel located on or off of the camshaft. The sensor-trigger wheel combination is used to determine cam position (with respect to TDC cylinder #1 compression). Determination of the camshaft position is necessary to identify the stroke (or cycle) of the engine to properly activate the fuel injection system and ignition (for coil-on-plug engines) for precise engine control.

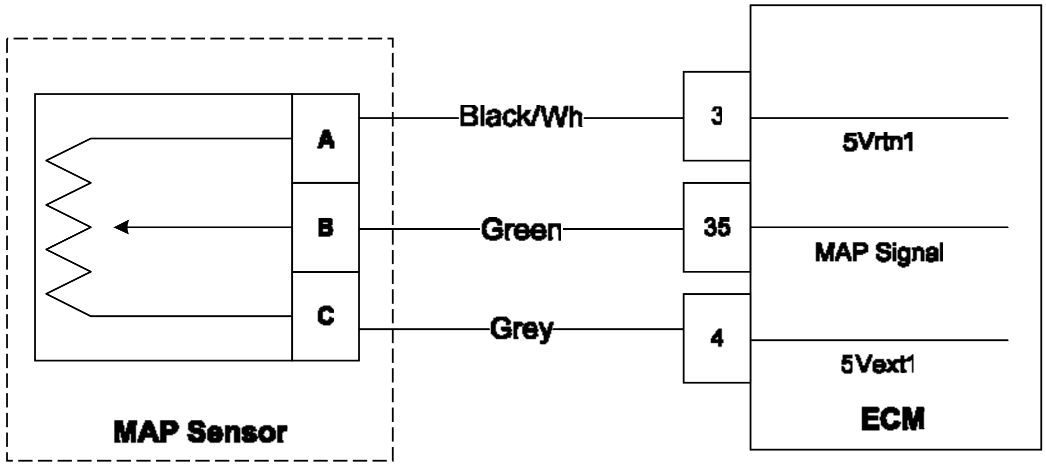
The ECM must see a valid crankshaft position and camshaft position (if applicable) signal properly aligned during cranking before it can synchronize the injection and ignition systems to initiate starting. If engine speed > x RPM and the crank and/or cam (if applicable) can not synchronize within y cranking revs, this fault will set. Typically, this fault will result in an engine that will not start or run.

SPN 636, FMI 8- Crank and/or Cam Could Not Synchronize During Start

Diagnostic Aids

- ☐ Check that crankshaft and/or camshaft position sensor(s) is/are securely connected to harness
- ☐ Check that crankshaft and/or camshaft position sensor(s) is/are securely installed into engine block
- ☐ Check crankshaft and/or camshaft position sensor(s) circuit(s) wiring for open circuit

SPN 106, FMI 4 - MAP Low Voltage



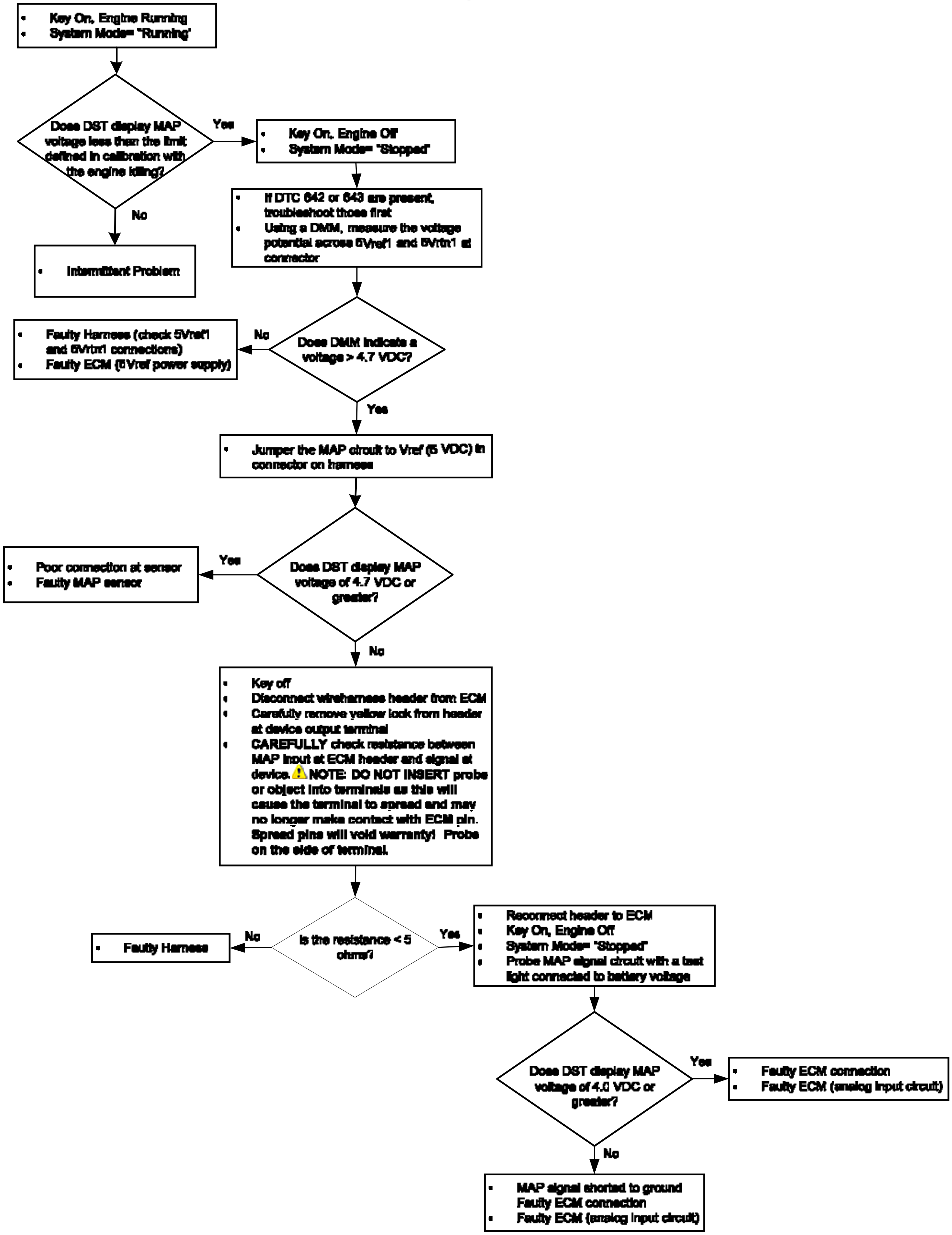
- Manifold Absolute Pressure Sensor
- Check Condition- Engine Cranking or Running
- Fault Condition-MAP sensor voltage feedback less than the limit defined in calibration when throttle position is greater than and engine speed is less than the operating conditions defined in calibration.
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, recommend power derate 1, disable adaptive learn fueling correction for key-cycle, or any combination thereof as defined in calibration.
- Emissions related fault

The Manifold Absolute Pressure sensor is a pressure transducer connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used in conjunction with other inputs to determine the rate of airflow to the engine, which thereby determines the required fuel flow rate.

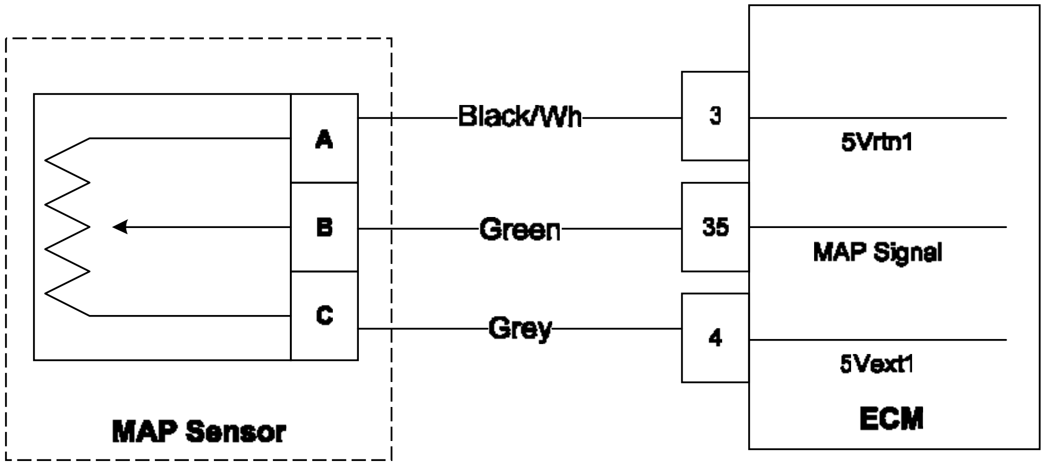
This fault will set when the MAP sensor voltage feedback is sensed as lower than the sensor should normally produce as set in the diagnostic calibration. The limit is generally set at 0.10 VDC. In many cases, this condition is caused by the MAP sensor being disconnected from the engine harness, an open-circuit or short-to-ground of the MAP circuit in the wireharness, a loss of sensor reference voltage, or a failure of the sensor. When this fault occurs, the ECM operates in a limp home mode in which an estimated MAP based on TPS feedback is used to fuel the engine. Recommended corrective actions include setting power derate 1, disabling adaptive learn for the remainder of the key-on cycle with closed-loop remain enabled, and outputting a warning to the user.

If the MAP sensor is integrated in a TMAP sensor and an IAT High Voltage fault (DTC 113) is also present, the sensor is likely disconnected from the wireharness.

SPN 106, FMI 4 - MAP Low Voltage



SPN 106, FMI 16 - MAP High Pressure

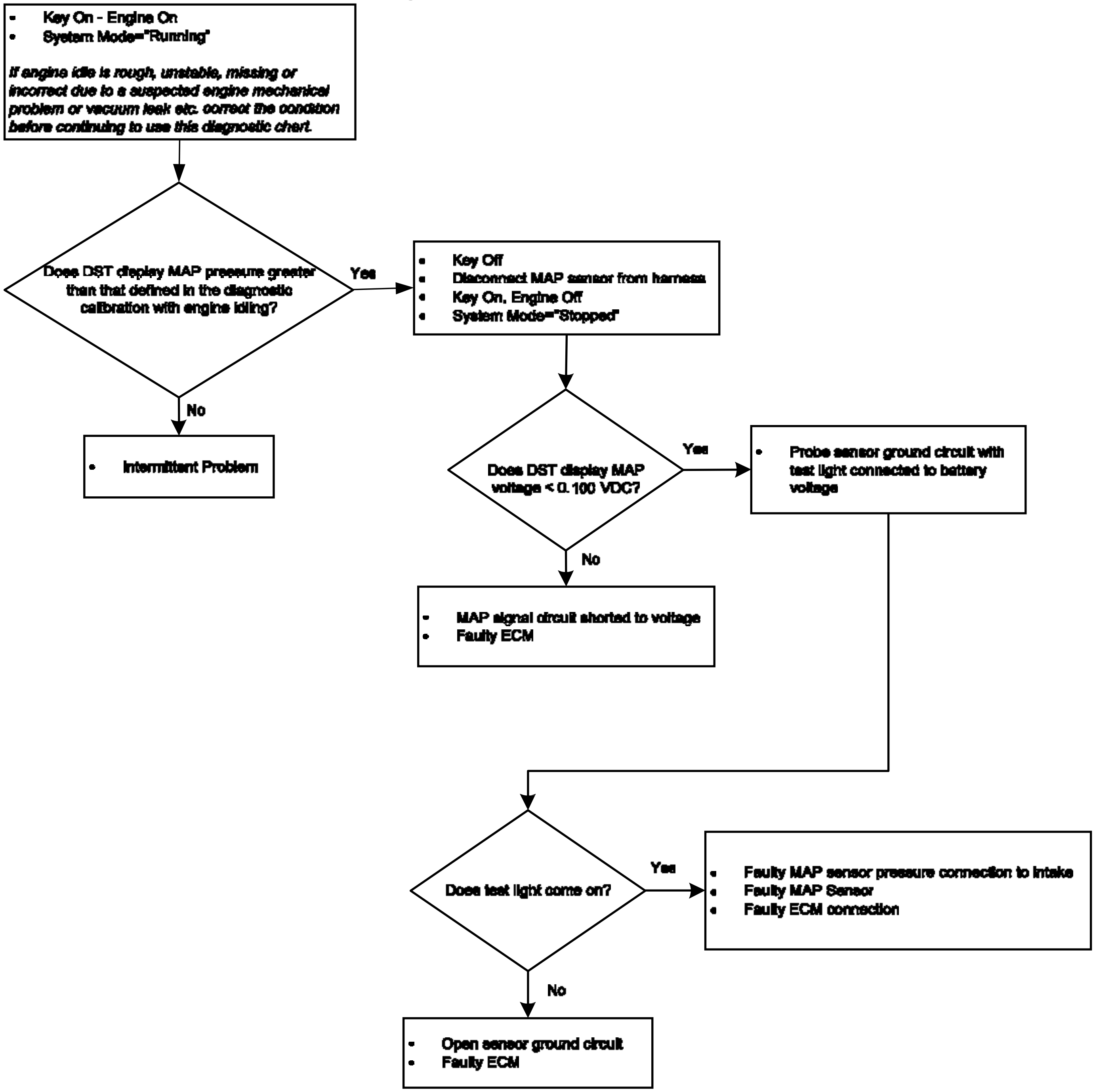


- Manifold Absolute Pressure Sensor
- Check Condition- Engine Cranking or Running
- Fault Condition-MAP is higher than the limit defined in calibration when throttle position is less than and engine speed is greater than the operating conditions defined in calibration.
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, or any combination thereof as defined in calibration. Power derate is sometimes used with this fault.
- Emissions related fault

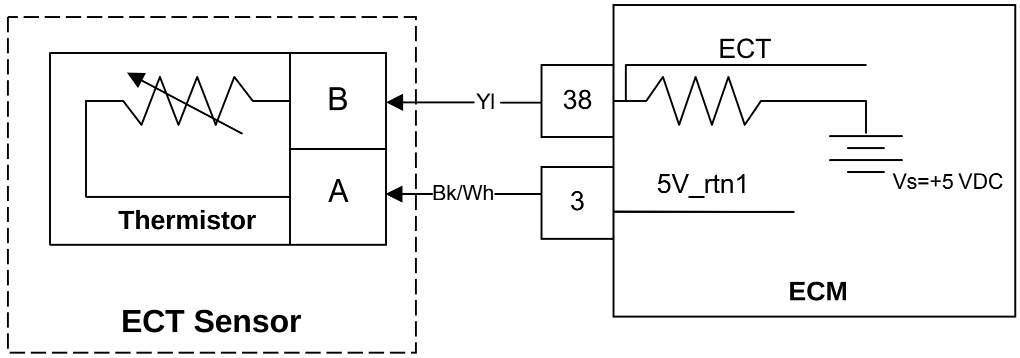
The Manifold Absolute Pressure sensor is a pressure transducer connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used as an index for spark, fuel, base fuel, etc. and is used in conjunction with other inputs to determine the airflow rate to the engine. The air flow rate in conjunction with the base fuel command determines the fuel flow rate.

This fault will set when the MAP reading is higher than it should be for the given TPS, and RPM. When the fault is set the engine will typically operate in a “limp home” mode using an estimated MAP based on TPS feedback. It is recommended that Adaptive Learn be disabled to prevent improper learning and population of the table. In addition, power derate is sometimes used.

SPN 106, FMI 16 - MAP High Pressure



SPN 110, FMI 15 - ECT Higher Than Expected Stage 1



- Engine Coolant Temperature Sensor
- Check Condition-Engine Running
- Fault Condition-Engine Coolant Temperature reading or estimate greater than the stage 1 limit when operating at a speed greater than defined in the diagnostic calibration
- Corrective Action(s): Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 1/2 and/or a low rev limit to protect engine from possible damage.
- Non-emissions related fault

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. Some engines use a CHT sensor that is located in the coolant in the cylinder head. Some engines use an ECT (Engine Coolant Temperature) sensor that is located in the coolant near the thermostat. If the engine is equipped with a CHT sensor then the ECT value is estimated. If equipped with an ECT sensor then the CHT value is estimated. They are used for engine airflow calculation, ignition timing control, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor reading is cool the sensor reads higher voltage, and lower when warm.

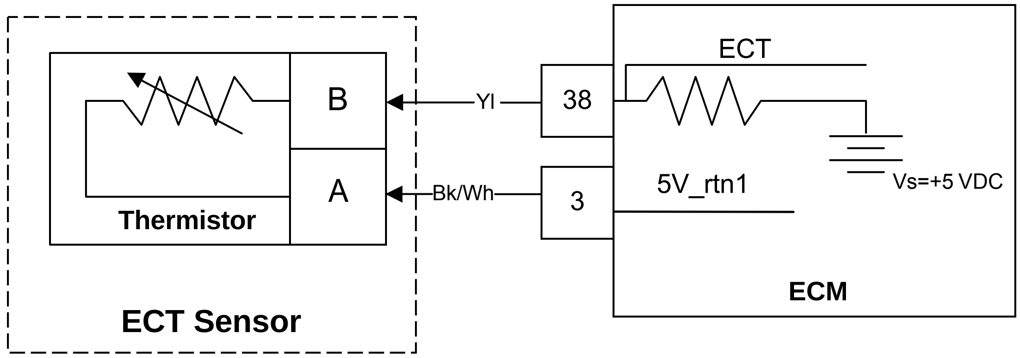
This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

SPN 110, FMI 15 - ECT Higher Than Expected Stage 1

Diagnostic Aids

- D If the "ECT High Voltage" fault is also present, follow the troubleshooting procedures for that fault as it may have caused "ECT Higher Than Expected 1."
- D If the cooling system utilizes an air-to-water heat exchanger (radiator) and fan:
  - o Check that the radiator has a proper amount of ethylene glycol/water and that the radiator is not leaking
  - o Ensure that there is no trapped air in the cooling path
  - o Inspect the cooling system (radiator and hoses) for cracks and ensure connections are leak free
  - o Check that the fan is operating properly
  - o Check that the thermostat is not stuck closed
- D If the cooling system utilizes a water-to-water heat exchanger:
  - o Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
  - o Ensure that there is no trapped air in the cooling path
  - o Inspect the cooling system (radiator and hoses) for cracks and ensure connections are leak free
  - o Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
  - o Check that the thermostat is not stuck closed
  - o Check that the raw water pump/impeller is tact and that it is not restricted

SPN 110, FMI 4 - ECT/CHT Low Voltage

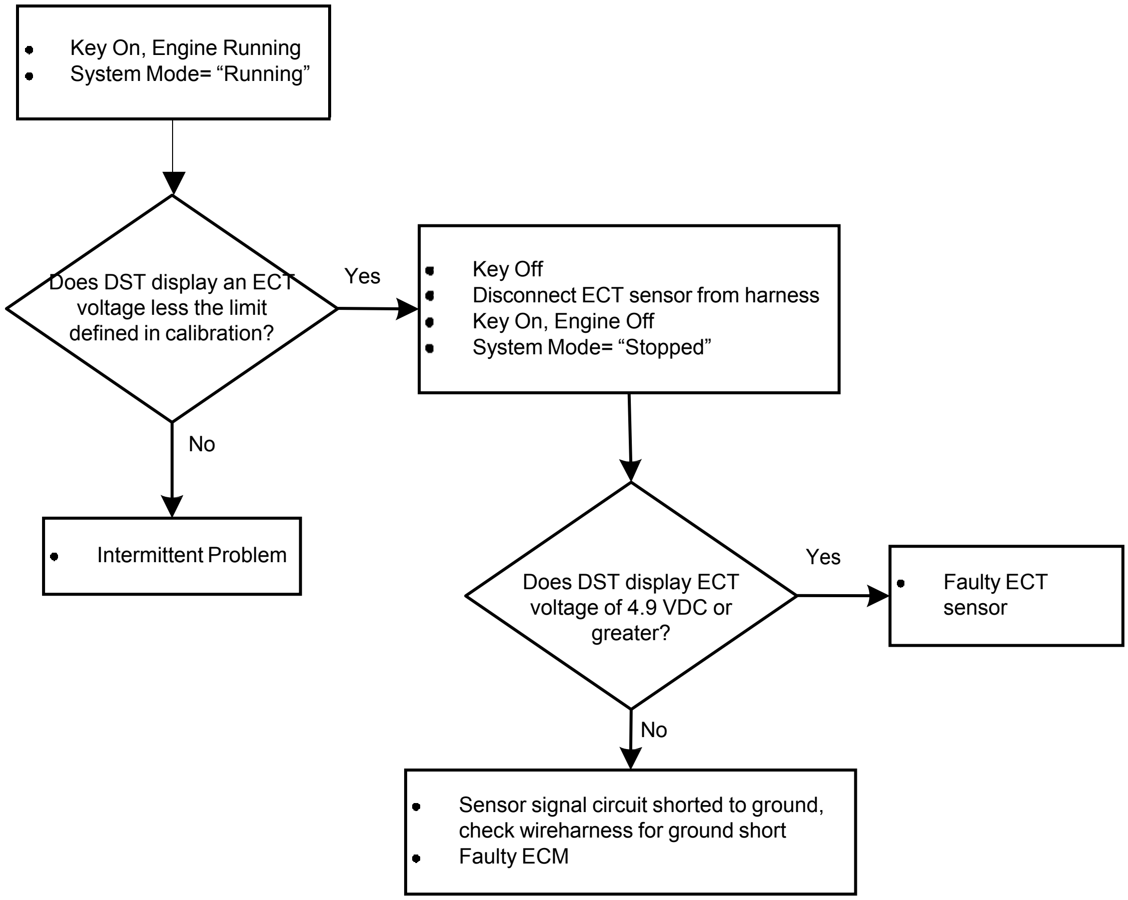


- Engine Coolant Temperature Sensor
- Check Condition-Engine Running
- Fault Condition-CHT/ECT sensor voltage less than the limit defined in the diagnostic calibration
- Corrective Action(s)- Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

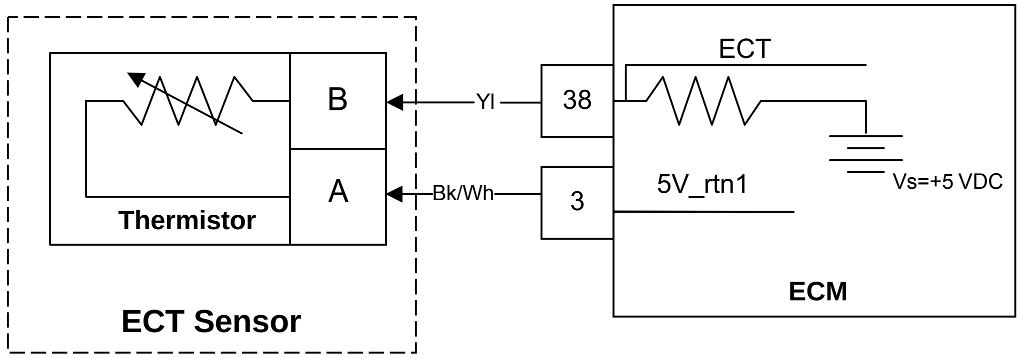
The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. Some engines use an ECT sensor that is located in the coolant near the thermostat. Some engines use a CHT (Cylinder Head Temperature) sensor that is located in the coolant in the cylinder head. If the engine is equipped with an ECT sensor then the CHT value is estimated. If equipped with a CHT sensor then the ECT value is estimated. They are used in the engine airflow calculation, and to enable certain features. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

This fault will set if the signal voltage is less than the limit defined in the diagnostic calibration anytime the engine is running. The limit is generally set to 0.10 VDC. The ECM will use a default value for the CHT/ECT sensor in the event of this fault.

SPN 110, FMI 4 - ECT/CHT Low Voltage



SPN 110, FMI 3 - ECT/CHT High Voltage

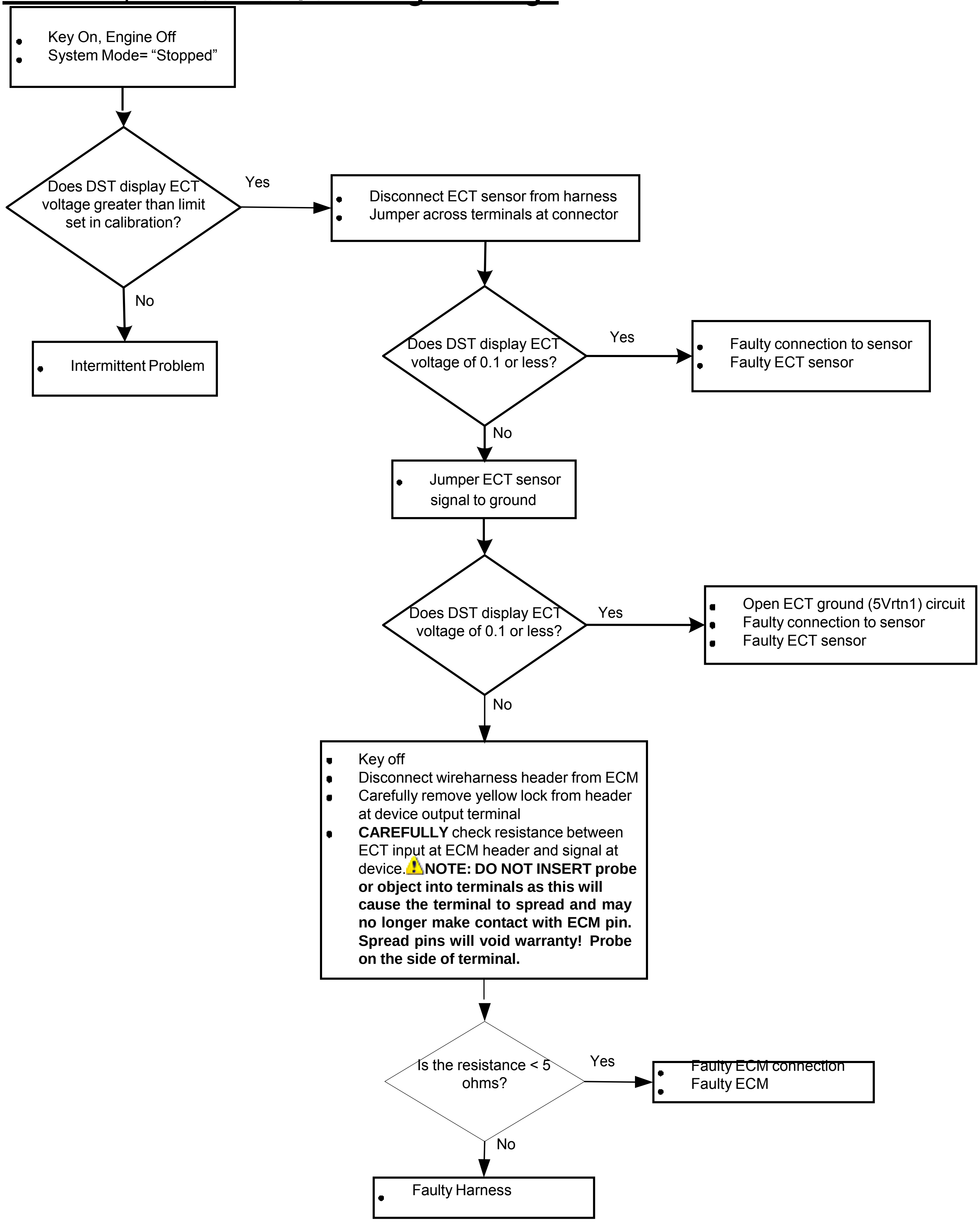


- Engine Coolant Temperature Sensor
- Check Condition-Engine Running
- Fault Condition-CHT/ECT sensor voltage higher than the limit defined in the diagnostic calibration
- Corrective Action(s)- Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

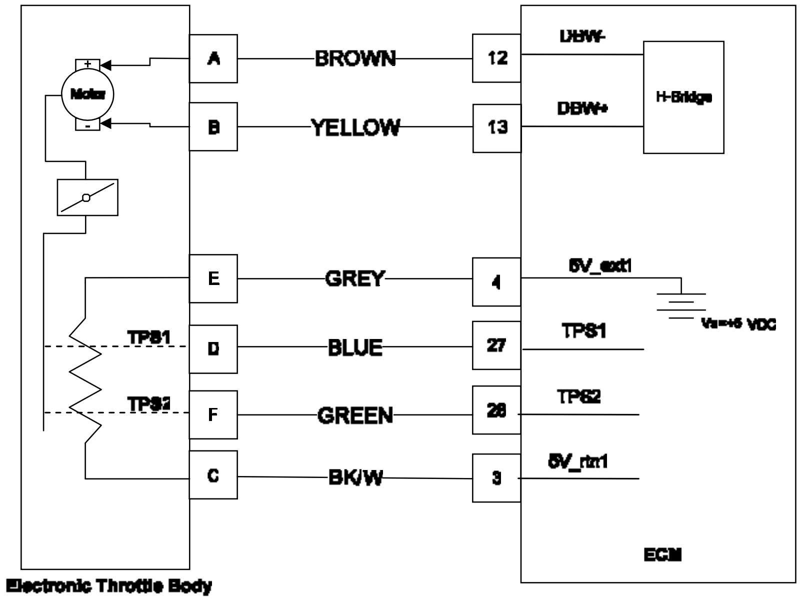
The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. Some engines use an ECT sensor that is located in the coolant near the thermostat. Some engines use a CHT (Cylinder Head Temperature) sensor that is located in the coolant in the cylinder head. If the engine is equipped with an ECT sensor then the CHT value is estimated. If equipped with a CHT sensor then the ECT value is estimated. They are used in the engine airflow calculation, and to enable features. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

This fault will set if the signal voltage is higher than the high voltage limit as defined in the diagnostic calibration anytime the engine is running. The limit is generally set to 4.90 VDC. In many cases, this condition is caused by the CHT/ECT sensor being disconnected from the engine harness, an open-circuit or short-to-power of the CHT/ECT circuit in the wireharness, or a failure of the sensor. The ECM will use a default value for the CHT/ECT sensor in the event of this fault.

SPN 110, FMI 3 - ECT/CHT High Voltage



SPN 51, FMI 1 - TPS1 % Lower Than TPS2 %



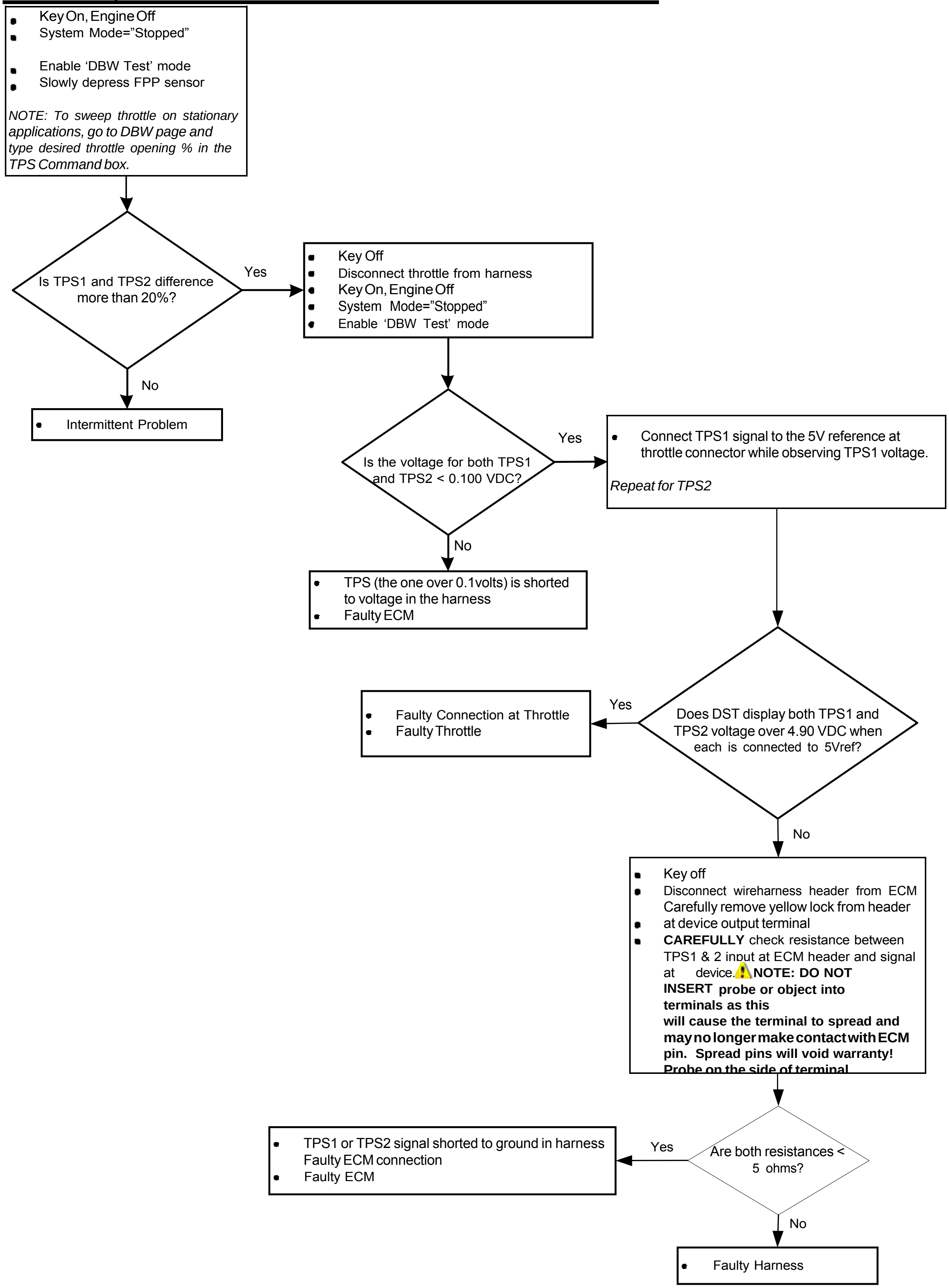
- Throttle Body-Throttle Position Sensor 1 & 2 (electronic throttle body only)
- Check Condition-Key-On, Engine Cranking, or Running
- Fault Condition-TPS1 lower than TPS2 by the % set in the diagnostic calibration
- Corrective Action(s): Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

The throttle controls the airflow through the engine, directly affecting the power output of the engine. When the throttle is electronically controlled in an Electronic Throttle Body it can be used to control the idle stability and limit engine speed based on operating conditions.

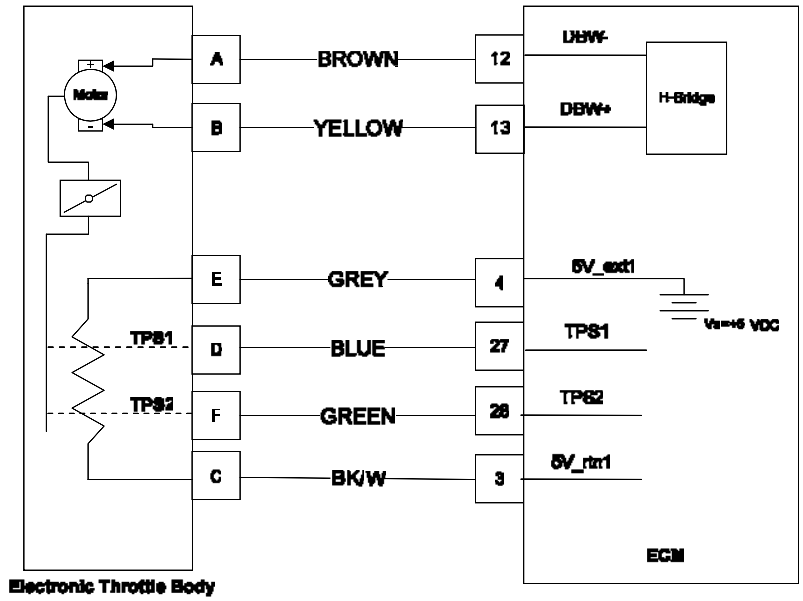
The Throttle Position Sensor uses either 1) a variable resistor and voltage divider circuit or 2) a non-contact hall-effect sensor to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In mechanical throttle bodies this sensor is typically used to help improve return-to-idle governing when working in combination with an Idle Air Control motor. In an Electronic Throttle Body multiple position feedback sensors (usually two counteracting potentiometers/hall-effects) are used to perform speed governing with improved safety and redundancy.

This fault will set if TPS1 % is lower than TPS2 % by the amount defined in the diagnostic calibration. At this point the throttle is considered to be out of specification, or there is a problem with the TPS signal circuit. During this active fault, an audible/visual alert device is activated and either an engine shutdown should is triggered or throttle control is set to use the higher of the two feedback signals for control in combination with a low rev limit and/or power derate.

SPN 51, FMI 1 - TPS1 % Lower Than TPS2 %



SPN 51, FMI 4 - TPS1 Signal Voltage Low



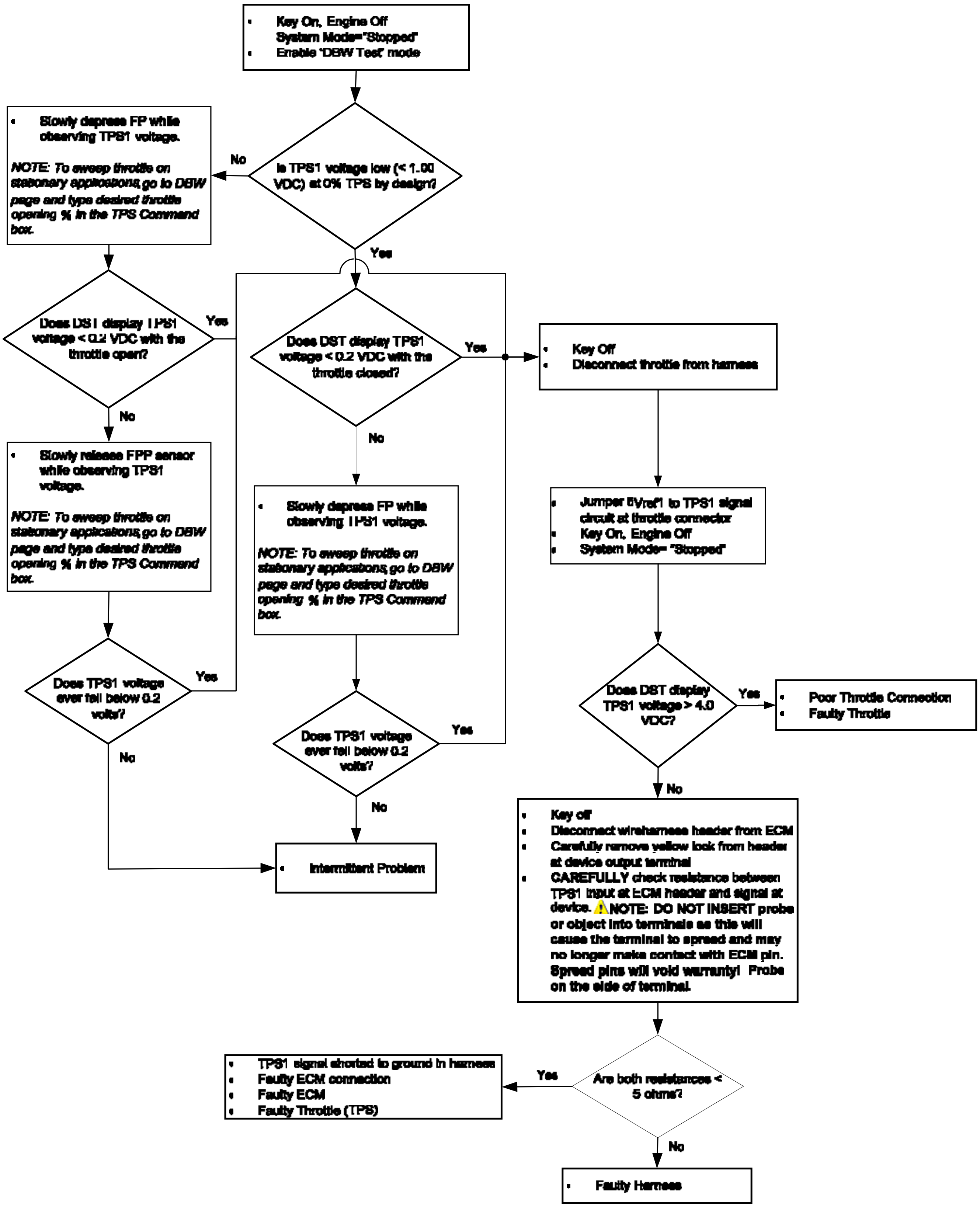
- Throttle Body-Throttle Position Sensor 1
- Check Condition-Key On, Engine Cranking or Running
- Fault Condition-TPS1 sensor voltage lower than the limit defined in the diagnostic calibration
- Corrective Action(s): Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

The throttle controls the airflow through the engine, directly affecting the power output of the engine. When the throttle is electronically controlled in an Electronic Throttle Body it can be used to control the idle stability and limit engine speed based on operating conditions.

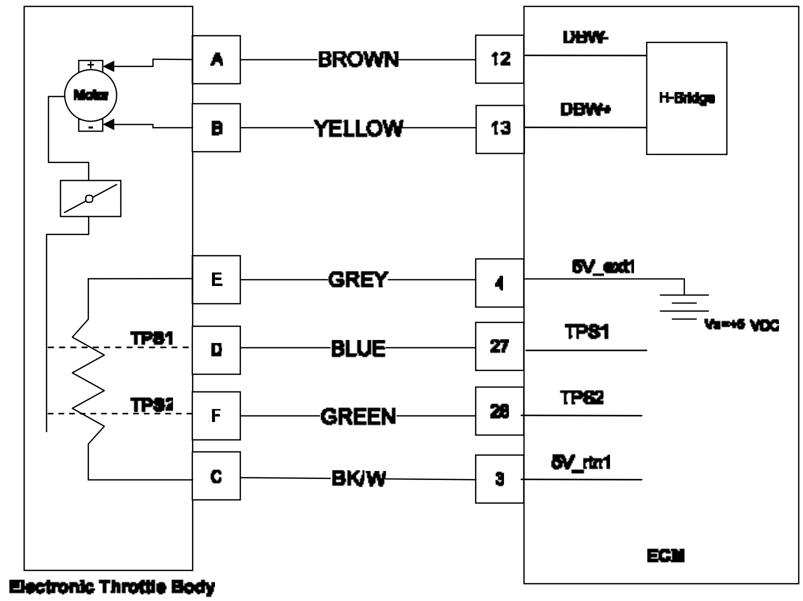
The Throttle Position Sensor uses either 1) a variable resistor and voltage divider circuit or 2) a non-contact hall-effect sensor to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In mechanical throttle bodies this sensor is typically used to help improve return-to-idle governing when working in combination with an Idle Air Control motor. In an Electronic Throttle Body multiple position feedback sensors (usually two counteracting potentiometers/hall-effects) are used to perform speed governing with improved safety and redundancy.

This fault will set if TPS1 voltage is lower than the low voltage limit as defined in the diagnostic calibration at any operating condition while the engine is cranking or running. The limit is generally set to 4.90 VDC. In many cases, this condition is caused by the TPS sensor being disconnected from the engine harness, an open-circuit or short-to-ground of the TPS circuit in the wireharness, or a failure of the sensor. This fault should be configured to trigger an engine shutdown and the engine will not start with this fault active.

SPN 51, FMI 4 - TPS1 Signal Voltage Low



SPN 51, FMI 3 - TPS1 Signal Voltage High



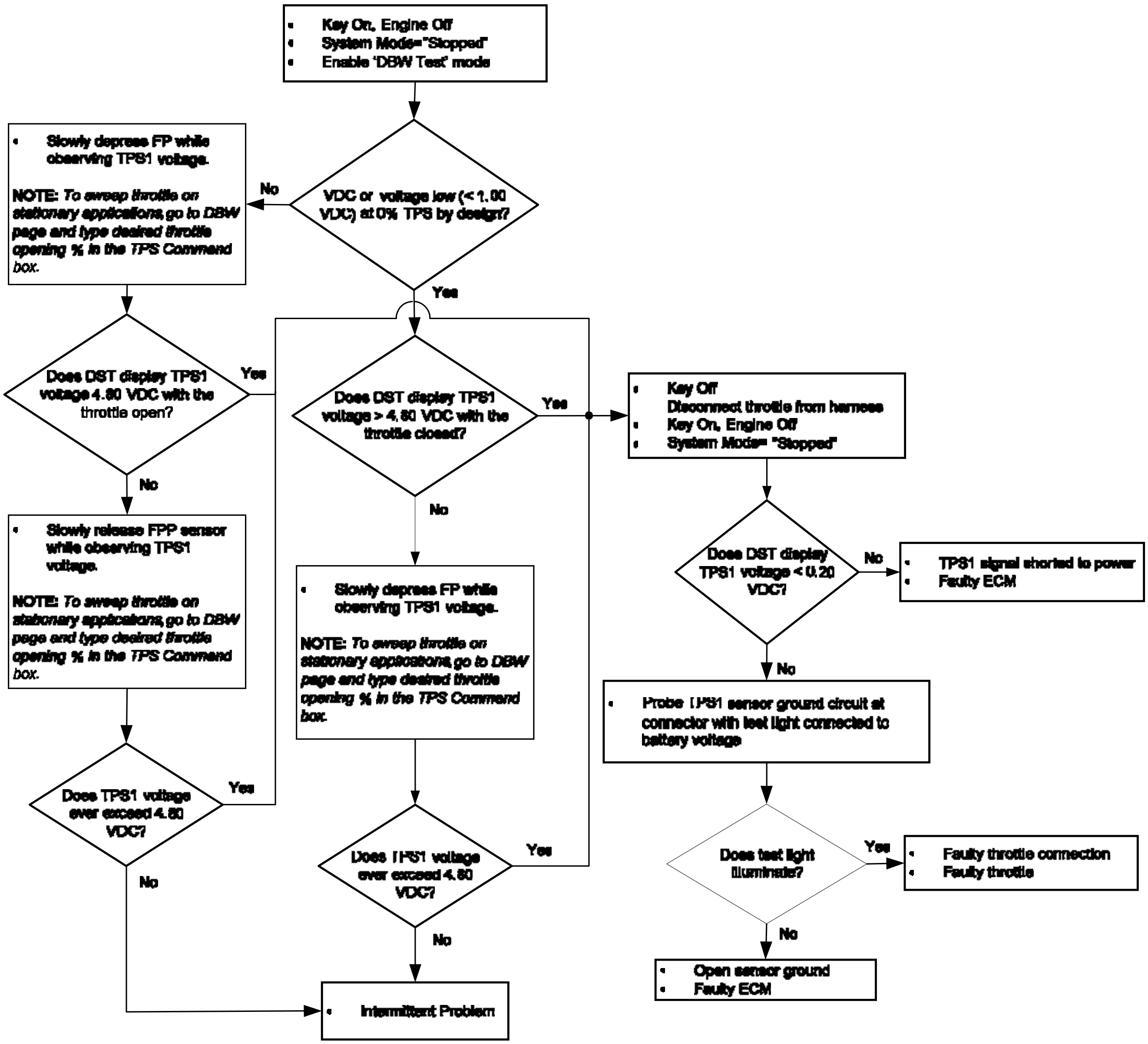
- Throttle Body-Throttle Position Sensor 1
- Check Condition-Key On, Engine Cranking or Running
- Fault Condition-TPS1 sensor voltage higher than the limit defined in the diagnostic calibration
- Corrective Action(s): Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

The throttle controls the airflow through the engine, directly affecting the power output of the engine. When the throttle is electronically controlled in an Electronic Throttle Body it can be used to control the idle stability and limit engine speed based on operating conditions.

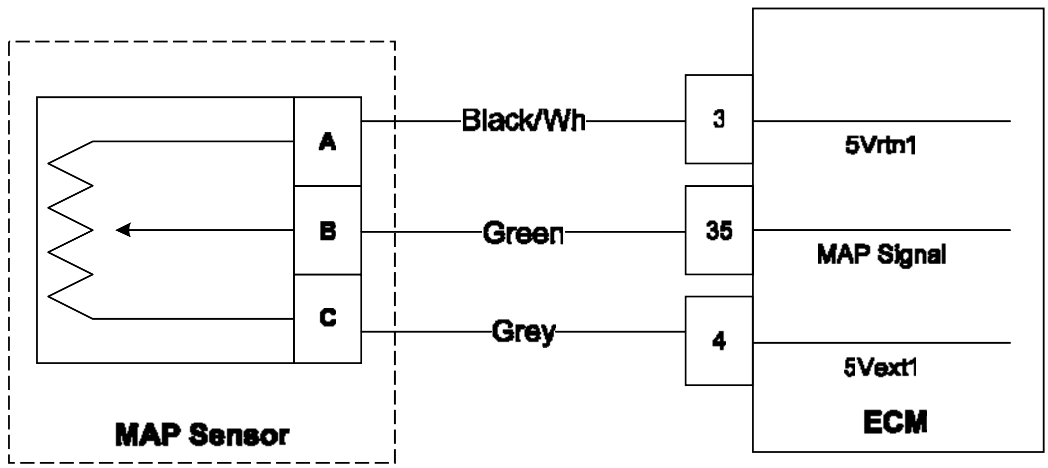
The Throttle Position Sensor uses either 1) a variable resistor and voltage divider circuit or 2) a non-contact hall-effect sensor to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In mechanical throttle bodies this sensor is typically used to help improve return-to-idle governing when working in combination with an Idle Air Control motor. In an Electronic Throttle Body multiple position feedback sensors (usually two counteracting potentiometers/hall-effects) are used to perform speed governing with improved safety and redundancy.

This fault will set if TPS1 voltage is higher than the limit set in the diagnostic calibration at any operating condition while the engine is cranking or running. The limit is generally set to 4.90 VDC. In many cases, this condition is caused by a short-to-power of the TPS circuit in the wireharness or a failure of the sensor. This fault should be configured to trigger an engine shutdown and the engine will not start with this fault active.

SPN 51, FMI 3 - TPS1 Signal Voltage High



SPN 108, FMI 1 - BP Low Pressure

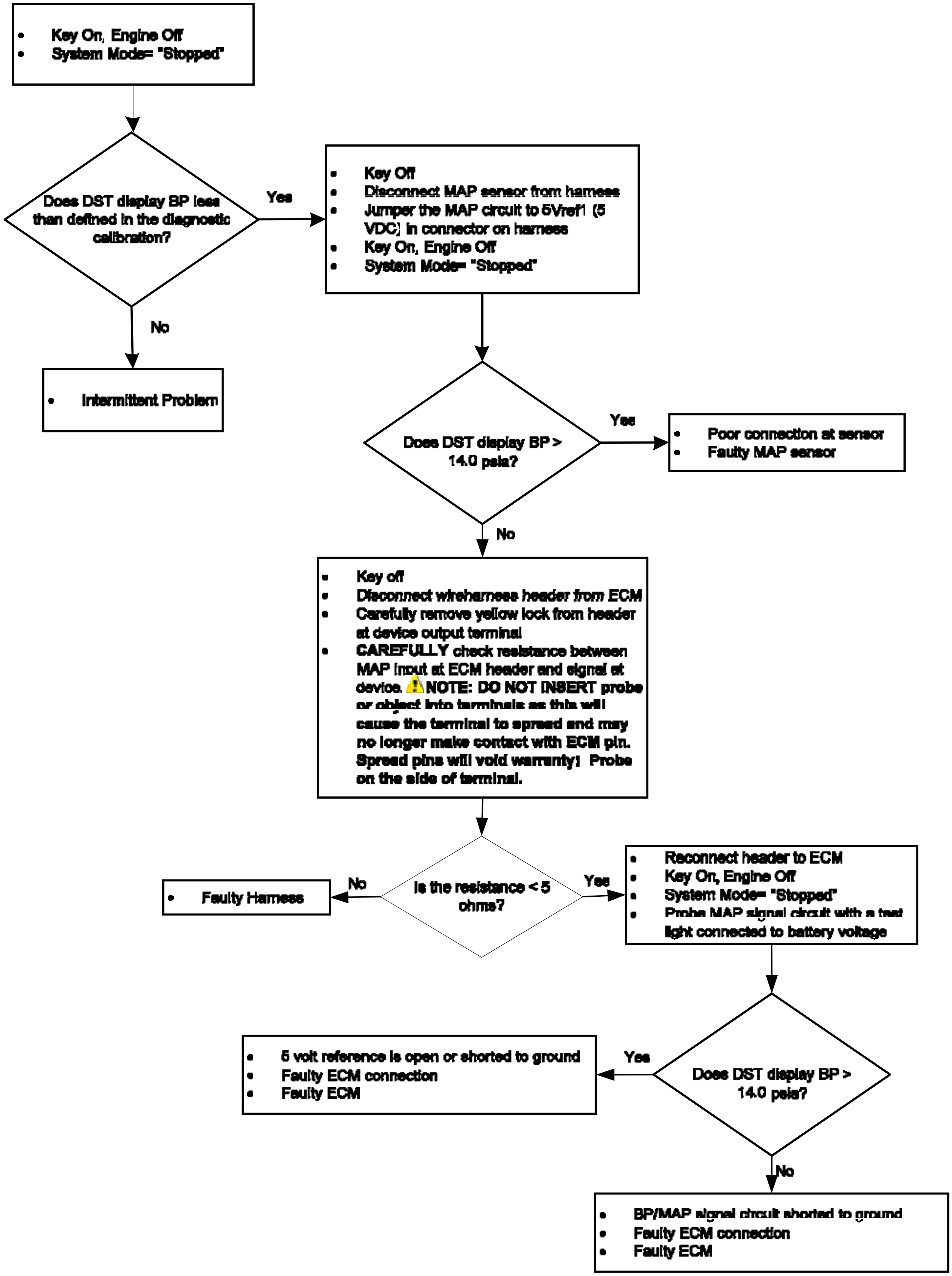


- Barometric Pressure
- Check Condition-Key On, Engine Off or after BP estimate during low-speed/high load operation
- Fault Condition-Barometric Pressure is less than x psia
- Corrective Action(s): Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle
- Emissions related fault

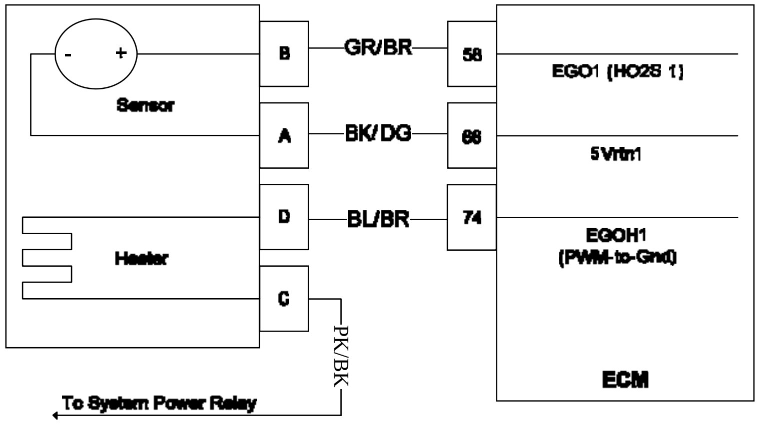
Barometric Pressure is estimated from the MAP sensor at key-on and in some calibrations during low speed/high load operation as defined in the engine's calibration. The barometric pressure value is used for fuel and airflow calculations and equivalence ratio targets based on altitude.

This fault sets if the barometric pressure is lower than x psia as defined in the diagnostic calibration.

SPN 108, FMI 1 - BP Low Pressure



SPN 3217, FMI 5 - EGO1 Open/Lazy (HO2S1)

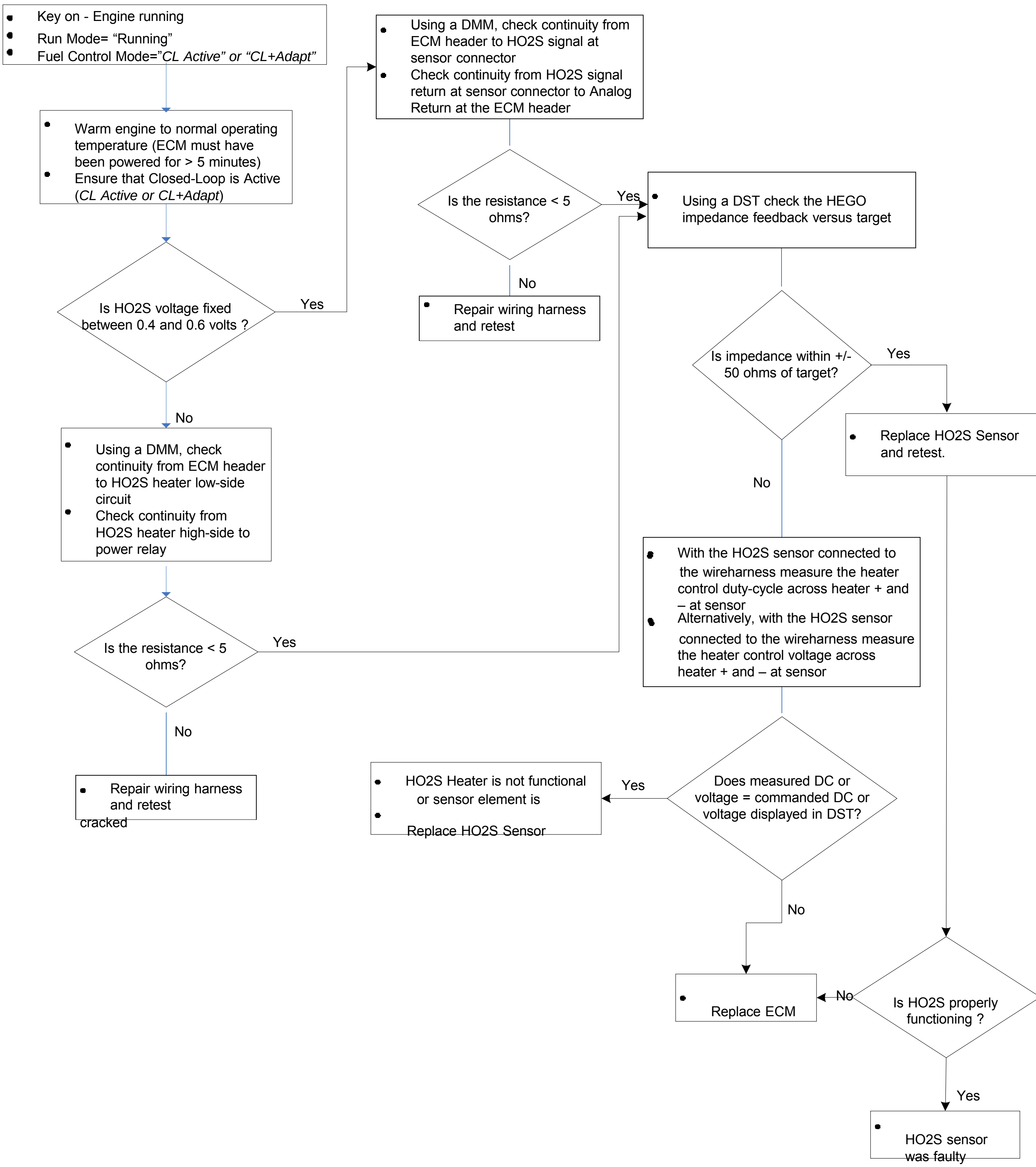


- Heated or Universal Exhaust Gas Oxygen Sensor (Bank 1-Sensor 1/Before Catalyst)
- Check Condition- Engine Running
- Fault Condition- HEGO/HO2S or UEGO cold longer than the time defined in the calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

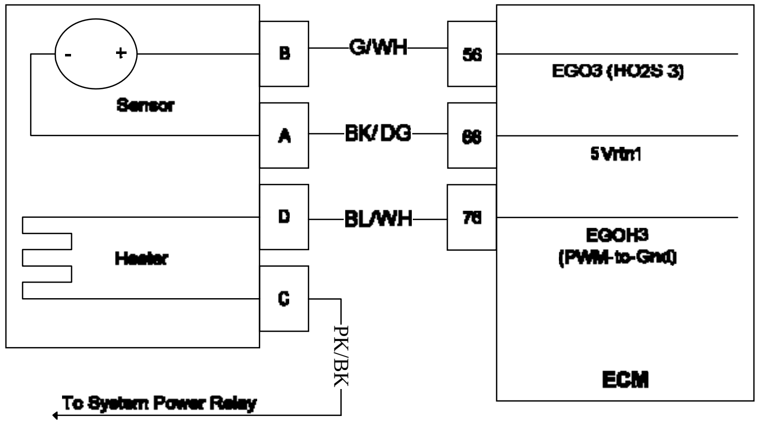
The HEGO/HO2S sensor is a switching-type sensor about stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear analog output proportional to lambda/equivalence ratio/air-fuel ratio. In either case, if there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted using the Closed Loop multiplier and then "learned" with the Adaptive multiplier. The multipliers only update when the system is in either *"CL Active"* or *"CL + Adapt"* control modes.

This fault will set if the sensor element is cold, non-responsive, or inactive for x seconds as defined in the diagnostic calibration. Cold, non-responsive, or inactive are determined based on two criteria 1) a measurement of the feedback sense element (zirconia) to determine its temperature or 2) a lack of change in sensor feedback. This fault should disable closed-loop when it is active and adaptive learn for the key-cycle.

SPN 3217, FMI 5 - EGO1 Open/Lazy (HO2S1)



SPN 3256, FMI 5 - EGO3 Open/Lazy (HO2S3)

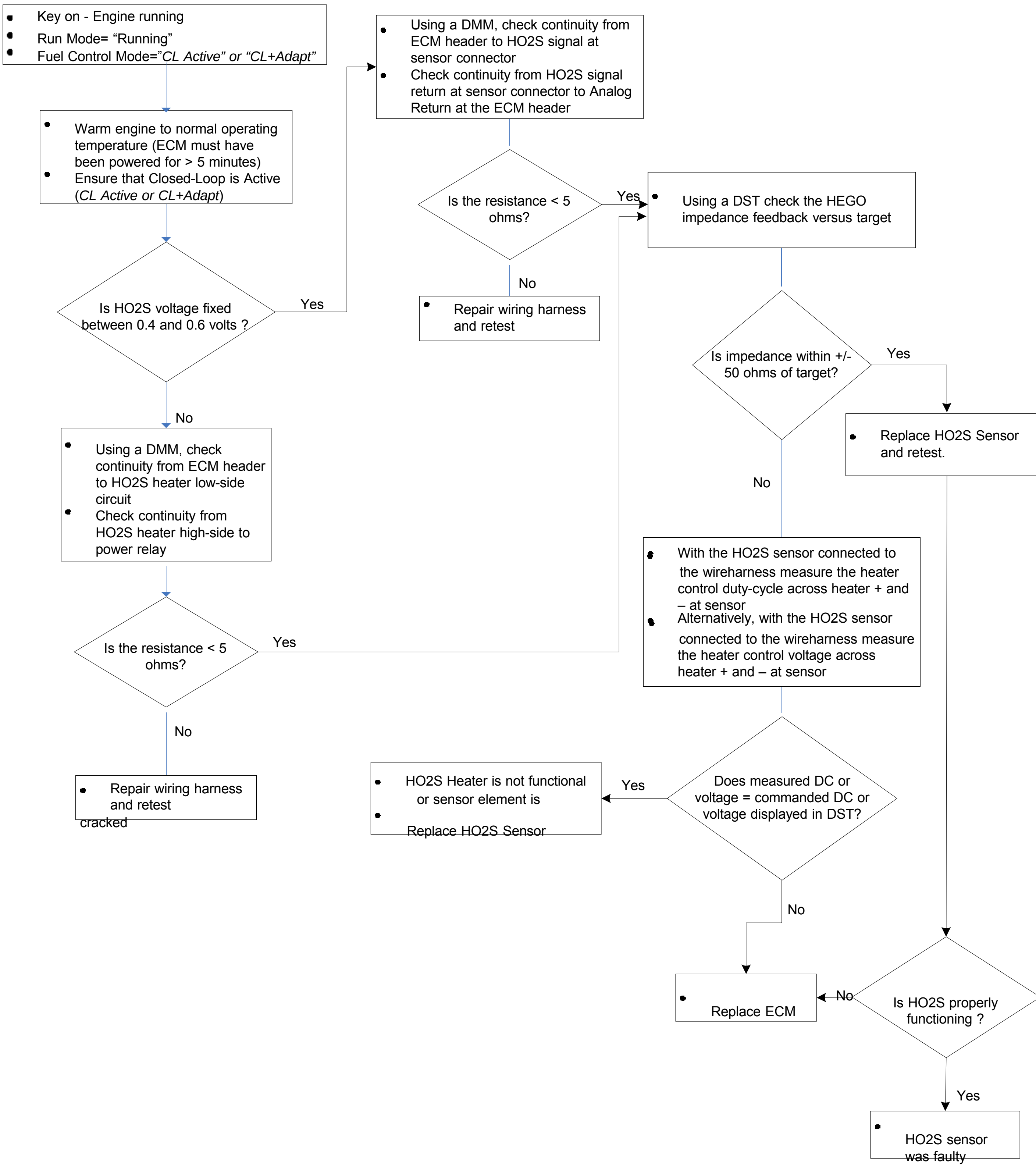


- Heated or Universal Exhaust Gas Oxygen Sensor (Bank 1-Sensor 2/After Catalyst)
- Check Condition- Engine Running
- Fault Condition- HEGO/HO2S or UEGO cold longer than the time defined in the calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp.
- Emissions related fault

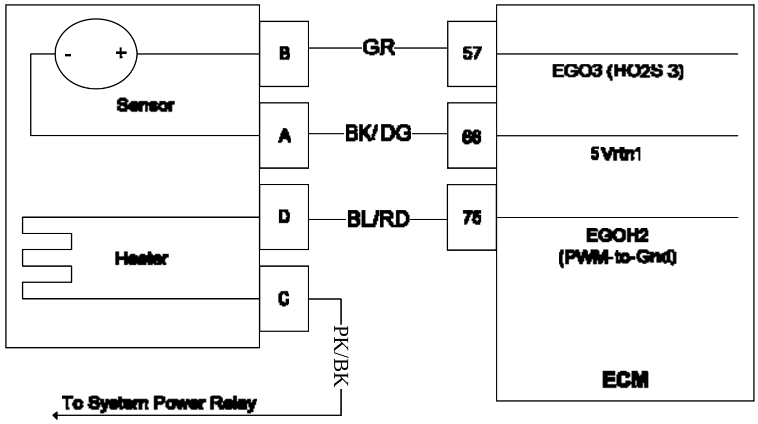
In a post-catalyst configuration the HEGO/HO2S sensor is a switching-type sensor around stoichiometry that measures the oxygen content downstream of the catalyst for two main functions: 1) to compare it to the oxygen content upstream of the catalyst to determine how efficiently the catalyst is using oxygen to determine its effectiveness and 2) trim the commanded equivalence ratio target to maximize the catalyst conversion efficiency. The post-catalyst strategy and diagnostic is only active when the system is in either *"CL Active"* or *"CL + Adapt"* control modes.

This fault will set if the sensor element is cold, non-responsive, or inactive for x seconds as defined in the diagnostic calibration. Cold, non-responsive, or inactive are determined based on two criteria 1) a measurement of the feedback sense element (zirconia) to determine its temperature or 2) a lack of change in sensor feedback.

SPN 3256, FMI 5 - EGO3 Open/Lazy (HO2S3)



SPN 3227, FMI 5 - EGO2 Open/Lazy (HO2S2)



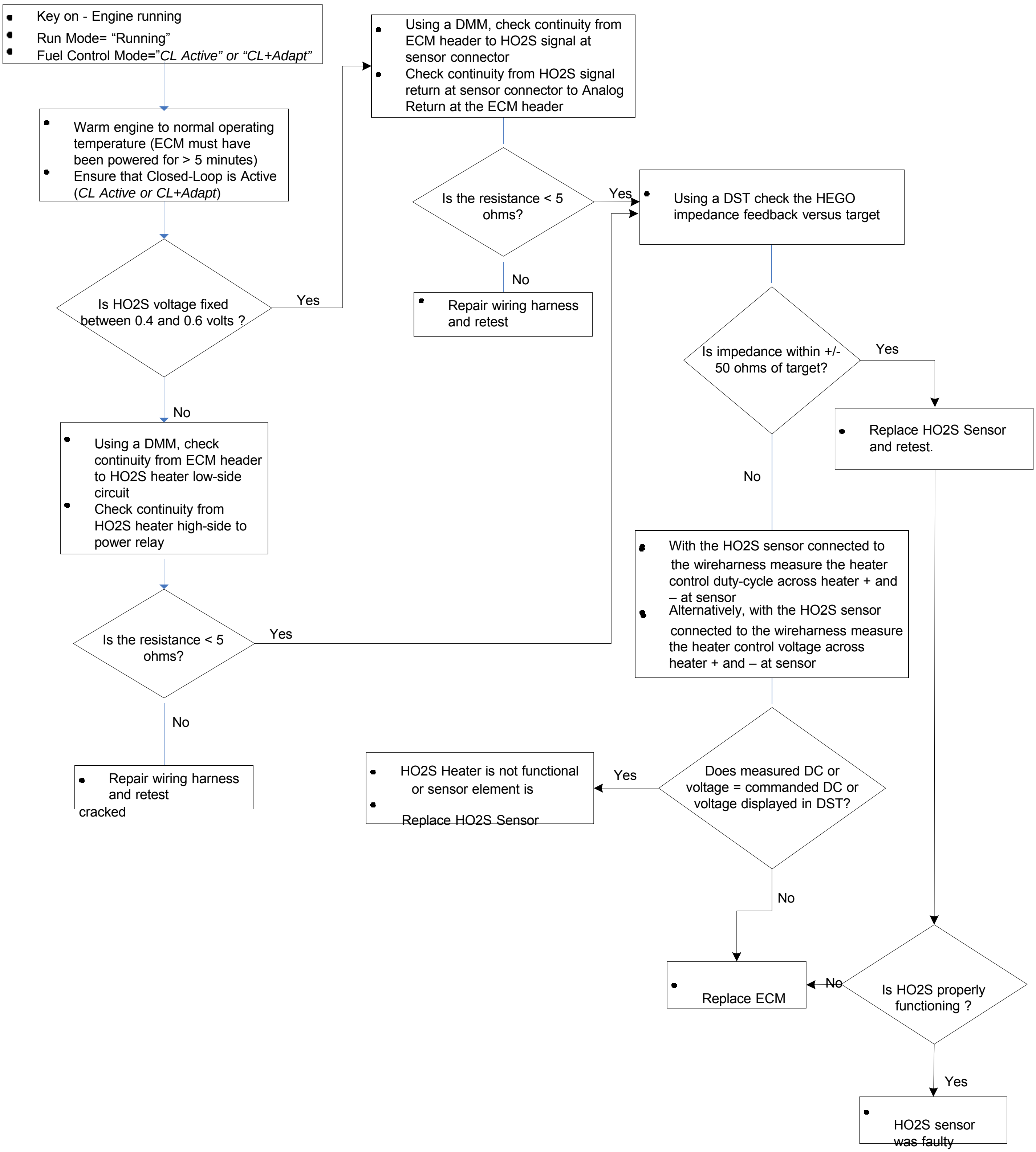
- Heated or Universal Exhaust Gas Oxygen Sensor (Bank 2-Sensor 1/Before Catalyst)
- Check Condition- Engine Running
- Fault Condition- HEGO/HO2S or UEGO cold longer than the time defined in the calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle and closed-loop fueling correction during active fault if used for pre-catalyst control.
- Emissions related fault

In a pre-catalyst configuration the HEGO/HO2S sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to lambda/equivalence ratio/air-fuel ratio. In either case, if there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted using the Closed Loop multiplier and then "learned" with the Adaptive multiplier. The multipliers only update when the system is in either *"CL Active"* or *"CL + Adapt"* control modes.

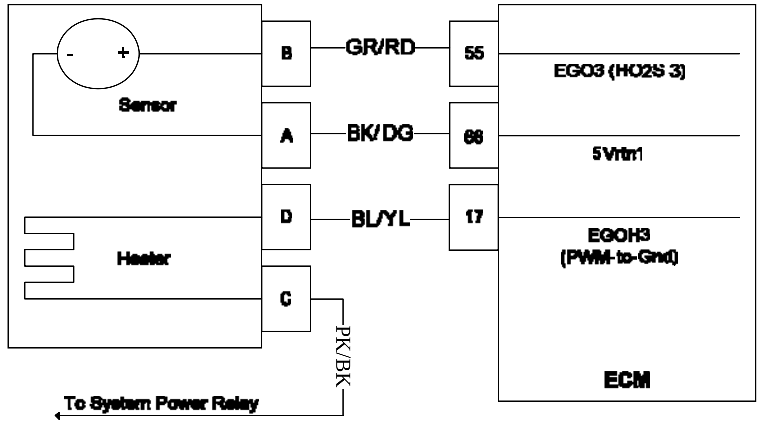
In a post-catalyst configuration the HEGO/HO2S sensor is a switching-type sensor around stoichiometry that measures the oxygen content downstream of the catalyst for two main functions: 1) to compare it to the oxygen content upstream of the catalyst to determine how efficiently the catalyst is using oxygen to determine its effectiveness and 2) trim the commanded equivalence ratio target to maximize the catalyst conversion efficiency. The post-catalyst strategy and diagnostic is only active when the system is in either *"CL Active"* or *"CL + Adapt"* control modes.

This fault will set if the sensor element is cold, non-responsive, or inactive for x seconds as defined in the diagnostic calibration. Cold, non-responsive, or inactive are determined based on two criteria 1) a measurement of the feedback sense element (zirconia) to determine its temperature or 2) a lack of change in sensor feedback. If used as a pre-catalyst sensor, this fault should disable closed-loop when it is active and adaptive learn for the key-cycle.

SPN 3227, FMI 5 - EGO2 Open/Lazy (HO2S2)



SPN 3266, FMI 5 - EGO4 Open/Lazy (HO2S4)

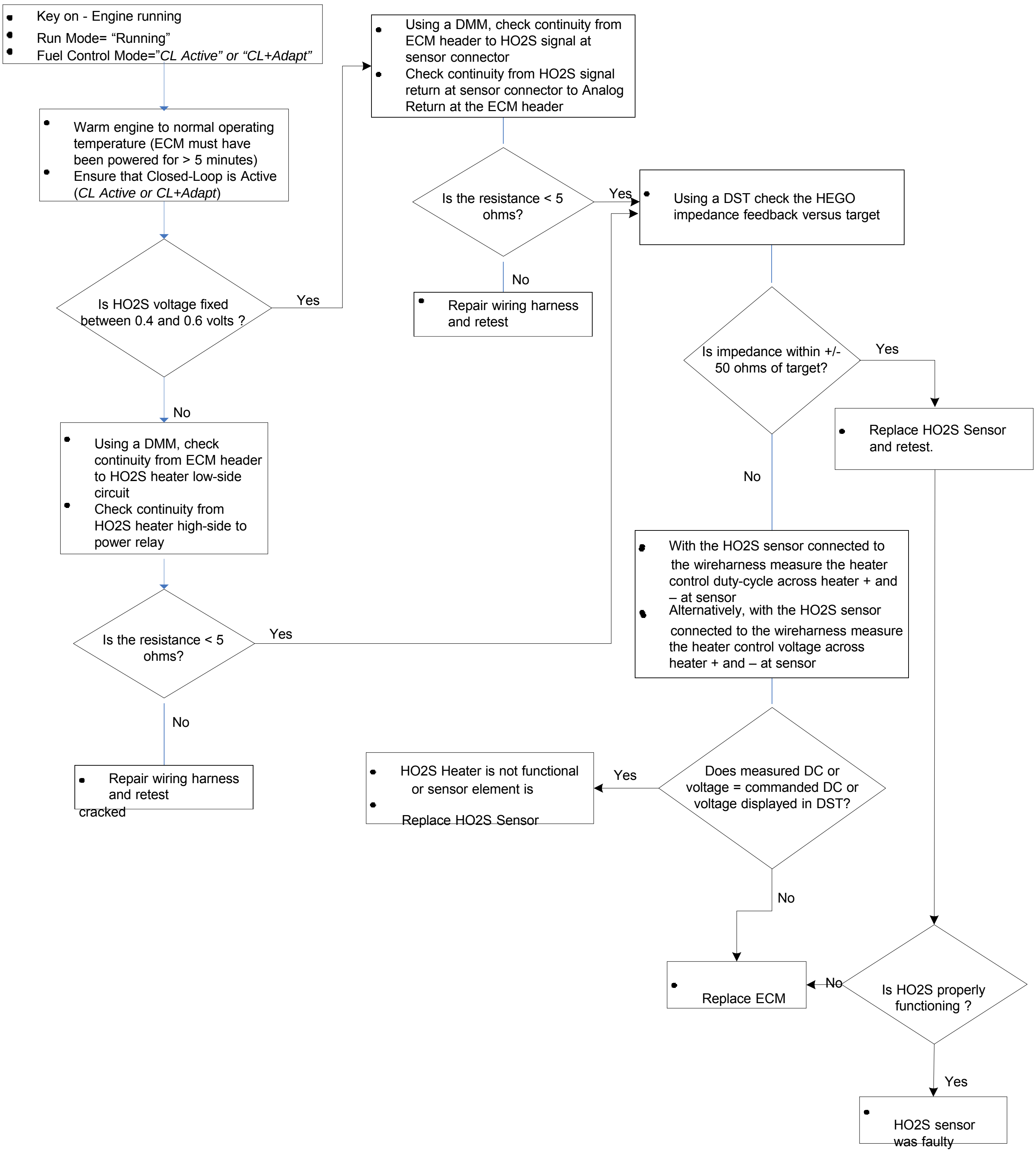


- Heated or Universal Exhaust Gas Oxygen Sensor (Bank 2-Sensor 2/Before Catalyst)
- Check Condition- Engine Running
- Fault Condition- HEGO/HO2S or UEGO cold longer than the time defined in the calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly disable adaptive learn and closed-loop during active fault
- Emissions related fault

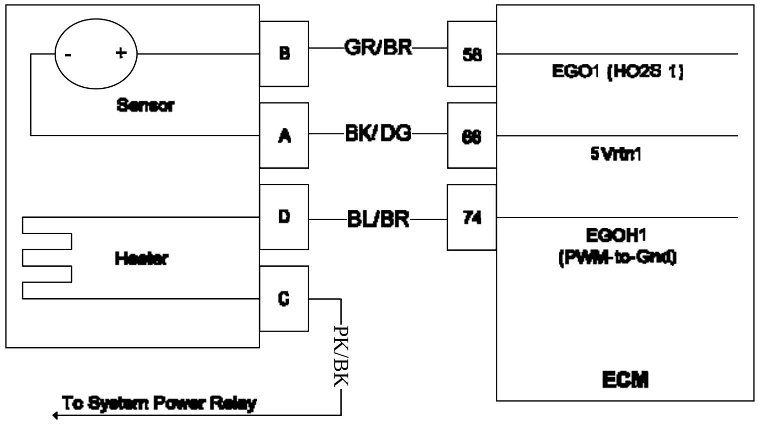
In a post-catalyst configuration the HEGO/HO2S sensor is a switching-type sensor around stoichiometry that measures the oxygen content downstream of the catalyst for two main functions: 1) to compare it to the oxygen content upstream of the catalyst to determine how efficiently the catalyst is using oxygen to determine its effectiveness and 2) trim the commanded equivalence ratio target to maximize the catalyst conversion efficiency. The post-catalyst strategy and diagnostic is only active when the system is in either *"CL Active"* or *"CL + Adapt"* control modes.

This fault will set if the sensor element is cold, non-responsive, or inactive for x seconds as defined in the diagnostic calibration. Cold, non-responsive, or inactive are determined based on two criteria 1) a measurement of the feedback sense element (zirconia) to determine its temperature or 2) a lack of change in sensor feedback.

SPN 3266, FMI 5 - EGO4 Open/Lazy (HO2S4)



SPN 4237, FMI 0 - Adaptive Lean Bank 1 High (Gasoline)



- Heated or Universal Exhaust Gas Oxygen Sensor (Bank 1-Sensor 1/Bank 1-Before Catalyst)
- Check Condition- Engine Running
- Fault Condition- Bank 1 adaptive fuel multiplier higher than defined in diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO/HO2S sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to lambda/equivalence ratio/air-fuel ratio. In either case, if there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either *“CL Active”* or *“CL + Adapt”* control modes. The purpose of the Adaptive Learn fuel multiplier is to adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation.

This fault sets if the Adaptive multiplier exceeds the high limit of normal operation indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near the HEGO sensor, 2) reduced fuel supply pressure to the fuel injection system, 3) a non-responsive HEGO/UEGO sensor, and/or 3) an injector that is stuck closed. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

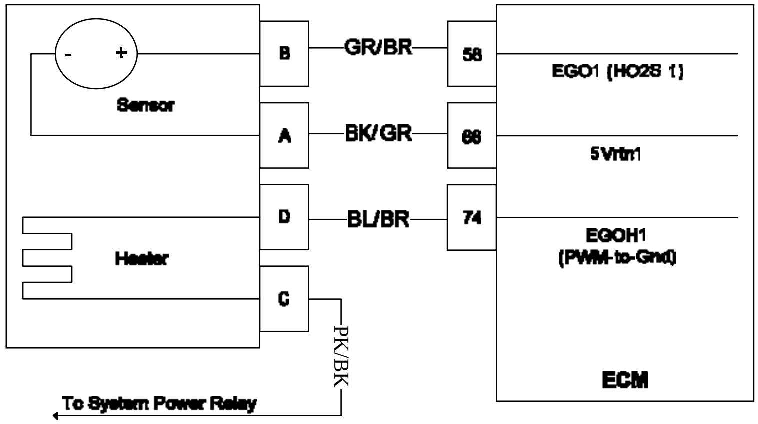
SPN 4237, FMI 0 - Adaptive Lean Bank 1 High (Gasoline)

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ☐ Vacuum Leaks - Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at light load.
- ☐ Injectors - System will be lean if an injector driver or driver circuit fails. The system will also be lean if an injector fails in a closed manner or is dirty.
- ☐ Fuel Pressure - System will be lean if fuel pressure is too low. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- ☐ Air in Fuel - If the fuel return hose/line is too close to the fuel supply pickup in the fuel tank, air may become entrapped in the pump or supply line causing a lean condition and driveability problems.
- ☐ Exhaust Leaks - If there is an exhaust leak, outside air can be pulled into the exhaust and past the O2 sensor causing a false lean condition.
- ☐ Fuel Quality - A drastic variation in fuel quality may cause the system to be lean including oxygenated fuels.
- ☐ System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- ☐ If all tests are OK, replace the HO2S sensor with a known good part and retest.

SPN 4237, FMI 1 - Adaptive Learn Bank1 Low (Gasoline)



- Heated or Universal Exhaust Gas Oxygen Sensor (Bank 1-Sensor 1/Bank 1-Before Catalyst)
- Check Condition- Engine Running
- Fault Condition- Bank 1 adaptive fuel multiplier lower than defined in diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO/HO2S sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to lambda/equivalence ratio/air-fuel ratio. In either case, if there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either *“CL Active”* or *“CL + Adapt”* control modes. The purpose of the Adaptive Learn fuel multiplier is to adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation.

This fault sets if the Adaptive multiplier exceeds the low limit of normal operation indicating that the engine is operating rich (excess fuel) and requires less fuel than allowed by corrections. Often high negative fueling corrections are a function of one or more of the following conditions: 1) high fuel supply pressure to the fuel injection system, 2) a non-responsive HEGO/UEGO sensor, and/or 3) an injector that is stuck open. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

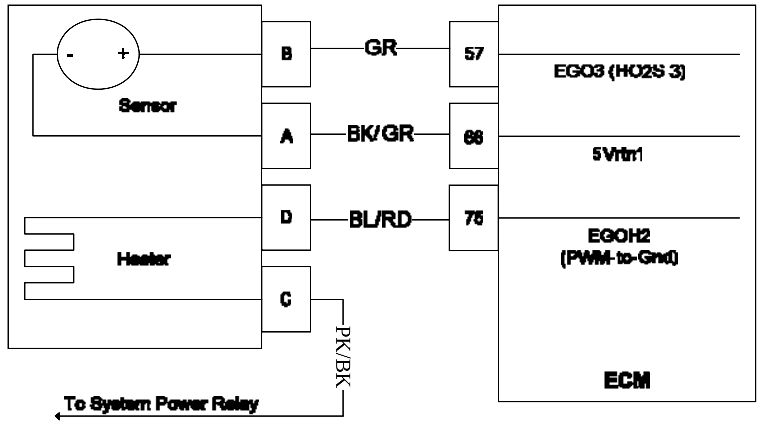
SPN 4237, FMI 1 - Adaptive Learn Bank1 Low (Gasoline)

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ☐ Injectors - System will be rich if an injector driver or driver circuit fails shorted-to-ground. The system will also be rich if an injector fails in an open.
- ☐ Fuel Pressure - System will be rich if fuel pressure is too high. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- ☐ System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- ☐ If all tests are OK, replace the HO2S sensor with a known good part and retest.

SPN 4239, FMI 0 - Adaptive-Learn Bank 2 High (Gasoline)



- Heated or Universal Exhaust Gas Oxygen Sensor (Bank 2-Sensor 1/Bank 1-Before Catalyst)
- Check Condition- Engine Running
- Fault Condition- Bank 2 adaptive fuel multiplier higher than defined in diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO/HO2S sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to lambda/equivalence ratio/air-fuel ratio. In either case, if there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then "learned" with the Adaptive multiplier. The multipliers only update when the system is in either *"CL Active"* or *"CL + Adapt"* control modes. The purpose of the Adaptive Learn fuel multiplier is to adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation.

This fault sets if the Adaptive multiplier exceeds the high limit of normal operation indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near the HEGO sensor, 2) reduced fuel supply pressure to the fuel injection system, 3) a non-responsive HEGO/UEGO sensor, and/or 3) an injector that is stuck closed. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

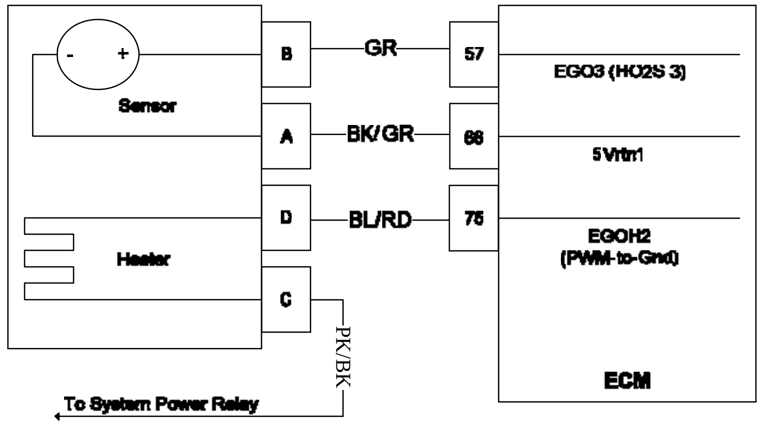
SPN 4239, FMI 0 - Adaptive-Learn Bank 2 High (Gasoline)

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ☐ Vacuum Leaks - Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at light load.
- ☐ Injectors - System will be lean if an injector driver or driver circuit fails. The system will also be lean if an injector fails in a closed manner or is dirty.
- ☐ Fuel Pressure - System will be lean if fuel pressure is too low. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- ☐ Air in Fuel - If the fuel return hose/line is too close to the fuel supply pickup in the fuel tank, air may become entrapped in the pump or supply line causing a lean condition and driveability problems.
- ☐ Exhaust Leaks - If there is an exhaust leak, outside air can be pulled into the exhaust and past the O2 sensor causing a false lean condition.
- ☐ Fuel Quality - A drastic variation in fuel quality may cause the system to be lean including oxygenated fuels.
- ☐ System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- ☐ If all tests are OK, replace the HO2S sensor with a known good part and retest.

SPN 4239, FMI 1 - Adaptive-Learn Bank 2 Low (Gasoline)



- Heated or Universal Exhaust Gas Oxygen Sensor (Bank 2-Sensor 1/Bank 1-Before Catalyst)
- Check Condition- Engine Running
- Fault Condition- Bank 2 adaptive fuel multiplier lower than defined in diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO/HO2S sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to lambda/equivalence ratio/air-fuel ratio. In either case, if there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then "learned" with the Adaptive multiplier. The multipliers only update when the system is in either *"CL Active"* or *"CL + Adapt"* control modes. The purpose of the Adaptive Learn fuel multiplier is to adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation.

This fault sets if the Adaptive multiplier exceeds the low limit of normal operation indicating that the engine is operating rich (excess fuel) and requires less fuel than allowed by corrections. Often high negative fueling corrections are a function of one or more of the following conditions: 1) high fuel supply pressure to the fuel injection system, 2) a non-responsive HEGO/UEGO sensor, and/or 3) an injector that is stuck open. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

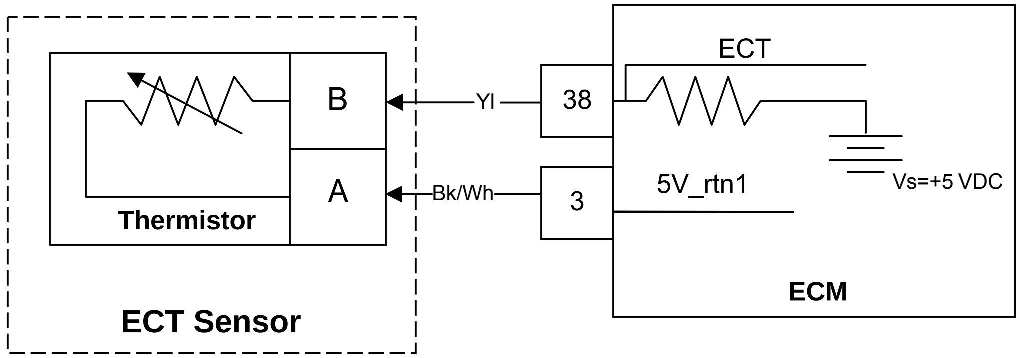
SPN 4239, FMI 1 - Adaptive-Learn Bank 2 Low (Gasoline)

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ☐ Injectors - System will be rich if an injector driver or driver circuit fails shorted-to-ground. The system will also be rich if an injector fails in an open.
- ☐ Fuel Pressure - System will be rich if fuel pressure is too high. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- ☐ System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- ☐ If all tests are OK, replace the HO2S sensor with a known good part and retest.

SPN 110, FMI 0 - ECT Higher Than Expected 2



- Engine Coolant Temperature Sensor
- Check Condition-Engine Running
- Fault Condition-Engine Coolant Temperature reading or estimate greater than the stage 2 limit when operating at a speed greater than defined in the diagnostic calibration
- Corrective Action(s)- Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 2 and/or a forced idle or engine shutdown to protect engine from possible damage.
- Non-emissions related fault

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. Some engines use a CHT sensor that is located in the coolant in the cylinder head. Some engines use an ECT (Engine Coolant Temperature) sensor that is located in the coolant near the thermostat. If the engine is equipped with a CHT sensor then the ECT value is estimated. If equipped with an ECT sensor then the CHT value is estimated. They are used for engine airflow calculation, ignition timing control, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor reading is cool the sensor reads higher voltage, and lower when warm.

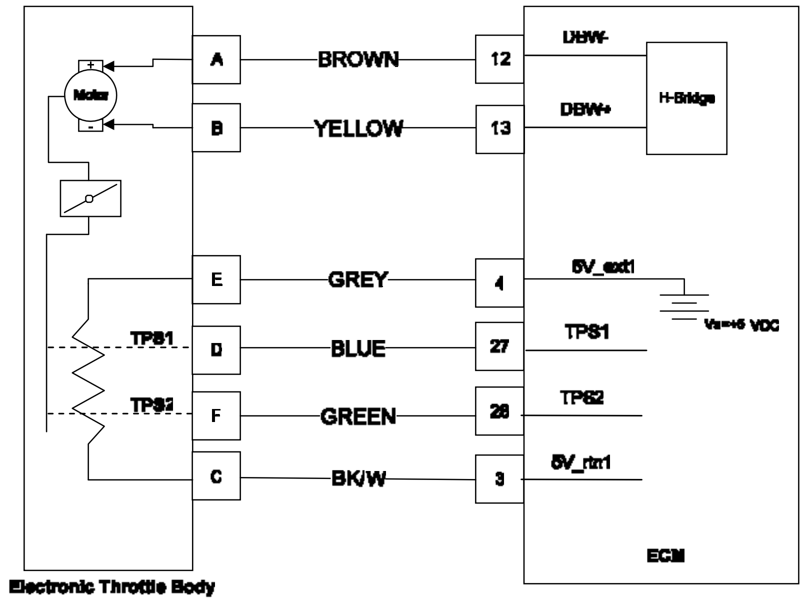
This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

SPN 110, FMI 0 - ECT Higher Than Expected 2

Diagnostic Aids

- ☐ If the "ECT High Voltage" fault is also present, follow the troubleshooting procedures for that fault as it may have caused "ECT Higher Than Expected 2."
- ☐ If the cooling system utilizes an air-to-water heat exchanger (radiator) and fan:
  - o Check that the radiator has a proper amount of ethylene glycol/water and that the radiator is not leaking
  - o Ensure that there is no trapped air in the cooling path
  - o Inspect the cooling system (radiator and hoses) for cracks and ensure connections are leak free
  - o Check that the fan is operating properly
  - o Check that the thermostat is not stuck closed
- ☐ If the cooling system utilizes a water-to-water heat exchanger:
  - o Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
  - o Ensure that there is no trapped air in the cooling path
  - o Inspect the cooling system (radiator and hoses) for cracks and ensure connections are leak free
  - o Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
  - o Check that the thermostat is not stuck closed
  - o Check that the raw water pump/impeller is tact and that it is not restricted

DTC 219- RPM Higher Than Max Allowed Governed Speed



- Max Govern Speed Override- Crankshaft Position Sensor
- Check Condition-Engine Running
- Fault Condition-Engine speed greater than the max gov override speed as defined in the diagnostic calibration
- Corrective Action(s): Sound audible warning or illuminate secondary warning lamp, reduce throttle to limit speed. Recommend closed loop and adaptive learn fueling correction remains active during fault.
- Non-emissions related fault

This fault will set anytime the engine RPM exceeds the limit set in the diagnostic calibration for the latch time or more. This speed overrides any higher max governor speeds programmed by the user. This fault is designed to help prevent engine or equipment damage.

The throttle will be lowered in order to govern the engine to the speed set in the diagnostic calibration.

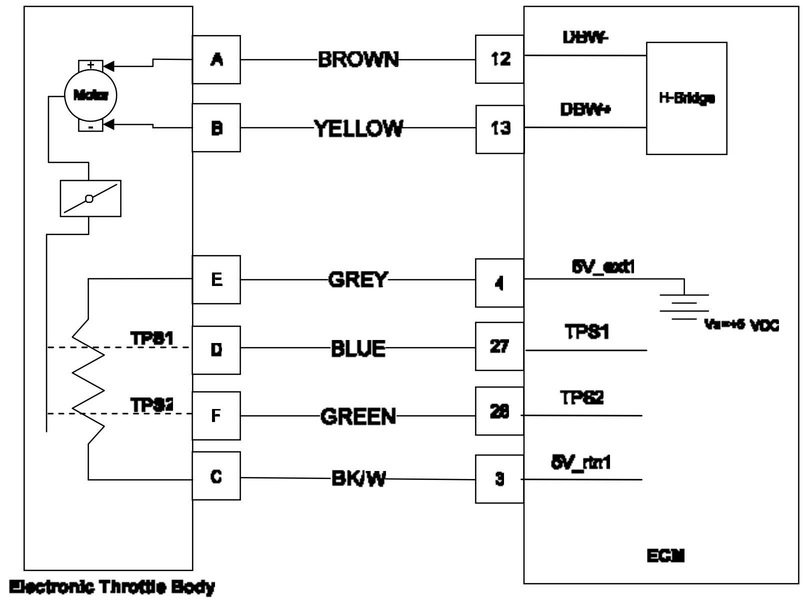
DTC 219- RPM Higher Than Max Allowed Governed Speed

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Ensure that no programmed governor speeds exceed the limit set in the diagnostic calibration for Max Gov Override Speed
- ☐ Check mechanical operation of the throttle
- ☐ Check the engine intake for large air leaks downstream of the throttle body

SPN 51, FMI 0 - TPS1 % Higher Than TPS2 %



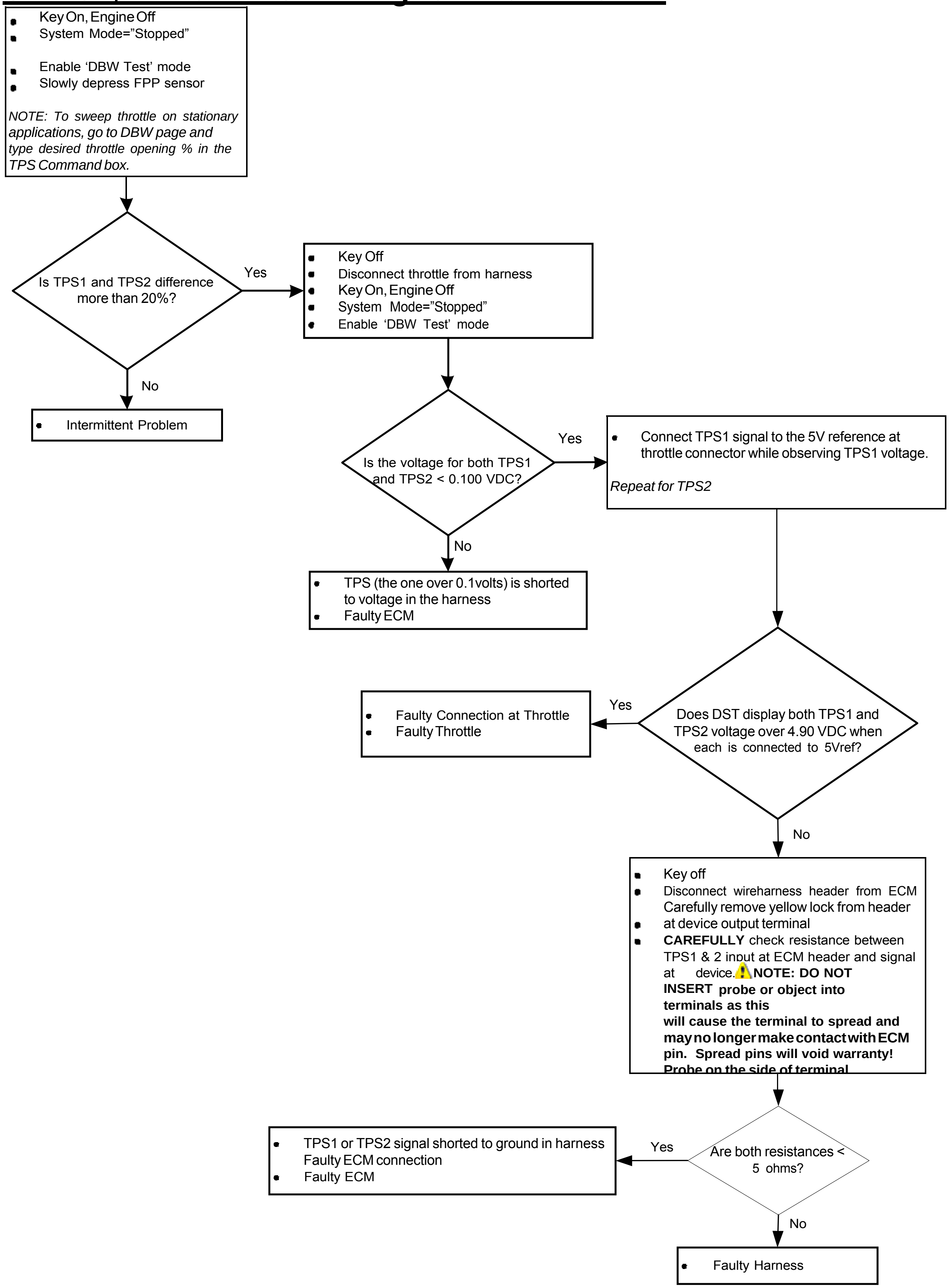
- Throttle Body-Throttle Position Sensor 1 & 2 (electronic throttle body only)
- Check Condition-Key-On, Engine Cranking, or Running
- Fault Condition-TPS1 lower than TPS2 by the % set in the diagnostic calibration
- Corrective Action(s)- Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

The throttle controls the airflow through the engine, directly affecting the power output of the engine. When the throttle is electronically controlled in an Electronic Throttle Body it can be used to control the idle stability and limit engine speed based on operating conditions.

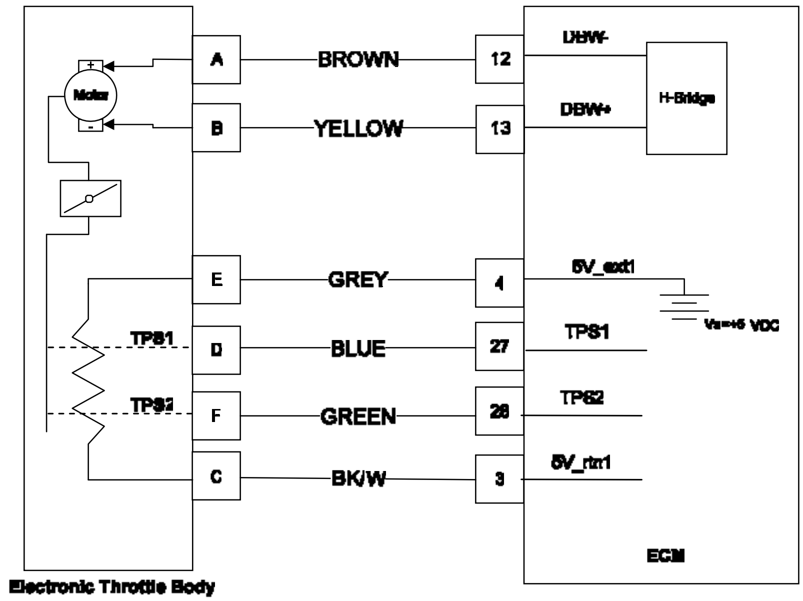
The Throttle Position Sensor uses either 1) a variable resistor and voltage divider circuit or 2) a non-contact hall-effect sensor to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic Throttle Body multiple position feedback sensors (usually two counteracting potentiometers/hall-effects) are used to perform speed governing with improved safety and redundancy.

This fault will set if TPS1 % is higher than TPS2 % by the amount defined in the diagnostic calibration. At this point the throttle is considered to be out of specification, or there is a problem with the TPS signal circuit. During this active fault, an audible/visual alert device is activated and either an engine shutdown should is triggered or throttle control is set to use the higher of the two feedback signals for control in combination with a low rev limit and/or power derate.

SPN 51, FMI 0 - TPS1 % Higher Than TPS2 %



SPN 3673, FMI 4 - TPS2 Signal Voltage Low



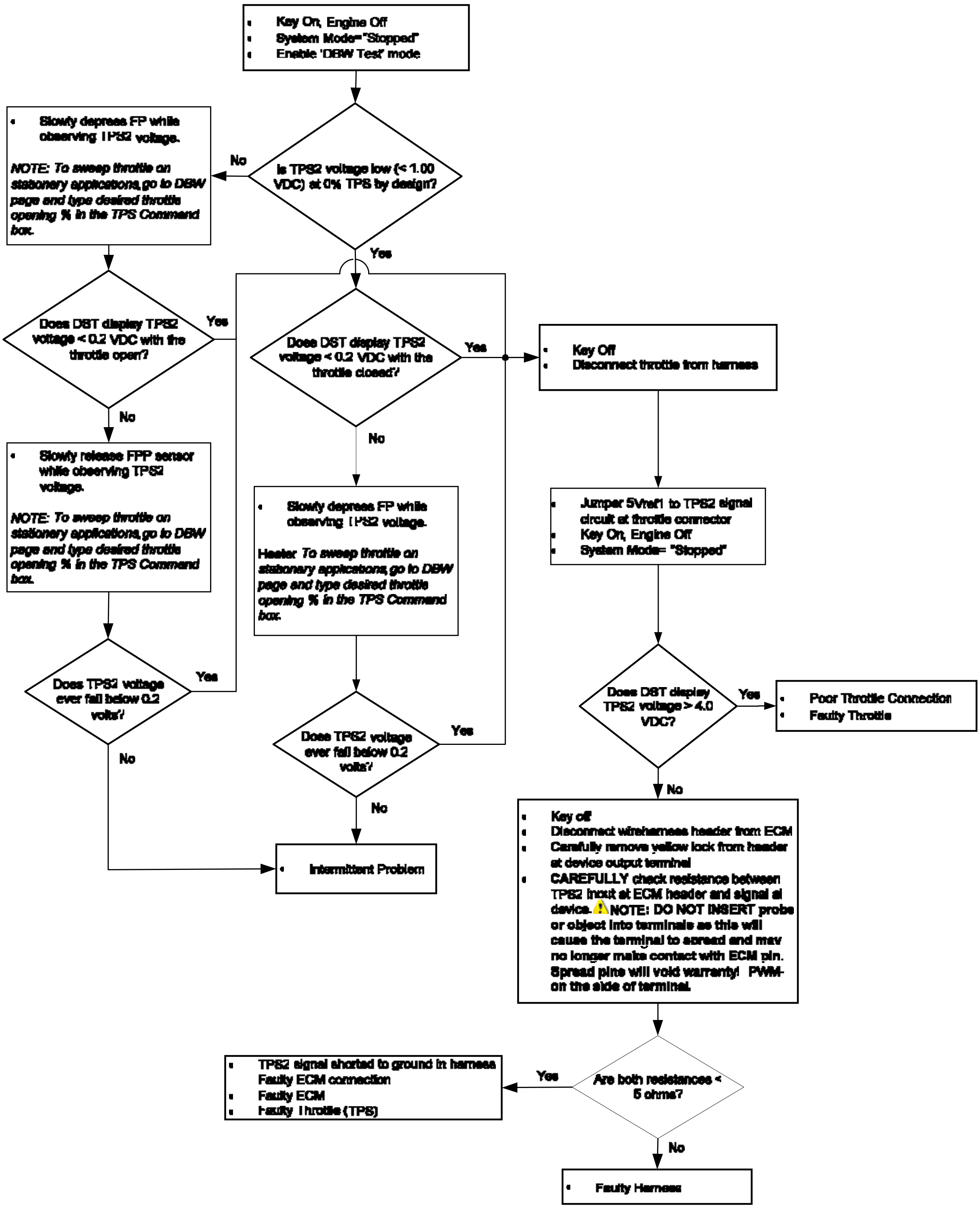
- Throttle Body-Throttle Position Sensor 2 (electronic throttle body only)
- Check Condition-Key-On, Engine Cranking, or Running
- Fault Condition-TPS2 sensor voltage lower than the limit defined in the diagnostic calibration
- Corrective Action(s)- Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

The throttle controls the airflow through the engine, directly affecting the power output of the engine. When the throttle is electronically controlled in an Electronic Throttle Body it can be used to control the idle stability and limit engine speed based on operating conditions.

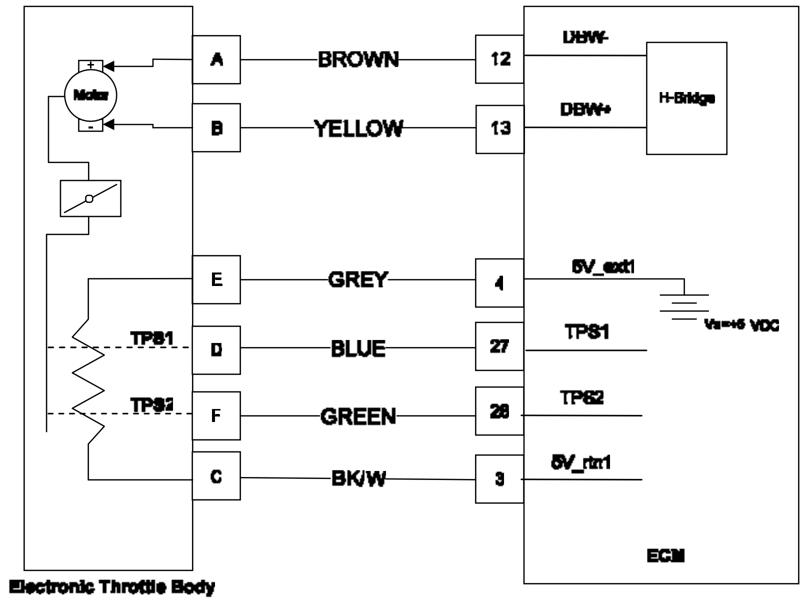
The Throttle Position Sensor uses either 1) a variable resistor and voltage divider circuit or 2) a non-contact hall-effect sensor to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic Throttle Body multiple position feedback sensors (usually two counteracting potentiometers/hall-effects) are used to perform speed governing with improved safety and redundancy.

This fault will set if TPS2 voltage is lower than the low voltage limit as defined in the diagnostic calibration at any operating condition while the engine is cranking or running. The limit is generally set to 4.90 VDC. In many cases, this condition is caused by the TPS sensor being disconnected from the engine harness, an open-circuit or short-to-ground of the TPS circuit in the wireharness, or a failure of the sensor. This fault should be configured to trigger an engine shutdown and the engine will not start with this fault active.

SPN 3673, FMI 4 - TPS2 Signal Voltage Low



SPN 3673, FMI 3 - TPS2 Signal Voltage High



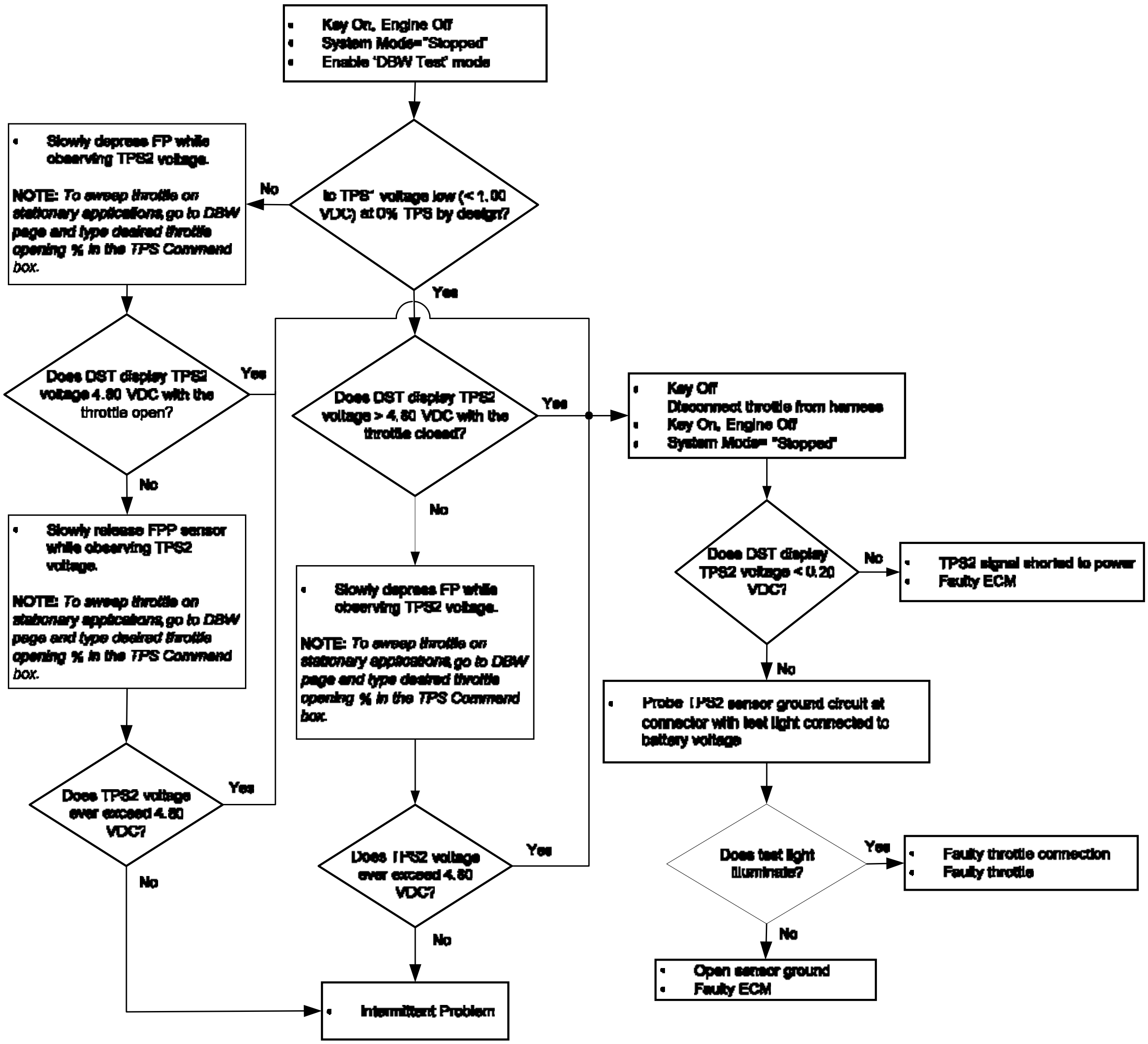
- Throttle Body-Throttle Position Sensor 2 (electronic throttle body only)
- Check Condition-Key-On, Engine Cranking, or Running
- Fault Condition-TPS2 sensor voltage higher than the limit defined in the diagnostic calibration
- Corrective Action(s)- Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

The throttle controls the airflow through the engine, directly affecting the power output of the engine. When the throttle is electronically controlled in an Electronic Throttle Body it can be used to control the idle stability and limit engine speed based on operating conditions.

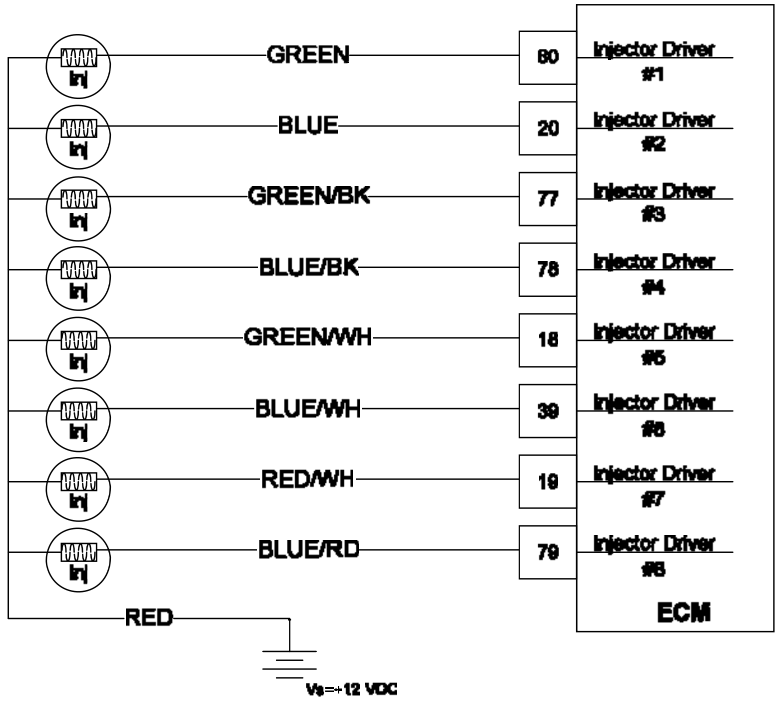
The Throttle Position Sensor uses either 1) a variable resistor and voltage divider circuit or 2) a non-contact hall-effect sensor to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic Throttle Body multiple position feedback sensors (usually two counteracting potentiometers/hall-effects) are used to perform speed governing with improved safety and redundancy.

This fault will set if TPS2 voltage is higher than the limit set in the diagnostic calibration at any operating condition while the engine is cranking or running. The limit is generally set to 4.90 VDC. In many cases, this condition is caused by a short-to-power of the TPS circuit in the wireharness or a failure of the sensor. This fault should be configured to trigger an engine shutdown and the engine will not start with this fault active.

SPN 3673, FMI 3 - TPS2 Signal Voltage High



SPN 651, FMI 5 - Injector Driver #1 Open/Short-To-Ground



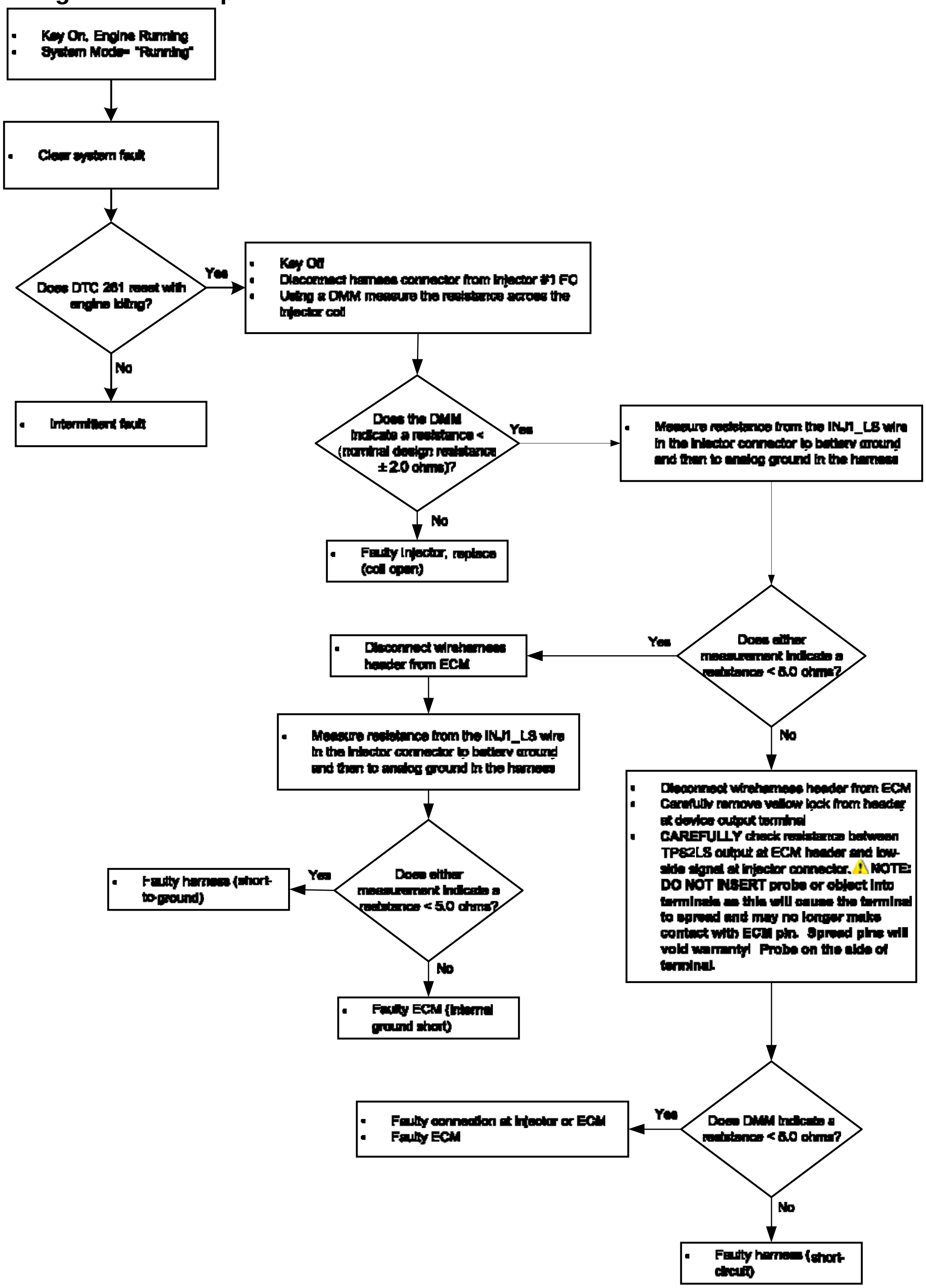
- Injector #1 Coil or Driver Open Circuit or Short-to-Ground
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM greater than x volts and injector low-side less than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 1st injector in the firing order or for the injector on cylinder #1 depending on the Firing Order/Block Order configuration of the engine's calibration.

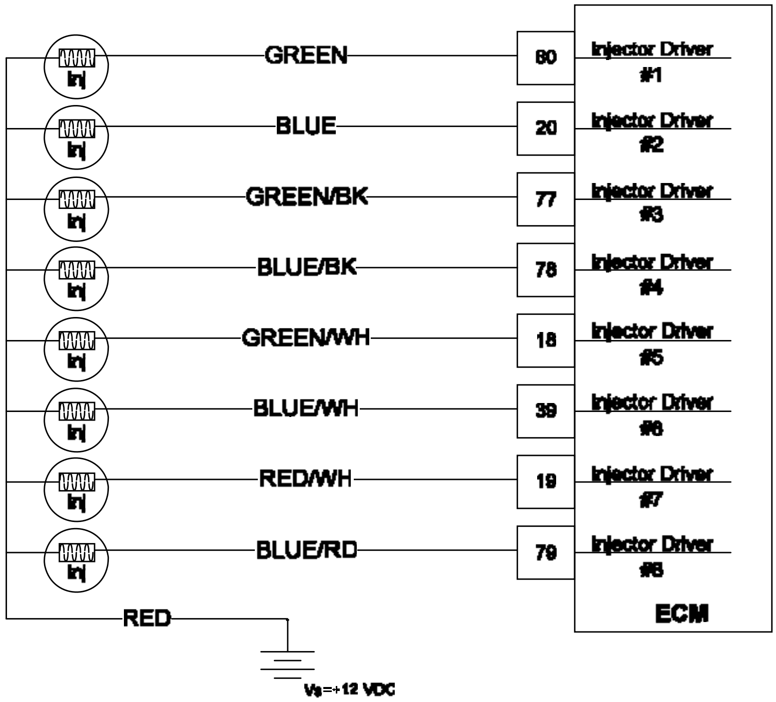
This fault will set if the ECM detects low feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 651, FMI 5 - Injector Driver #1 Open/Short-To-Ground

Firing Order Example



SPN 651, FMI 6 - Injector Driver #1 Short-To-Power



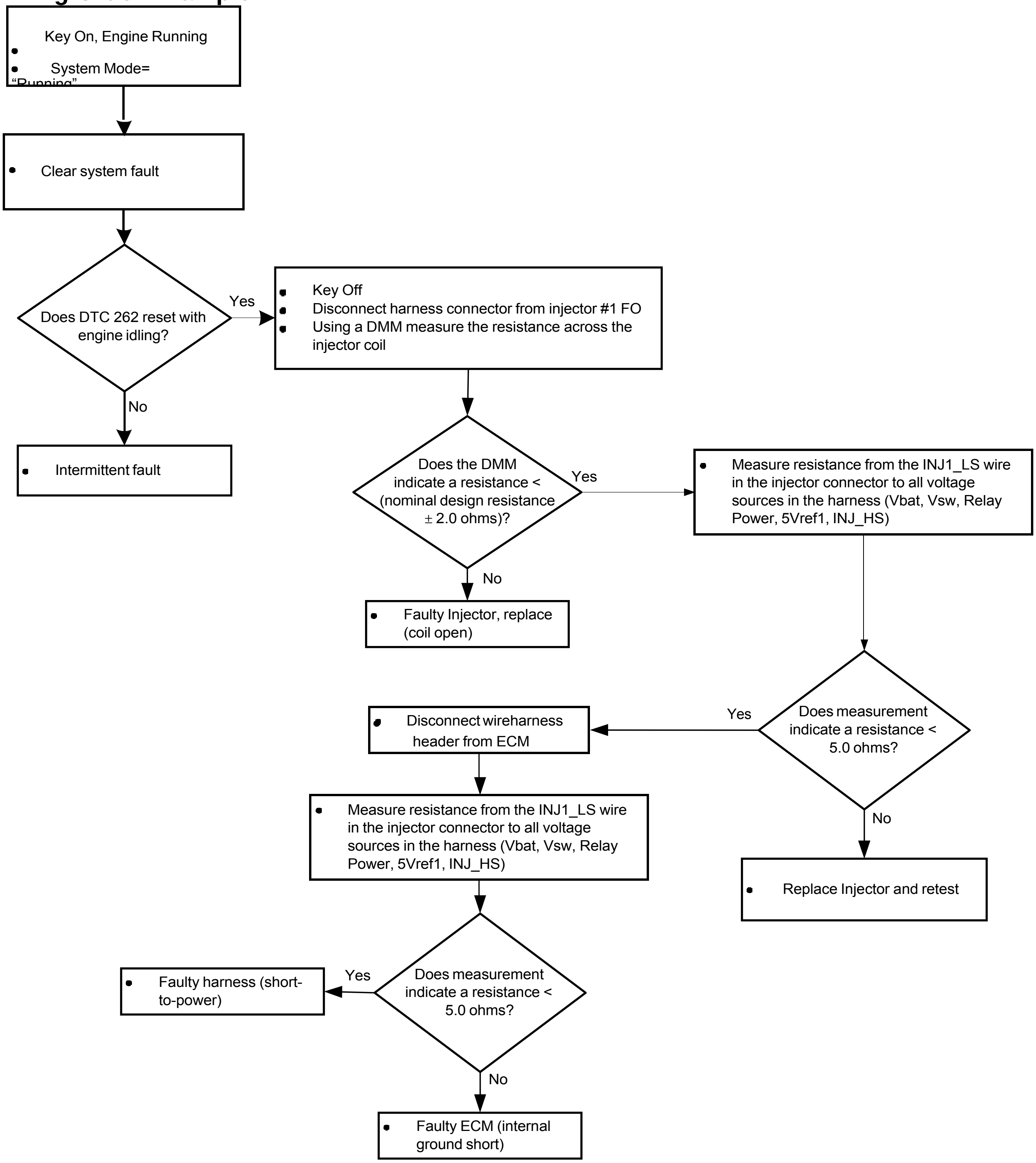
- Injector #1 Coil or Driver Short-to-Power
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM less than x volts and injector low-side greater than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 1st injector in the firing order or for the injector on cylinder #1 depending on the Firing Order/Block Order configuration of the engine's calibration.

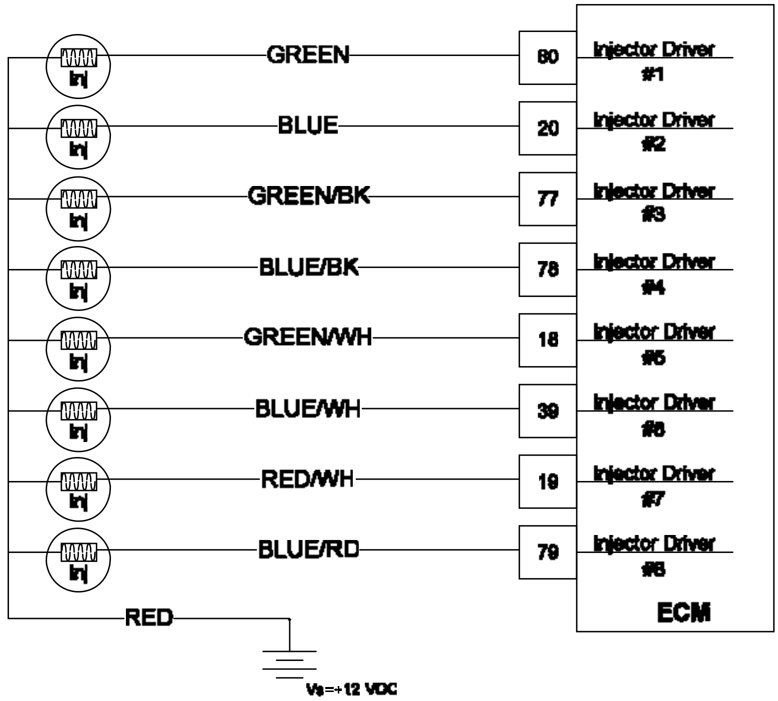
This fault will set if the ECM detects higher than expected feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 651, FMI 6 - Injector Driver #1 Short-To-Power

Firing Order Example



SPN 652, FMI 5 - Injector Driver #2 Open/Short-To-Ground



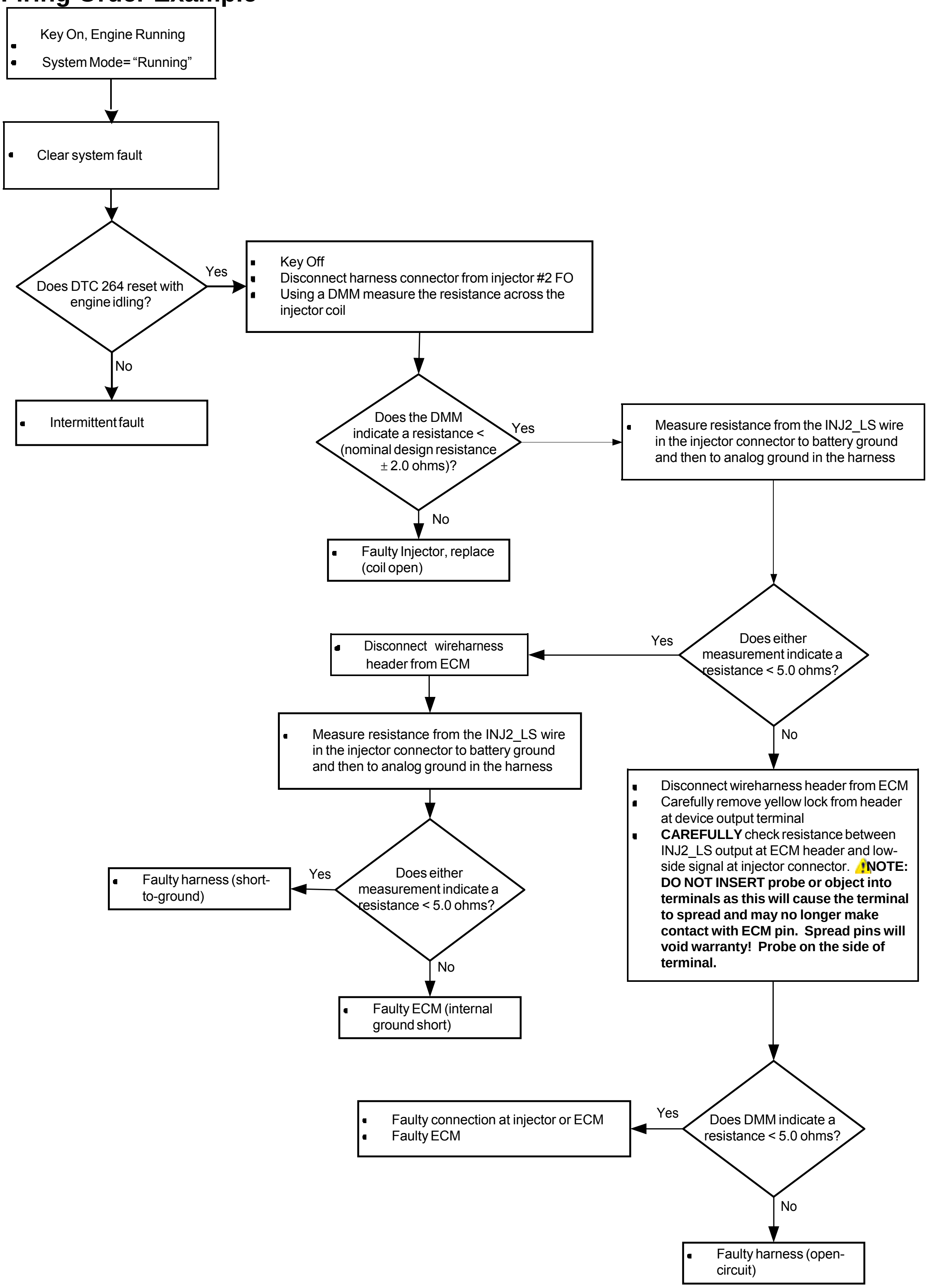
- Injector #2 Coil or Driver Open Circuit or Short-to-Ground
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM greater than x volts and injector low-side less than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 2nd injector in the firing order or for the injector on cylinder #2 depending on the Firing Order/Block Order configuration of the engine's calibration.

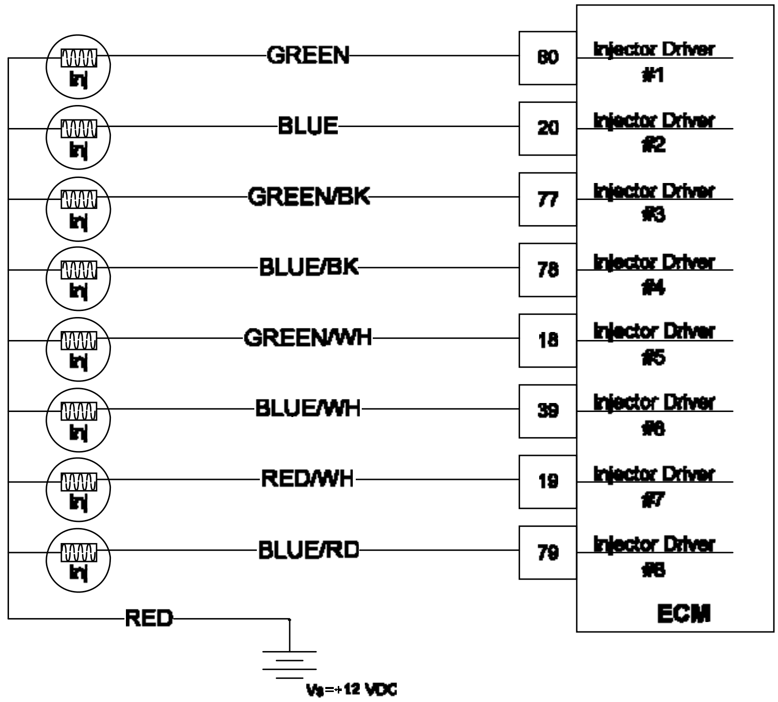
This fault will set if the ECM detects low feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 652, FMI 5 - Injector Driver #2 Open/Short-To-Ground

Firing Order Example



SPN 652, FMI 6 - Injector Driver #2 Short-To-Power



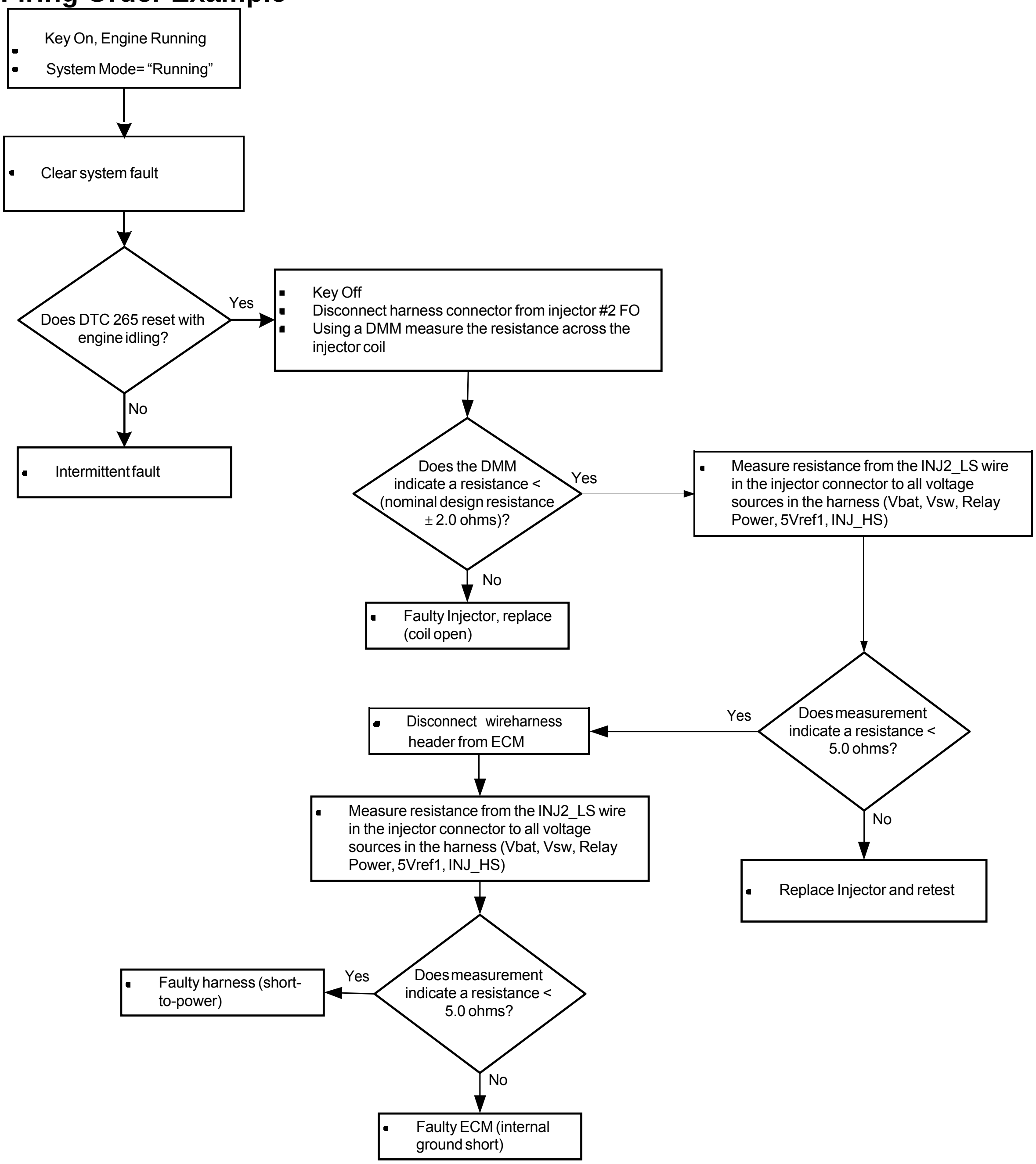
- Injector #2 Coil or Driver Short-to-Power
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM less than x volts and injector low-side greater than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 2nd injector in the firing order or for the injector on cylinder #2 depending on the Firing Order/Block Order configuration of the engine's calibration.

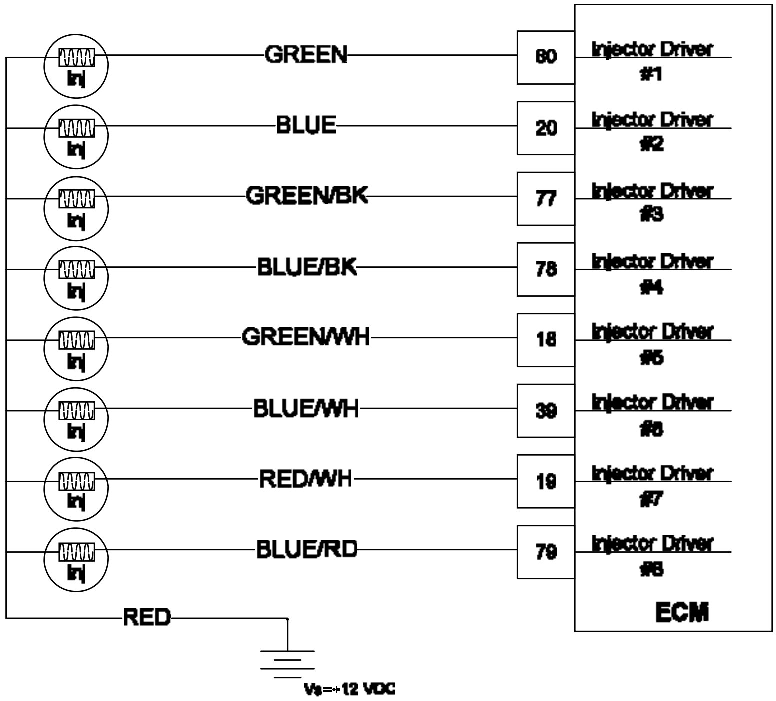
This fault will set if the ECM detects higher than expected feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 652, FMI 6 - Injector Driver #2 Short-To-Power

Firing Order Example



SPN 653, FMI 5 - Injector Driver #3 Open/Short-To-Ground



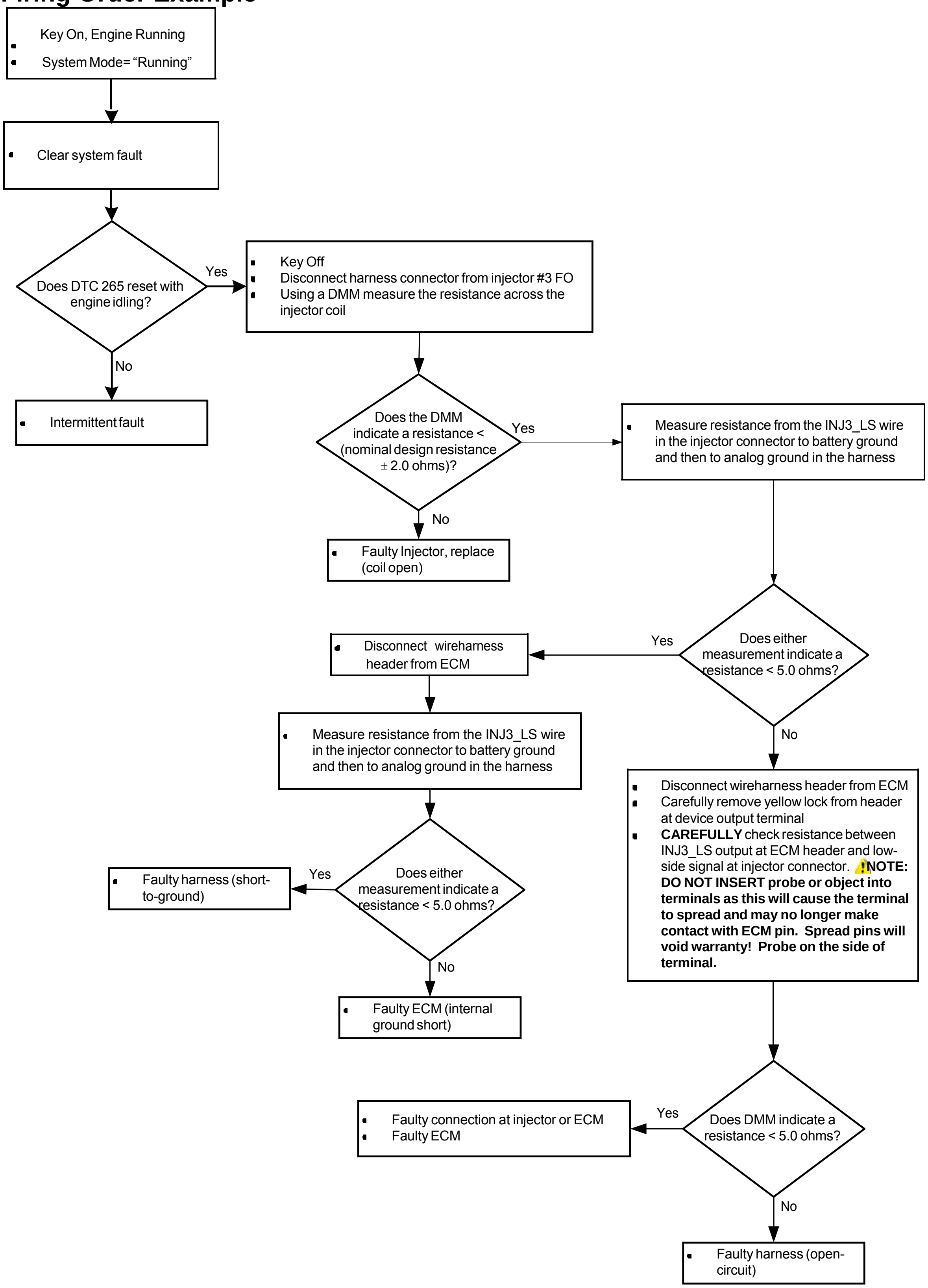
- Injector #3 Coil or Driver Open Circuit or Short-to-Ground
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM greater than x volts and injector low-side less than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 3rd injector in the firing order or for the injector on cylinder #3 depending on the Firing Order/Block Order configuration of the engine's calibration.

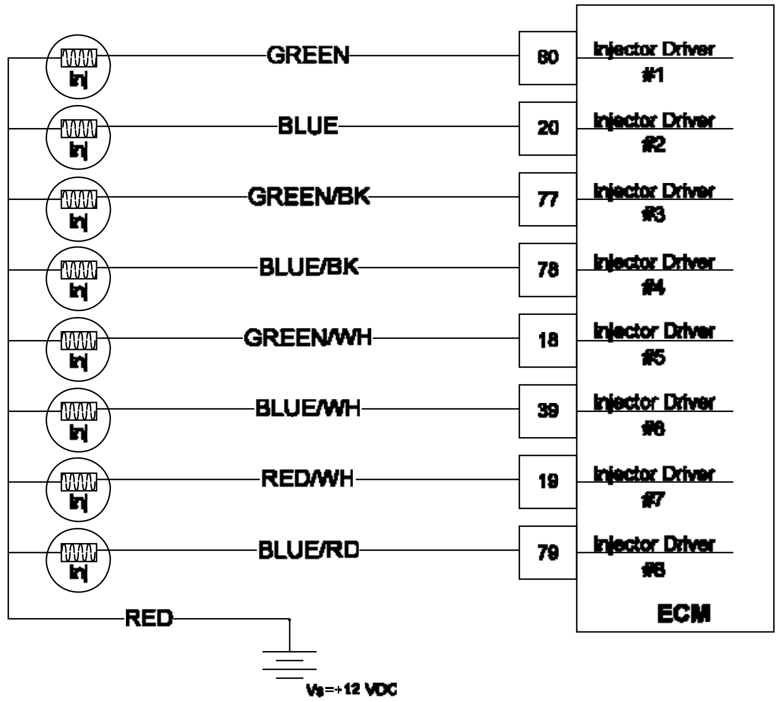
This fault will set if the ECM detects low feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 653, FMI 5 - Injector Driver #3 Open/Short-To-Ground

Firing Order Example



SPN 653, FMI 6 - Injector Driver #3 Short-To-Power



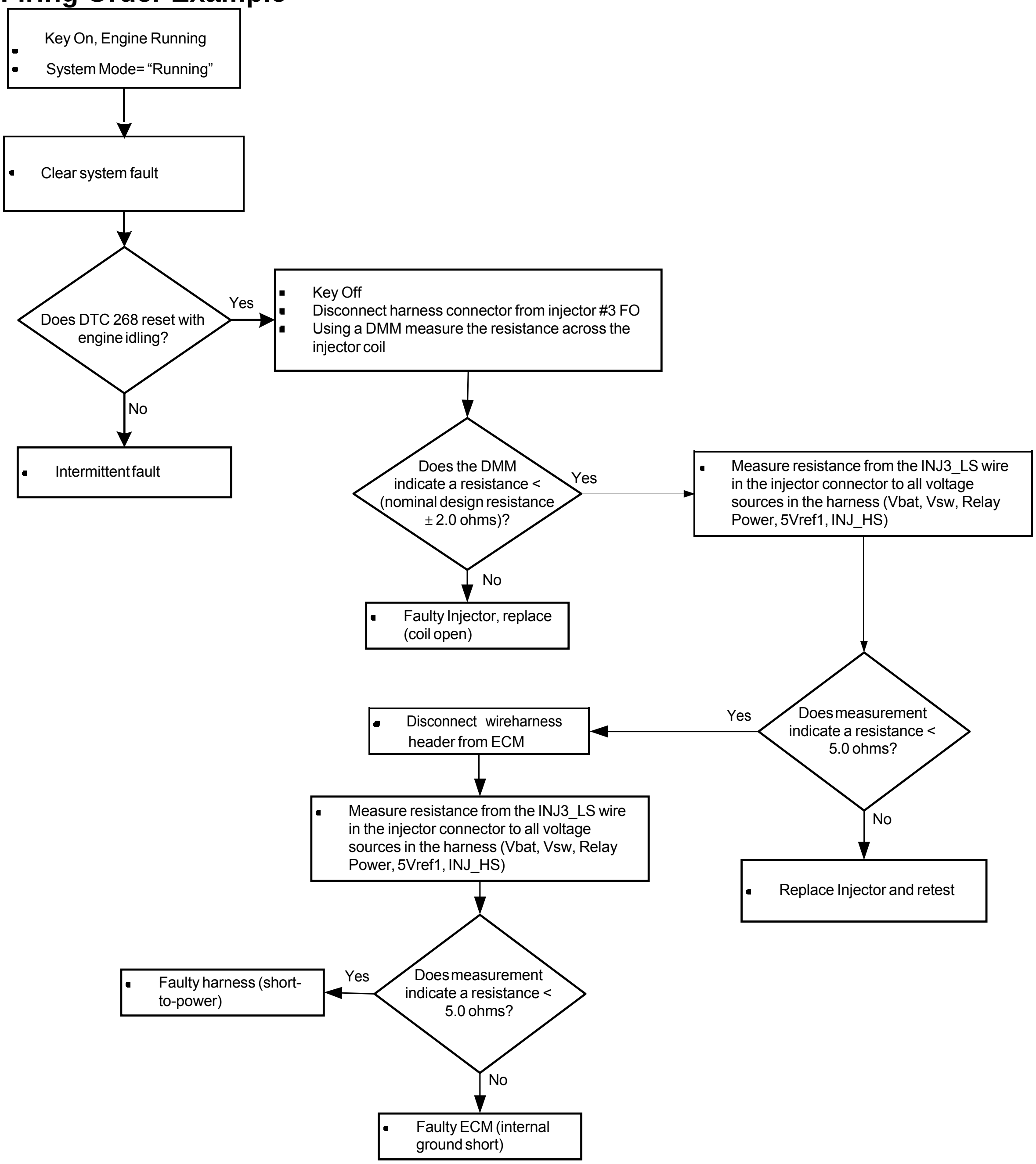
- Injector #3 Coil or Driver Short-to-Power
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM less than x volts and injector low-side greater than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 3rd injector in the firing order or for the injector on cylinder #3 depending on the Firing Order/Block Order configuration of the engine's calibration.

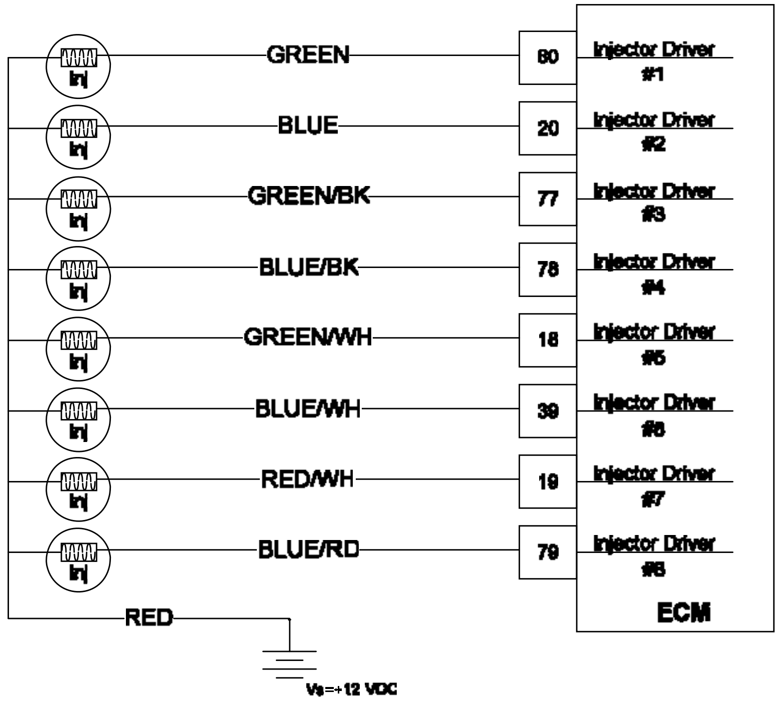
This fault will set if the ECM detects higher than expected feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 653, FMI 6 - Injector Driver #3 Short-To-Power

Firing Order Example



SPN 654, FMI 5 - Injector Driver #4 Open/Short-To-Ground



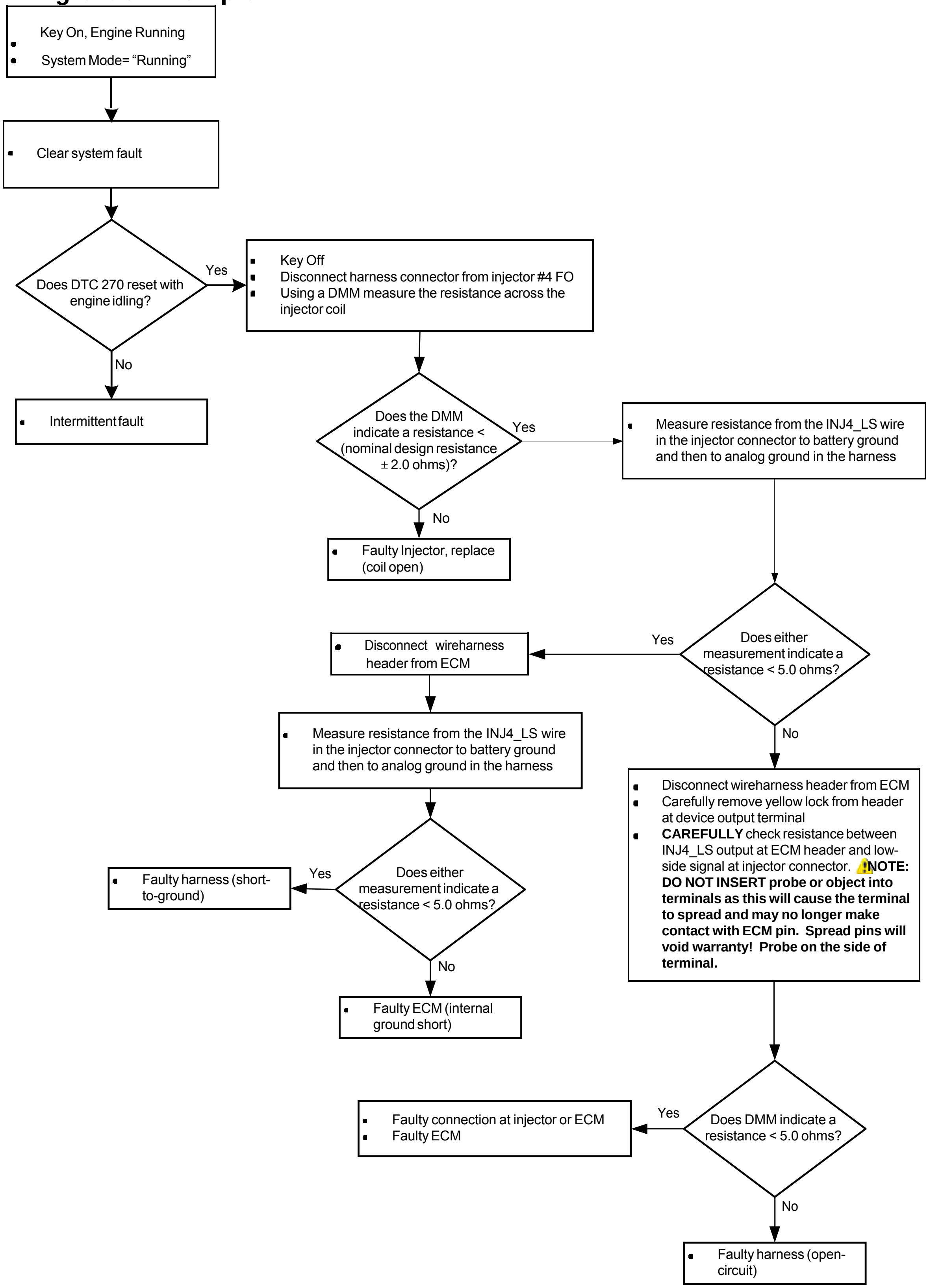
- Injector #4 Coil or Driver Open Circuit or Short-to-Ground
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM greater than x volts and injector low-side less than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 4th injector in the firing order or for the injector on cylinder #4 depending on the Firing Order/Block Order configuration of the engine's calibration.

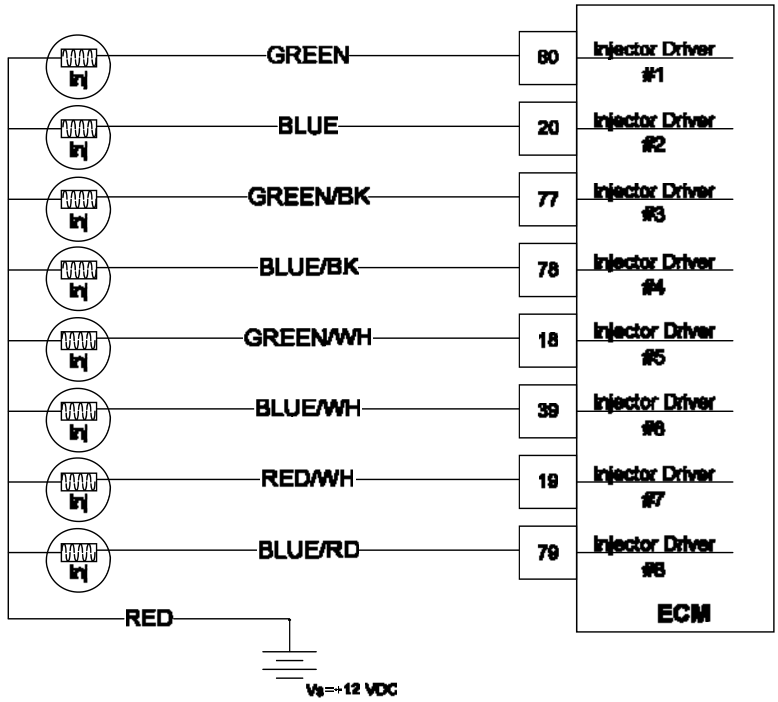
This fault will set if the ECM detects low feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 654, FMI 5 - Injector Driver #4 Open/Short-To-Ground

Firing Order Example



SPN 654, FMI 6 - Injector Driver #4 Short-To-Power



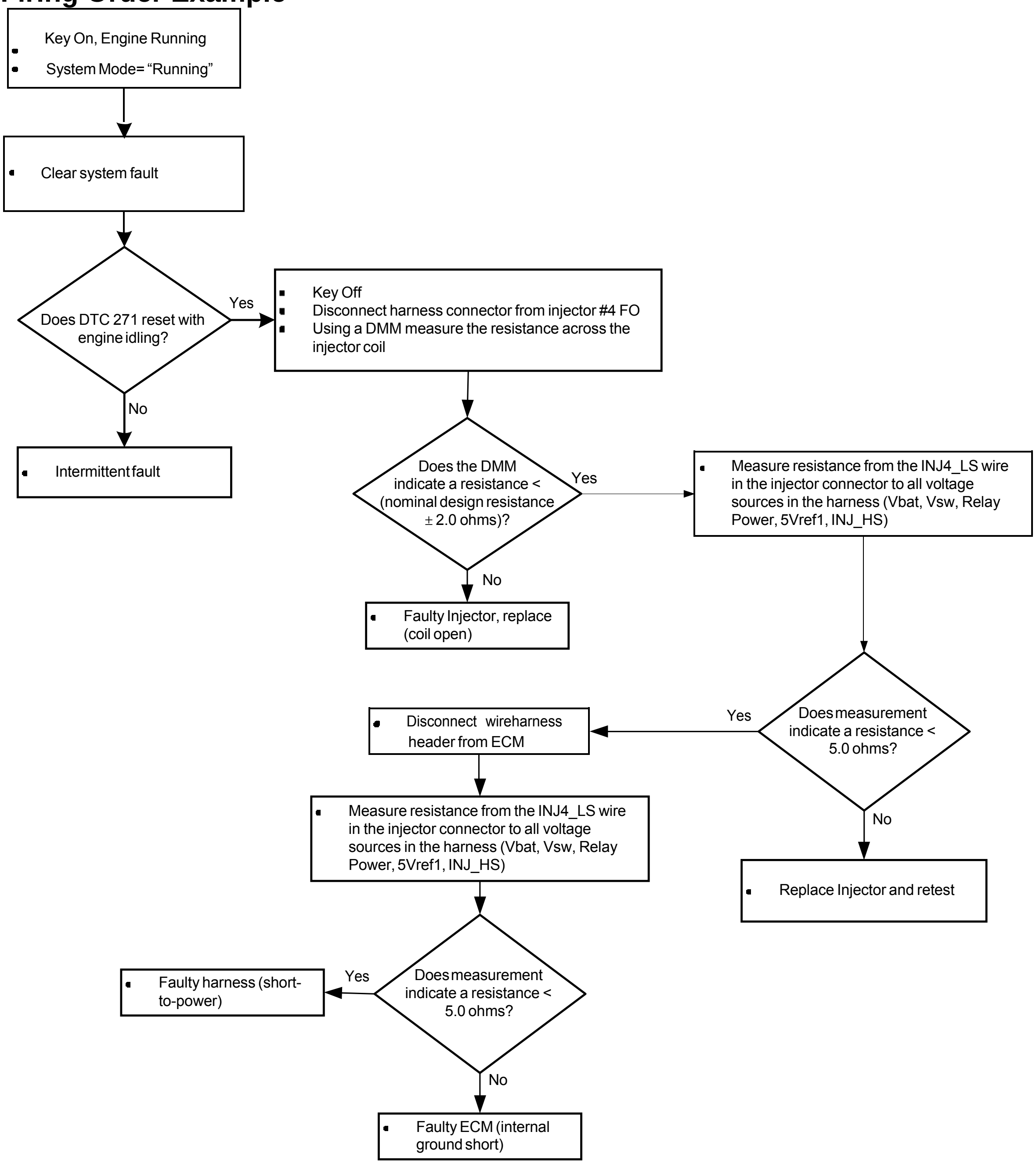
- Injector #4 Coil or Driver Short-to-Power
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM less than x volts and injector low-side greater than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 4^{th} injector in the firing order or for the injector on cylinder #4 depending on the Firing Order/Block Order configuration of the engine's calibration.

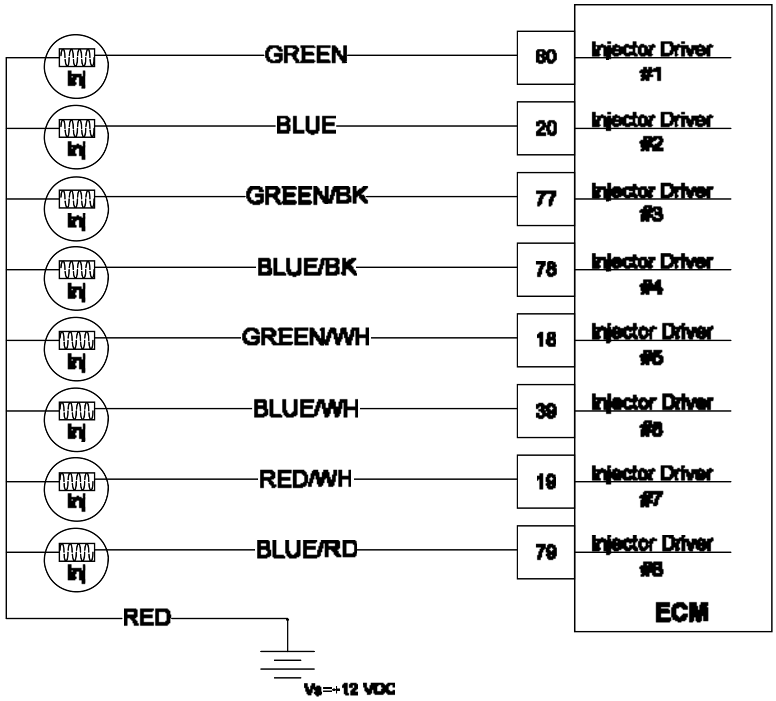
This fault will set if the ECM detects higher than expected feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 654, FMI 6 - Injector Driver #4 Short-To-Power

Firing Order Example



SPN 655, FMI 5 - Injector Driver #5 Open/Short-To-Ground



- Injector #5 Coil or Driver Open Circuit or Short-to-Ground
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM greater than x volts and injector low-side less than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 5th injector in the firing order or for the injector on cylinder #5 depending on the Firing Order/Block Order configuration of the engine's calibration.

This fault will set if the ECM detects low feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than x volts for the number of injector firings as defined in the diagnostic calibration.

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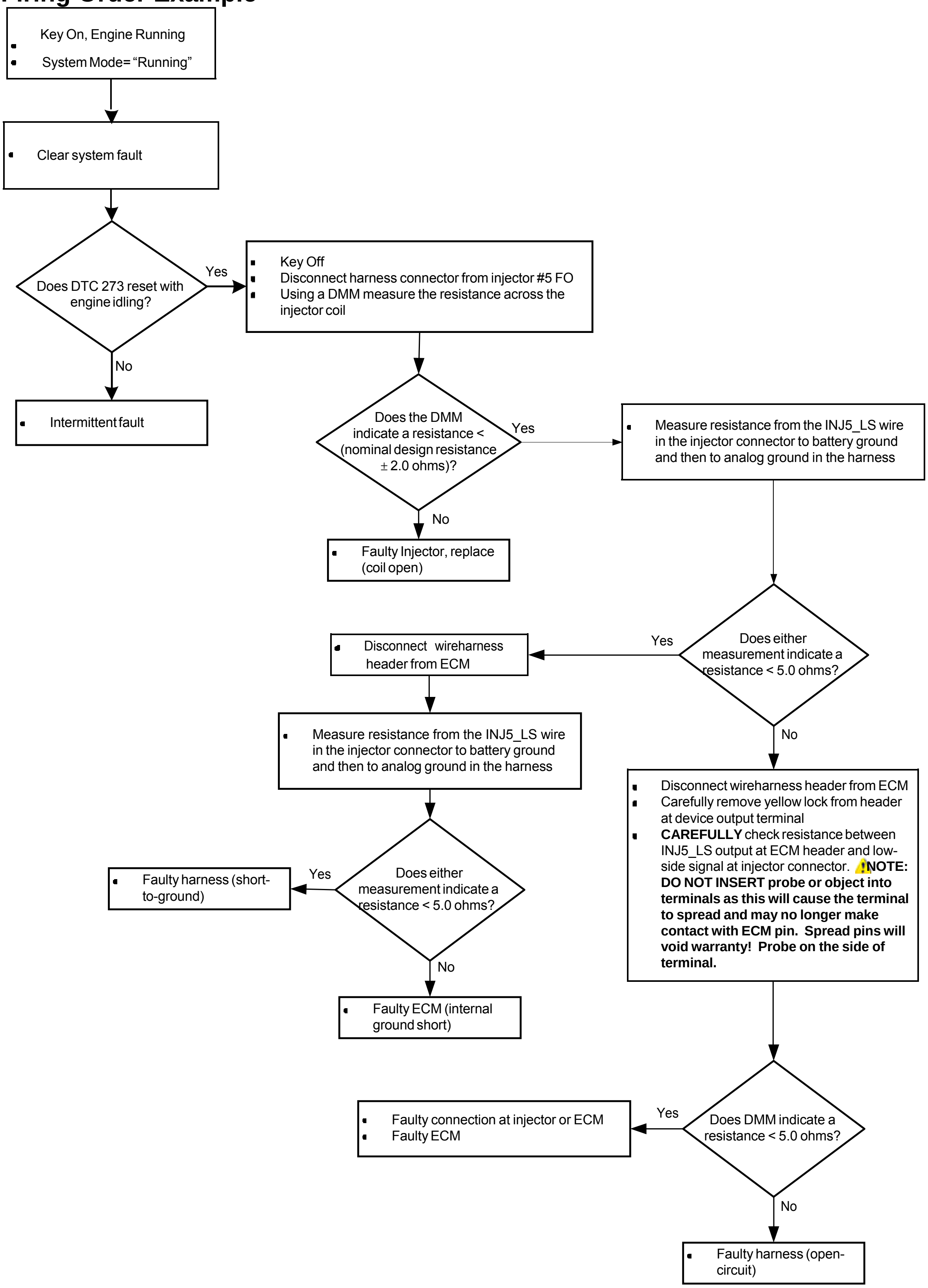
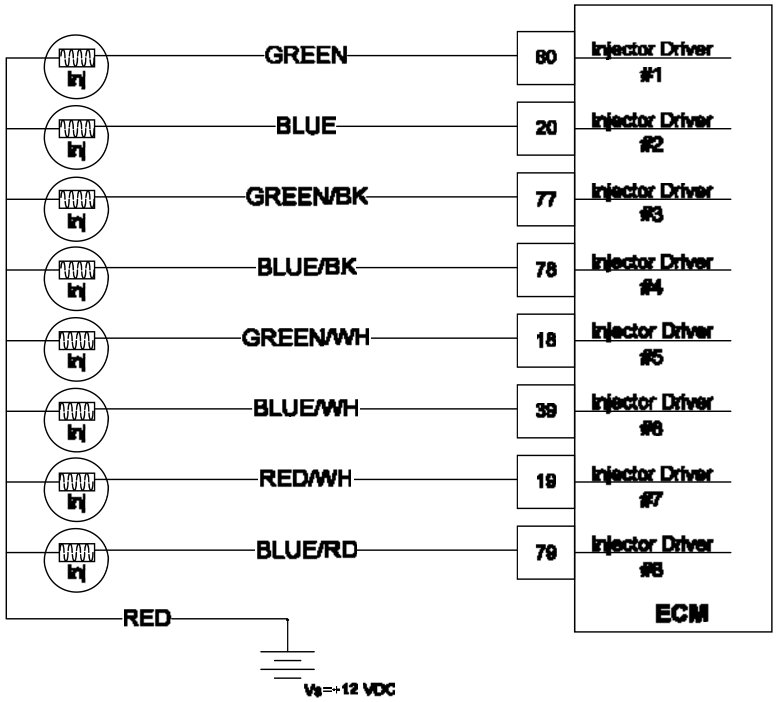
SPN 655, FMI 5 - Injector Driver #5 Open/Short-To-Ground

Firing Order Example



SPN 655, FMI 6 - Injector Driver #5 Short-To-Power



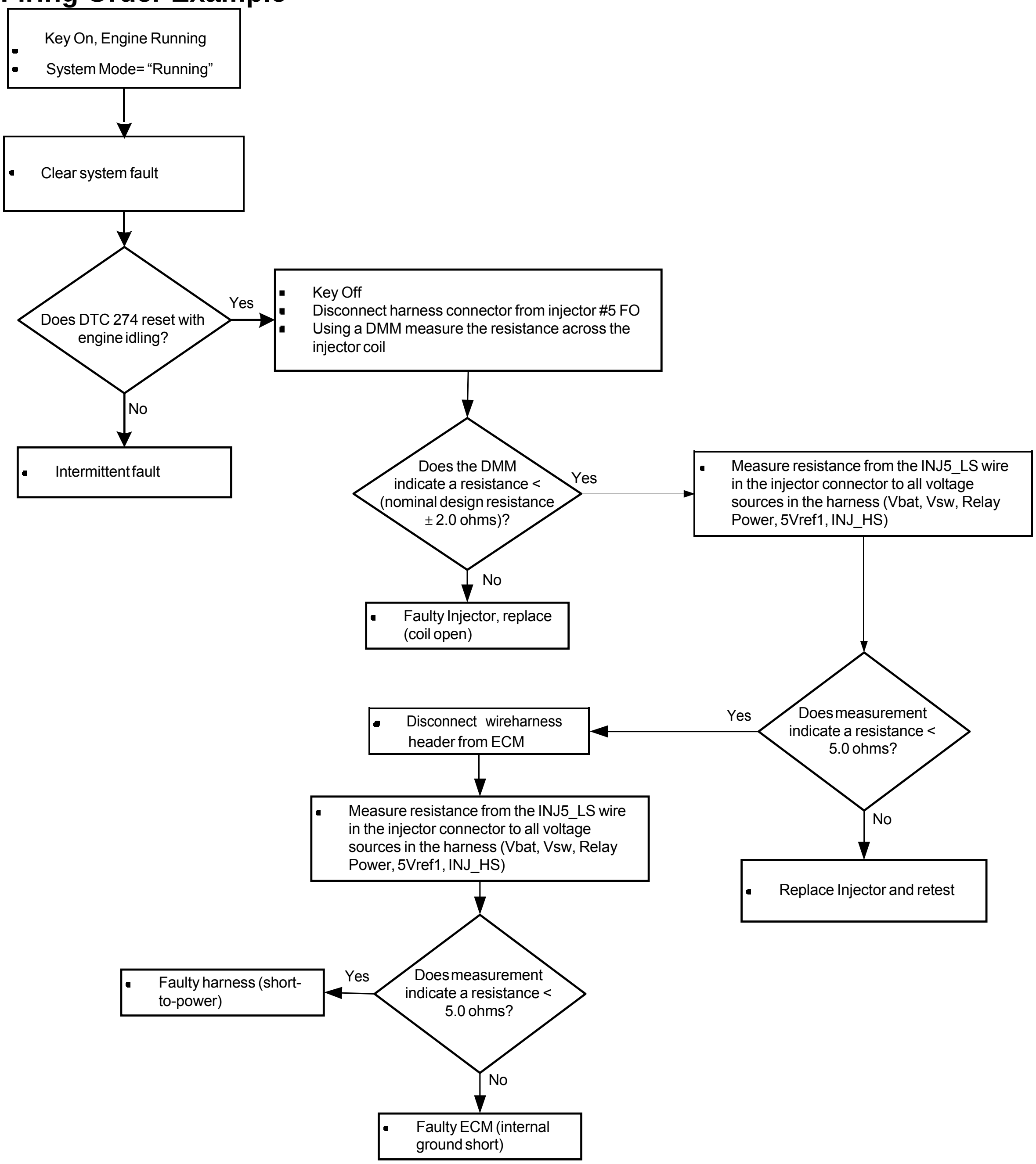
- Injector #5 Coil or Driver Short-to-Power
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM less than x volts and injector low-side greater than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 5th injector in the firing order or for the injector on cylinder #5 depending on the Firing Order/Block Order configuration of the engine's calibration.

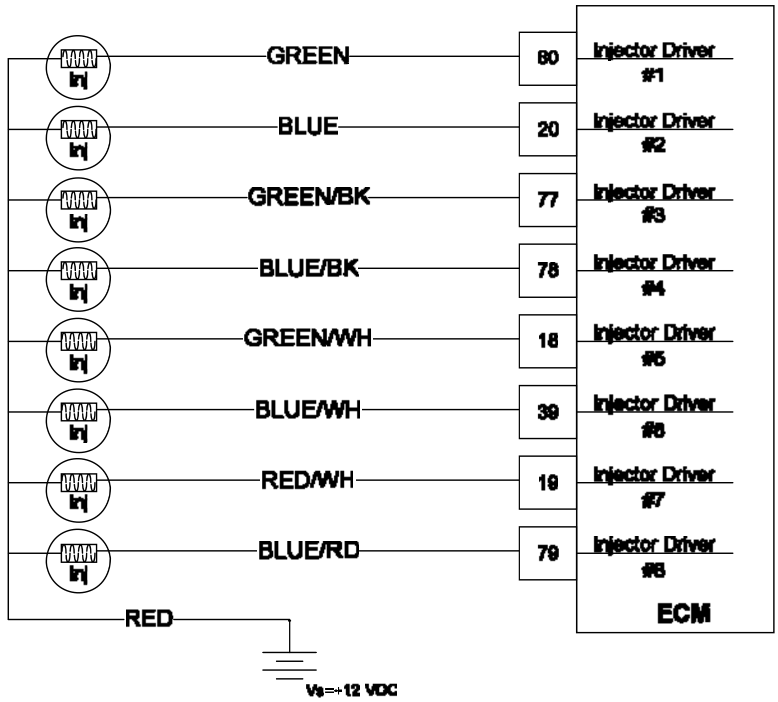
This fault will set if the ECM detects higher than expected feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 655, FMI 6 - Injector Driver #5 Short-To-Power

Firing Order Example



SPN 656, FMI 5 - Injector Driver #6 Open/Short-To-Ground



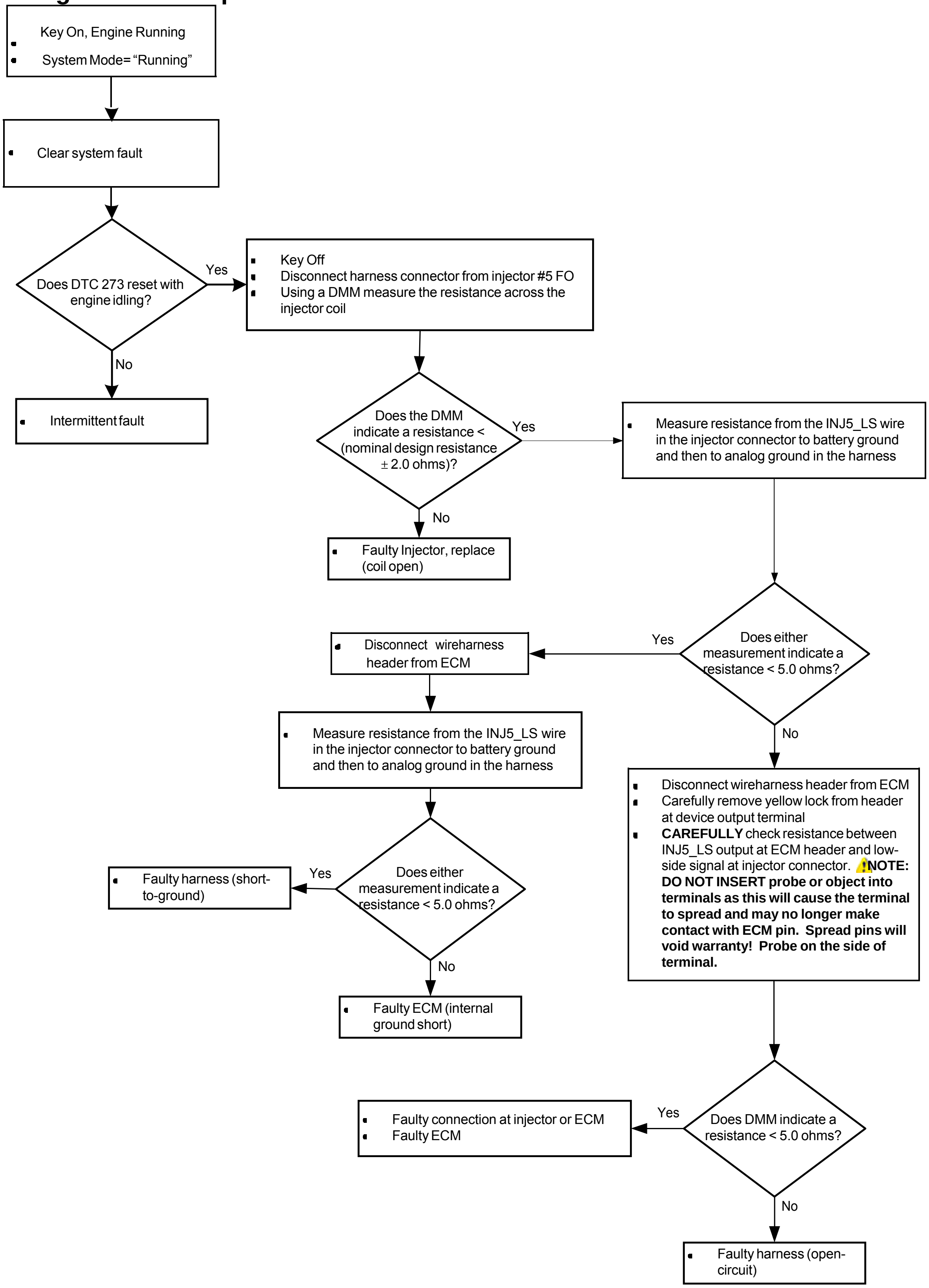
- Injector #6 (FO) Coil or Driver Open Circuit or Short-to-Ground
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM greater than x volts and injector low-side less than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 6th injector in the firing order or for the injector on cylinder #6 depending on the Firing Order/Block Order configuration of the engine's calibration.

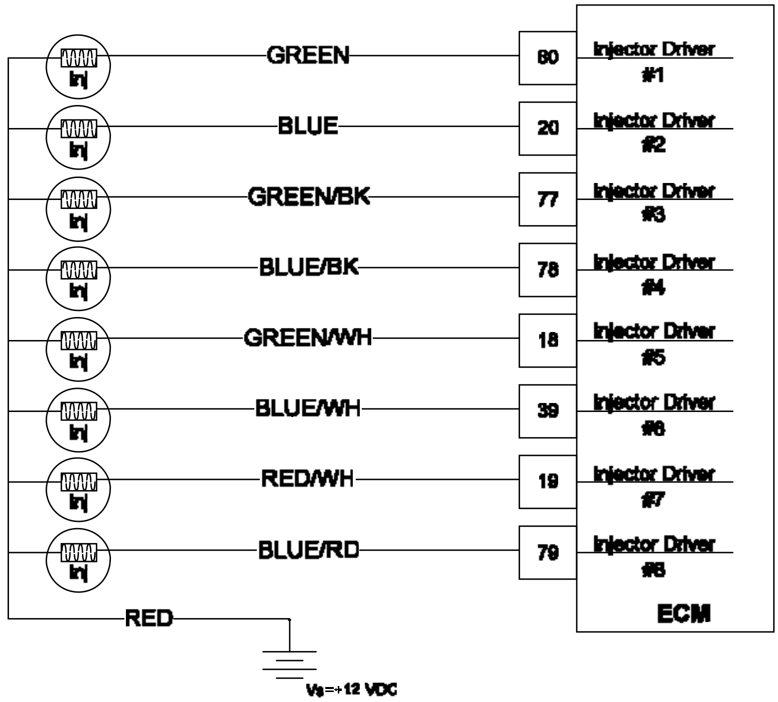
This fault will set if the ECM detects low feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 656, FMI 5 - Injector Driver #6 Open/Short-To-Ground

Firing Order Example



SPN 656, FMI 6 - Injector Driver #6 Short-To-Power



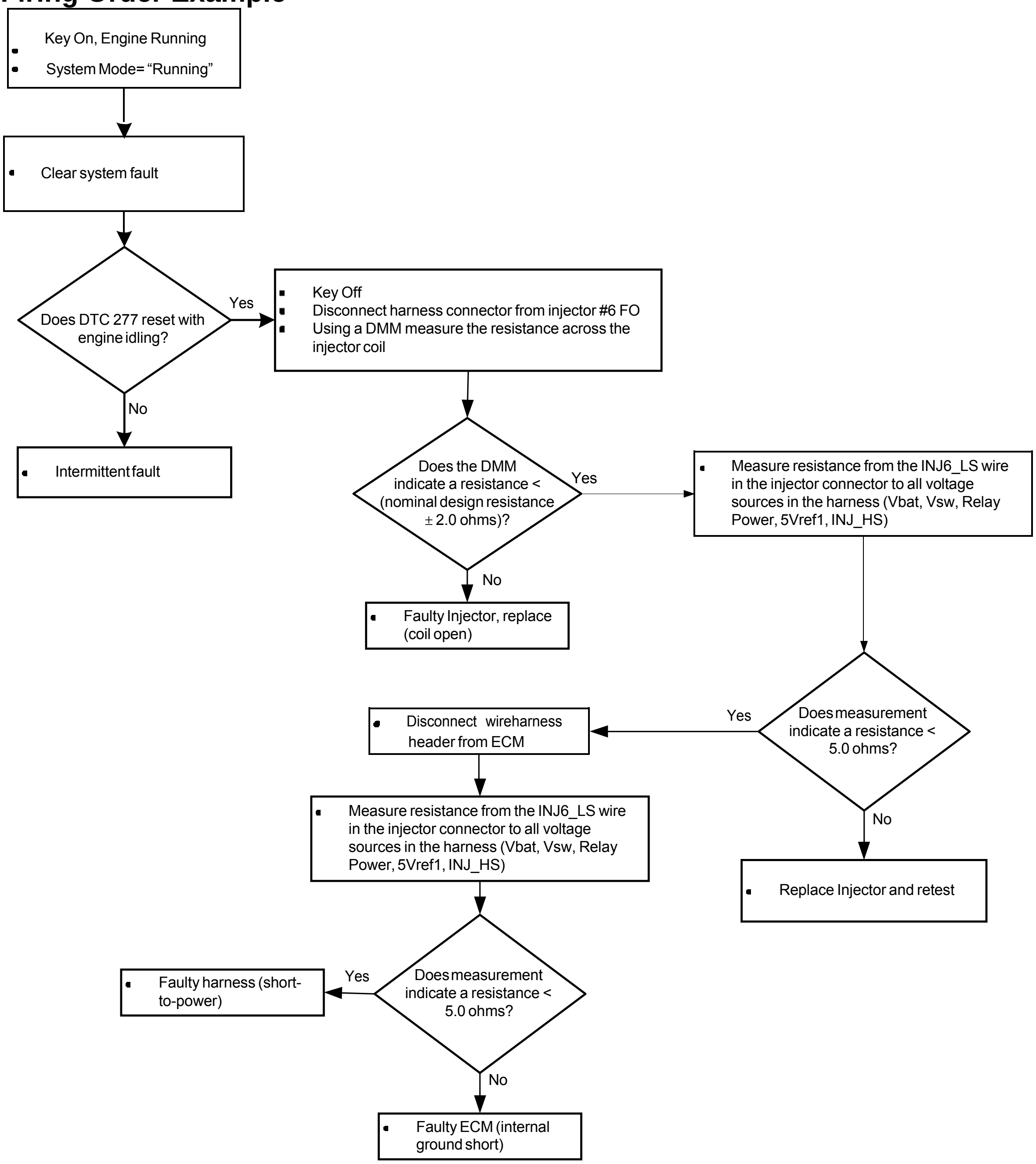
- Injector #6 Coil or Driver Short-to-Power
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM less than x volts and injector low-side greater than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 6th injector in the firing order or for the injector on cylinder #6 depending on the Firing Order/Block Order configuration of the engine's calibration.

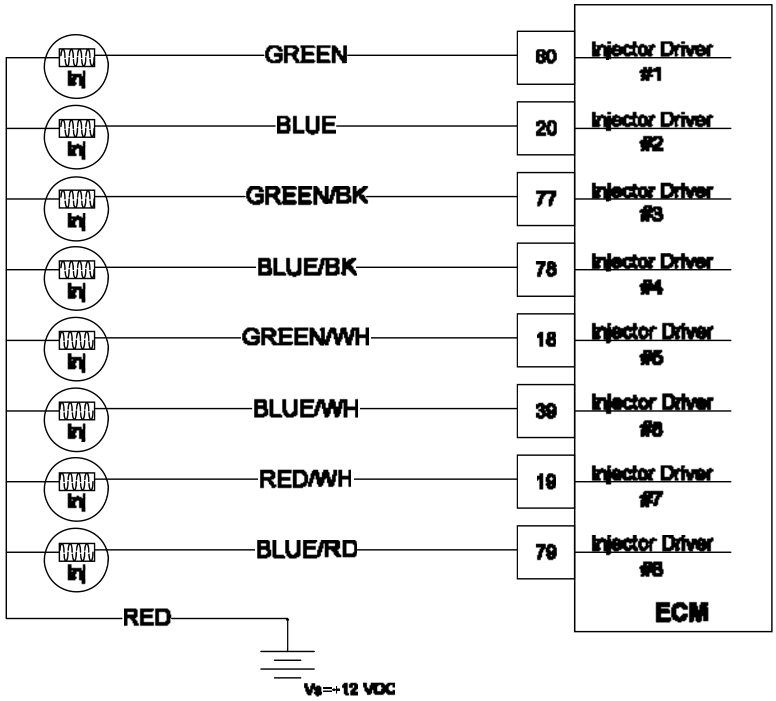
This fault will set if the ECM detects higher than expected feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 656, FMI 6 - Injector Driver #6 Short-To-Power

Firing Order Example



SPN 657, FMI 5 - Injector Driver #7 Open/Short-To-Ground



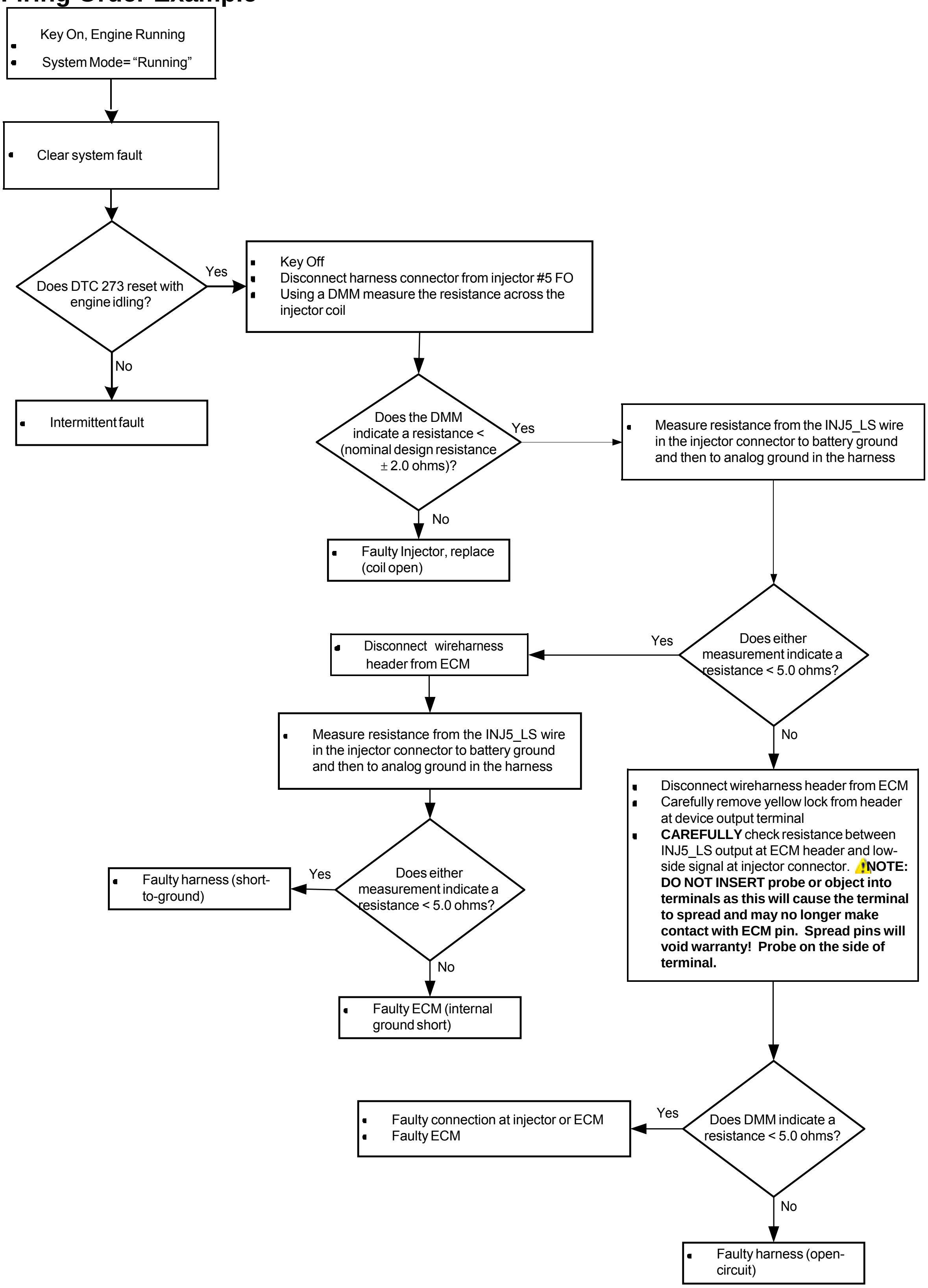
- Injector #7 Coil or Driver Open Circuit or Short-to-Ground
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM greater than x volts and injector low-side less than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 7th injector in the firing order or for the injector on cylinder #7 depending on the Firing Order/Block Order configuration of the engine's calibration.

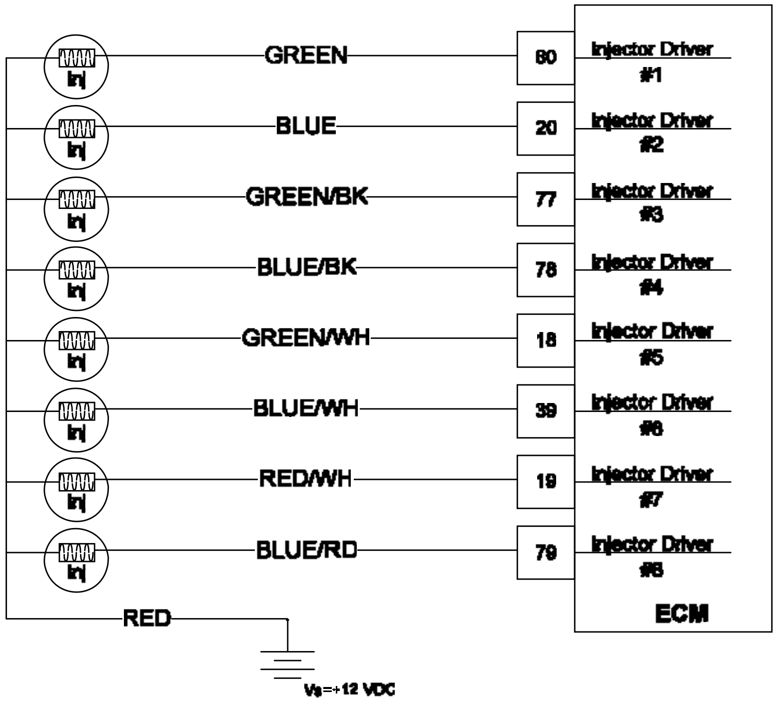
This fault will set if the ECM detects low feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 657, FMI 5 - Injector Driver #7 Open/Short-To-Ground

Firing Order Example



SPN 657, FMI 6 - Injector Driver #7 Short-To-Power



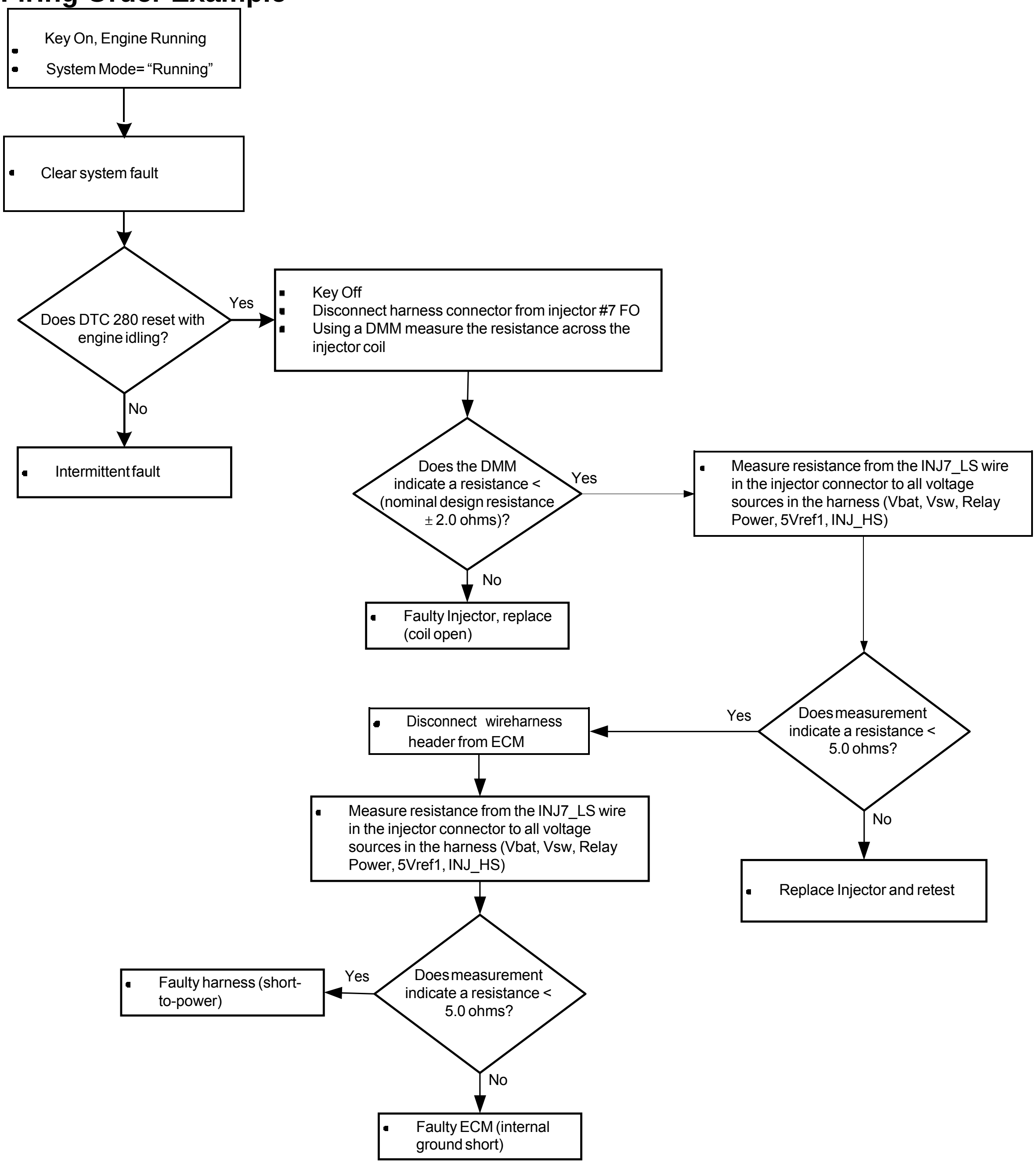
- Injector #7 Coil or Driver Short-to-Power
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM less than x volts and injector low-side greater than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 7th injector in the firing order or for the injector on cylinder #7 depending on the Firing Order/Block Order configuration of the engine's calibration.

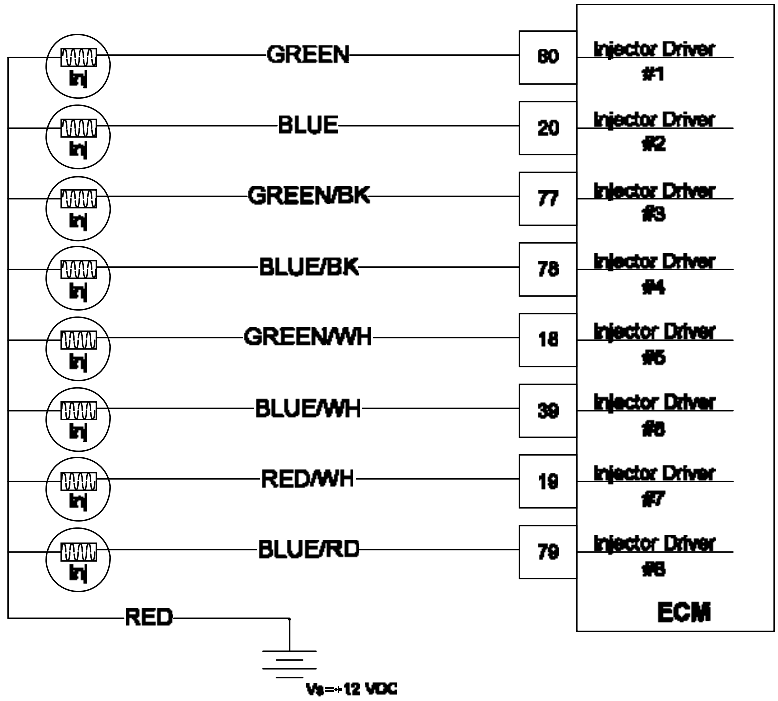
This fault will set if the ECM detects higher than expected feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 657, FMI 6 - Injector Driver #7 Short-To-Power

Firing Order Example



SPN 658, FMI 5 - Injector Driver #8 Open/Short-To-Ground



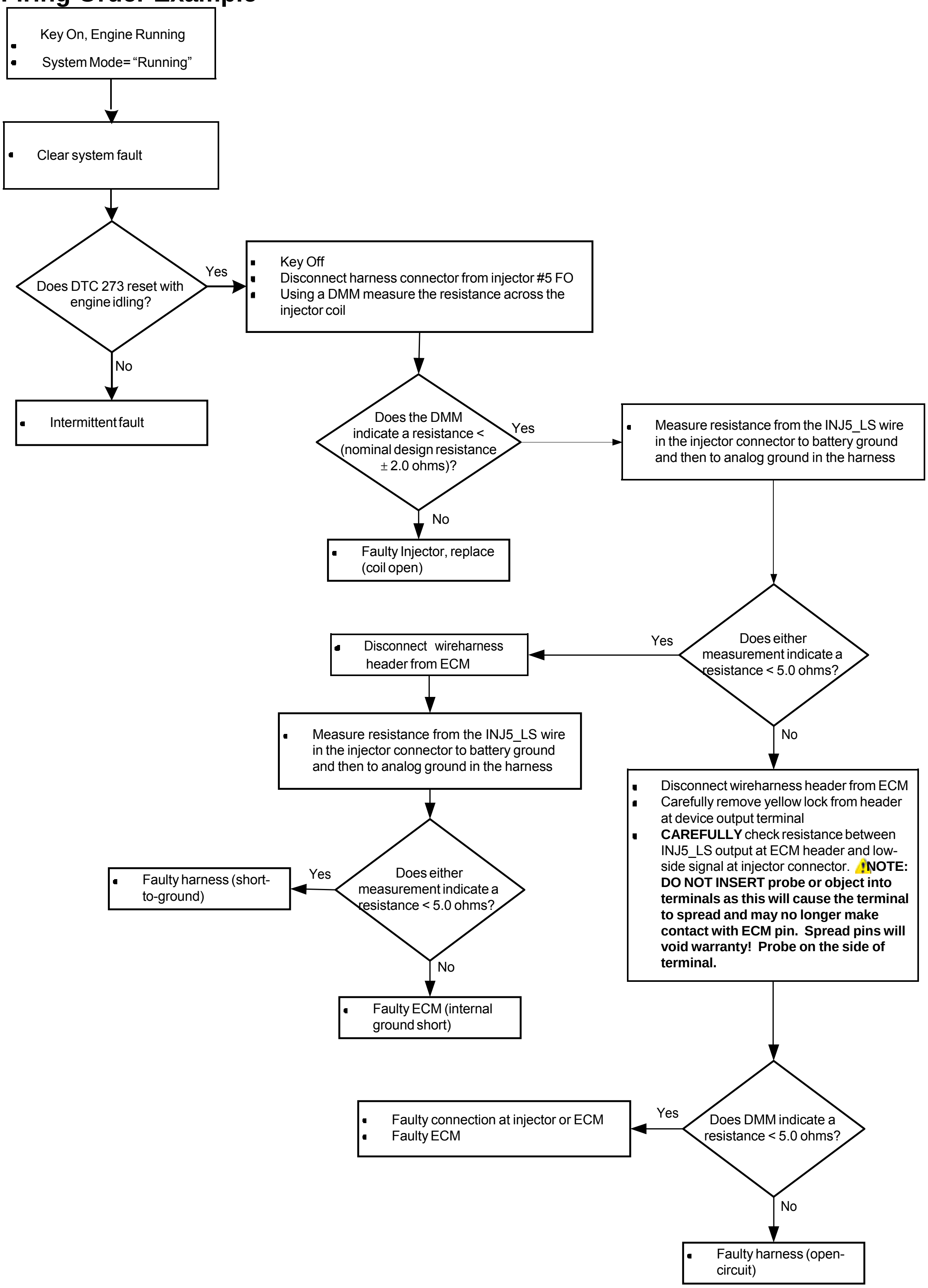
- Injector #8 Coil or Driver Open Circuit or Short-to-Ground
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM greater than x volts and injector low-side less than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 8th injector in the firing order or for the injector on cylinder #8 depending on the Firing Order/Block Order configuration of the engine's calibration.

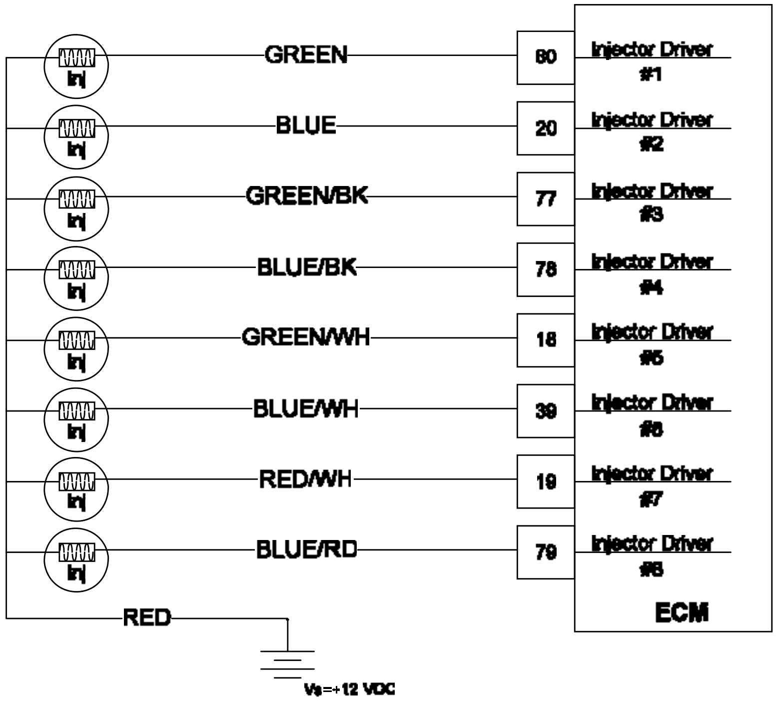
This fault will set if the ECM detects low feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 658, FMI 5 - Injector Driver #8 Open/Short-To-Ground

Firing Order Example



SPN 658, FMI 6 - Injector Driver #8 Short-To-Power



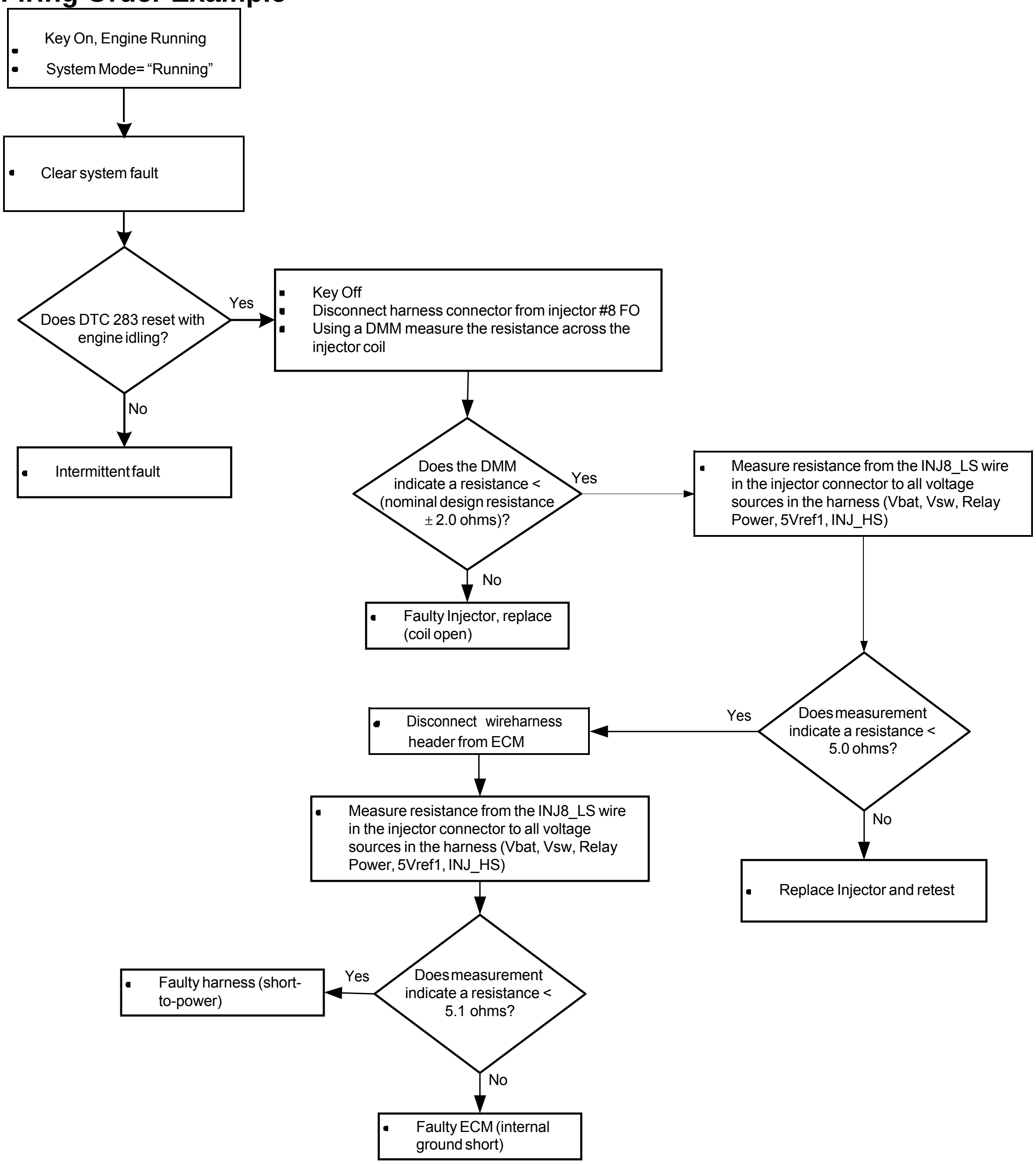
- Injector #8 Coil or Driver Short-to-Power
- Check Condition-Key-On, Engine Running
- Fault Condition-Battery voltage at ECM less than x volts and injector low-side greater than y volts for z injector firings as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction for key-cycle, possibly set power derate, low rev limit, or forced idle to protect aftertreatment from potential damage.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection) or the entire engine (Throttle Body Injection). This fault sets for either the 8th injector in the firing order or for the injector on cylinder #8 depending on the Firing Order/Block Order configuration of the engine's calibration.

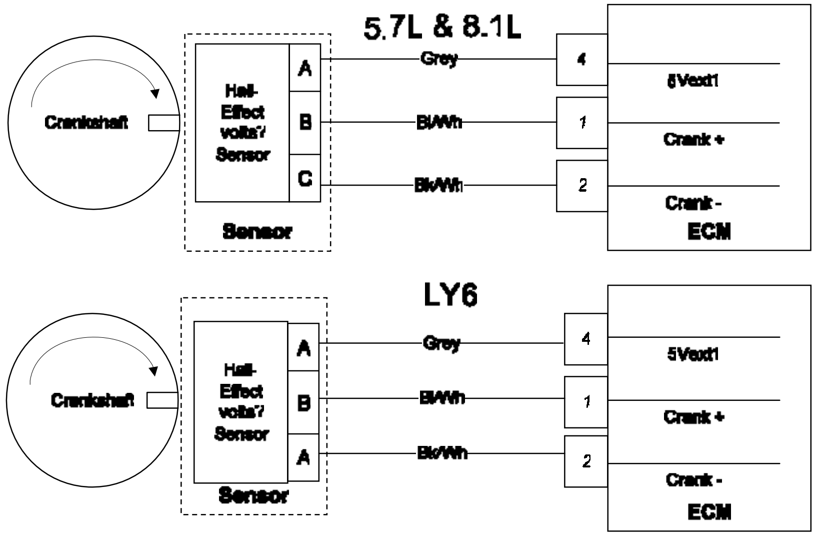
This fault will set if the ECM detects higher than expected feedback voltage (y VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than x volts for the number of injector firings as defined in the diagnostic calibration.

SPN 658, FMI 6 - Injector Driver #8 Short-To-Power

Firing Order Example



SPN 1323, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #1



- Cylinder #1 Misfire Detected-Emissions/Catalyst Damaging
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components

2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

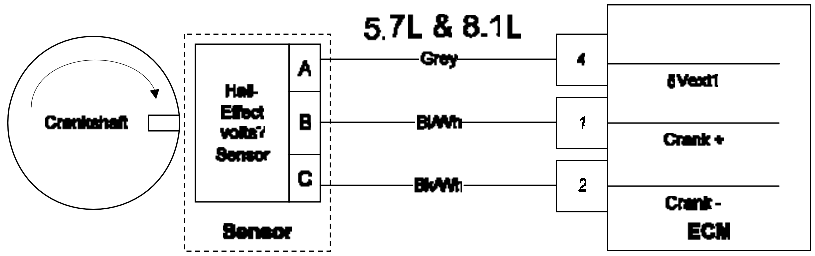
SPN 1323, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #1

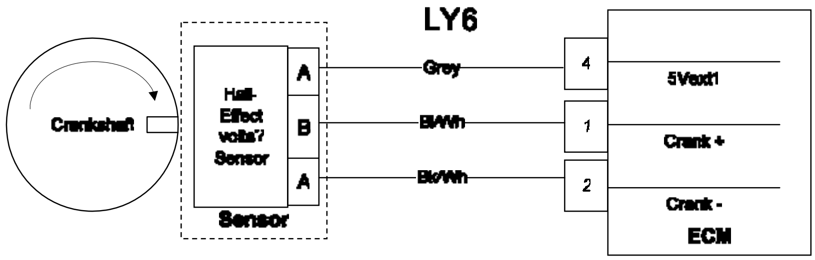
Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
  - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
  - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
  - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1324, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #2





- Cylinder #2 Misfire Detected-Emissions/Catalyst Damaging
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components

2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #2 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

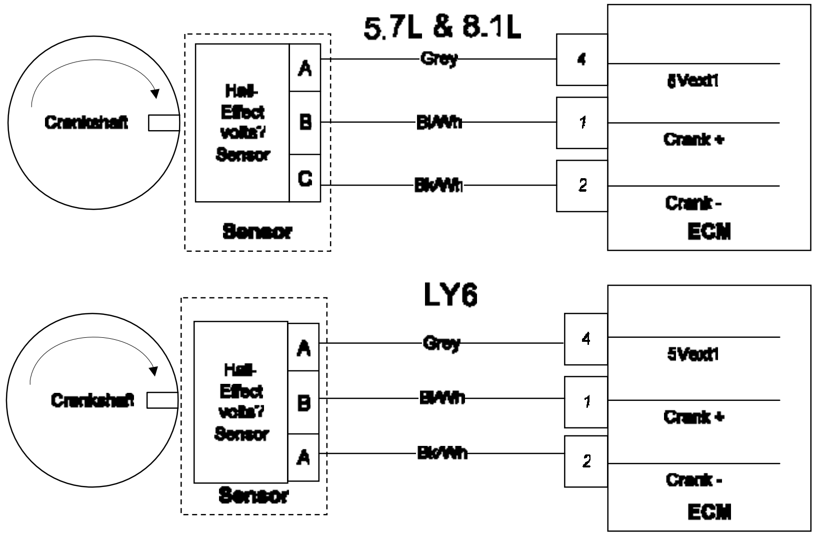
SPN 1324, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #2

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
    - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
    - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
    - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1325, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #3



- Cylinder #3 Misfire Detected-Emissions/Catalyst Damaging
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components

2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #3 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

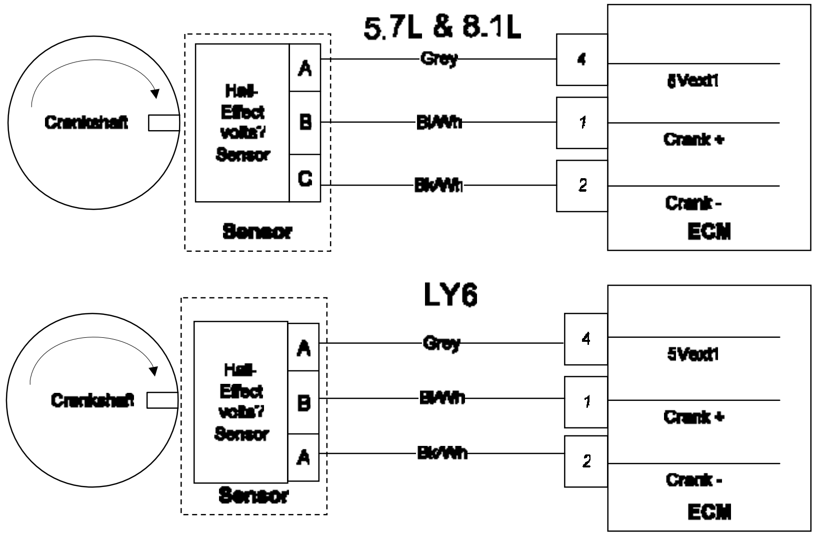
SPN 1325, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #3

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
    - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
    - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
    - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1326, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #4



- Cylinder #4 Misfire Detected-Emissions/Catalyst Damaging
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components

2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #4 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

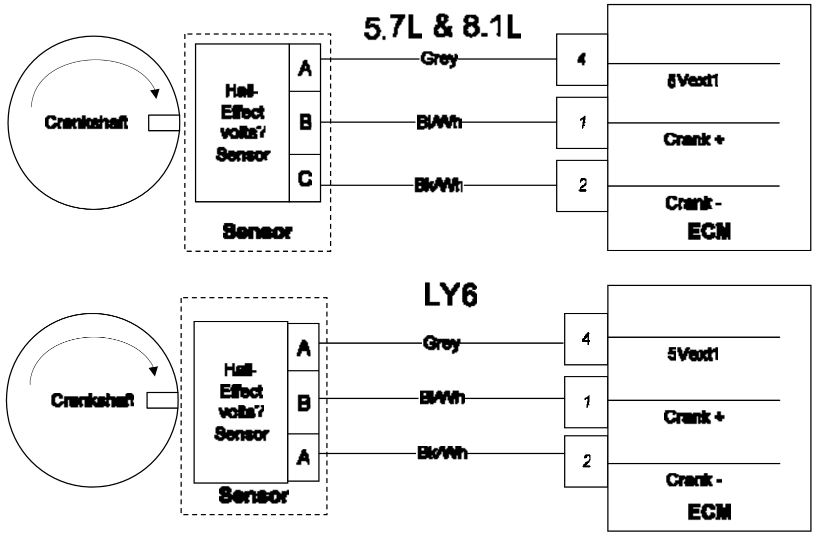
SPN 1326, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #4

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
  - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
  - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
  - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1327, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #5



- Cylinder #5 Misfire Detected-Emissions/Catalyst Damaging
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder’s rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine’s driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per “bank” fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components

2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #5 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

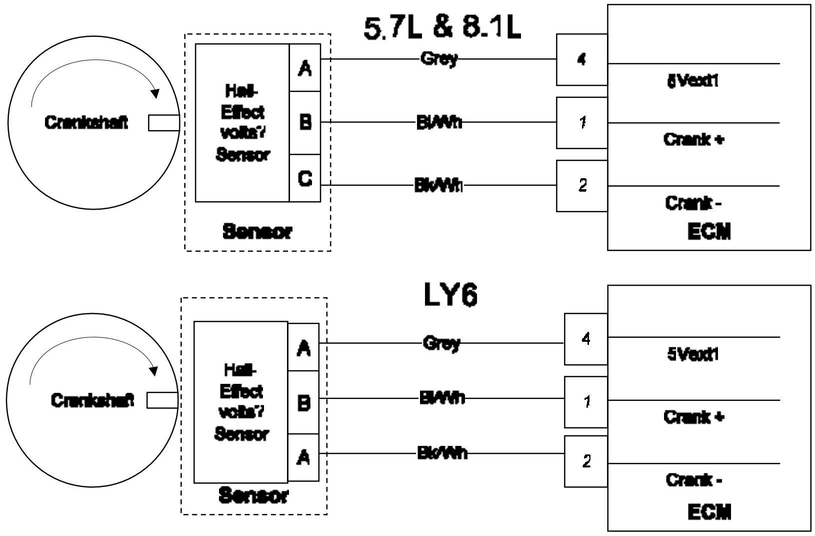
SPN 1327, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #5

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
  - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
  - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
  - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1328, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #6



- Cylinder #6 Misfire Detected-Emissions/Catalyst Damaging
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components

2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #6 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

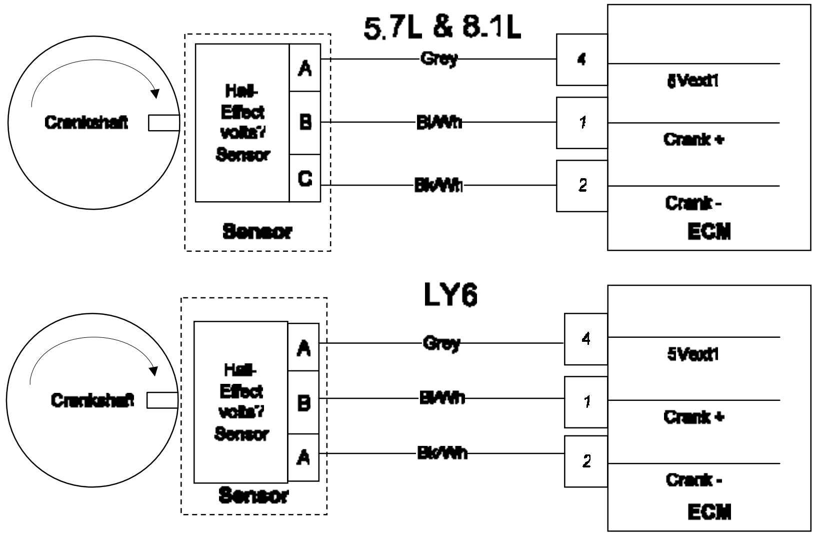
SPN 1328, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #6

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
    - Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
    - Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
    - Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1329, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #7



- Cylinder #7 Misfire Detected-Emissions/Catalyst Damaging
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components

2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #7 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

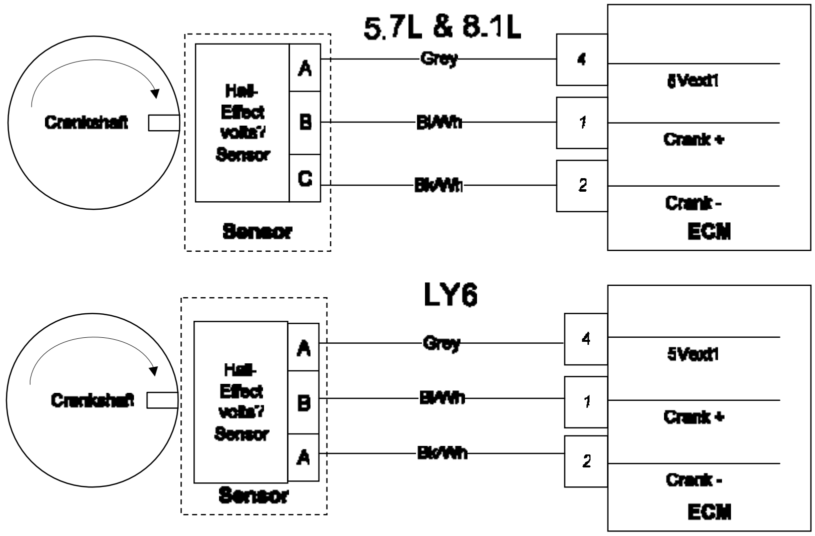
SPN 1329, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #7

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
  - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
  - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
  - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1330, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #8



- Cylinder #8 Misfire Detected-Emissions/Catalyst Damaging
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components

2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #8 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

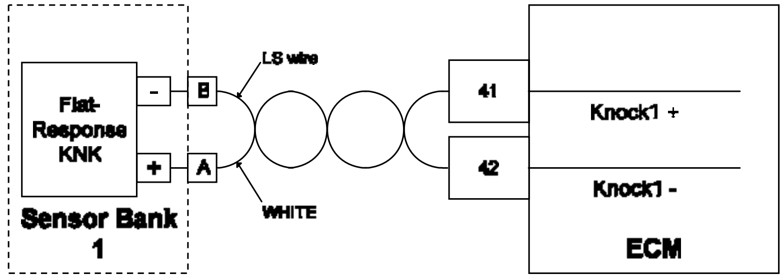
SPN 1330, FMI 31 - Emissions/Catalyst Damage Misfire Detected Cylinder #8

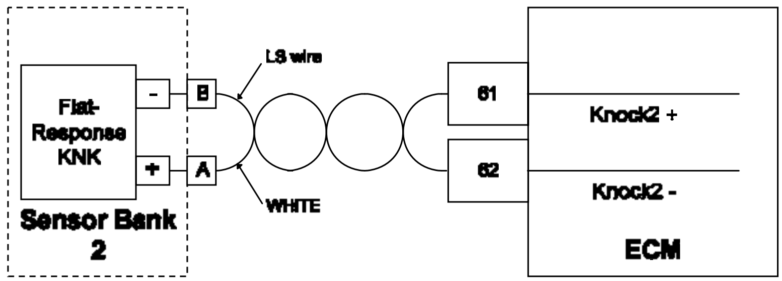
Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
  - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
  - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
  - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 731, FMI 2 - Knock 1 Excessive or Erratic Signal



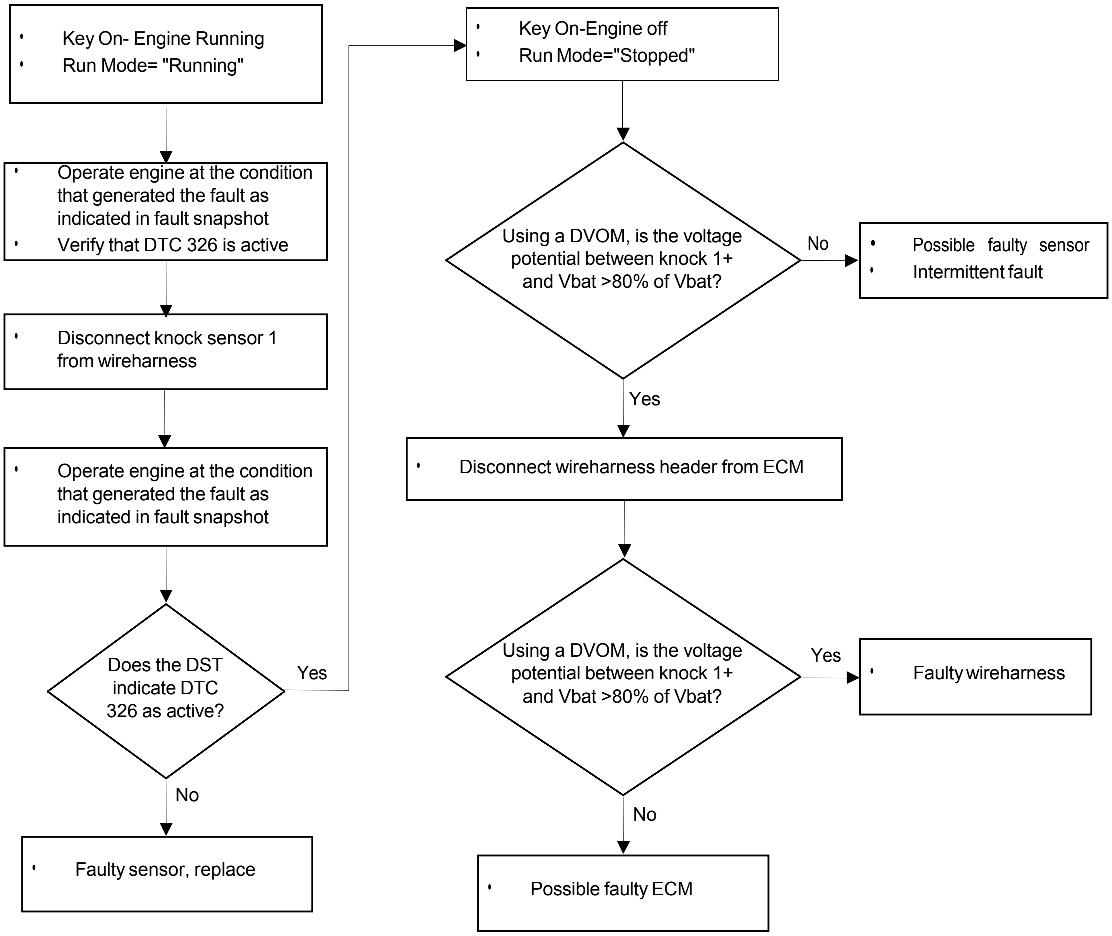


- Knock sensor #1
- Check Condition- Key On, Engine On
- Fault Condition- Knock sensor 1 indicates an excessive signal level
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly power derate the engine, and retard spark to *Faulted KNK Retard* level to protect engine from possible damage due to unsensed detonation
- Emissions related fault

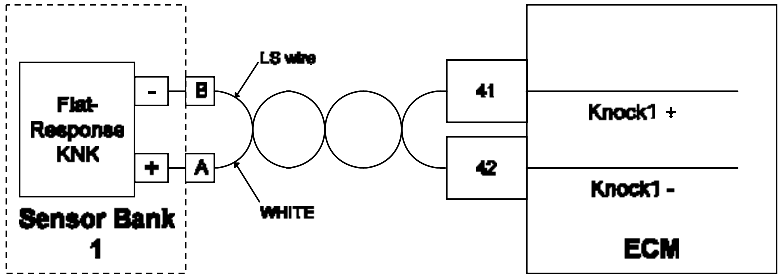
The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused from detonation or knock based on fixed spark advance. In other applications, the knock sensor is used to optimize spark advance and “learn” between spark tables based on fuel quality.

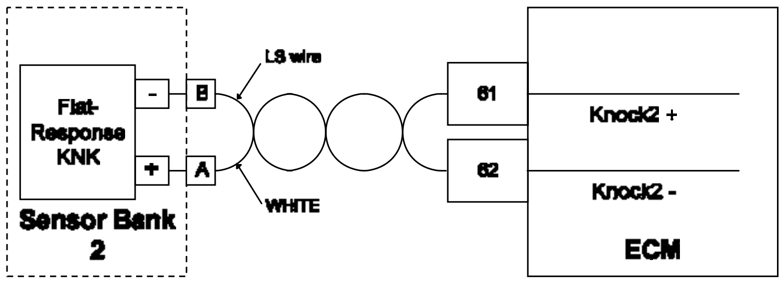
This fault sets if the signal from knock sensor 1 is higher than expected for low load operation as defined in calibration. If this fault sets, spark is lowered by the amount defined in calibration for *Faulted KNK Retard*.

SPN 731, FMI 2 - Knock 1 Excessive or Erratic Signal



SPN 731, FMI 4 - Knock 1 Sensor Open or Not Present



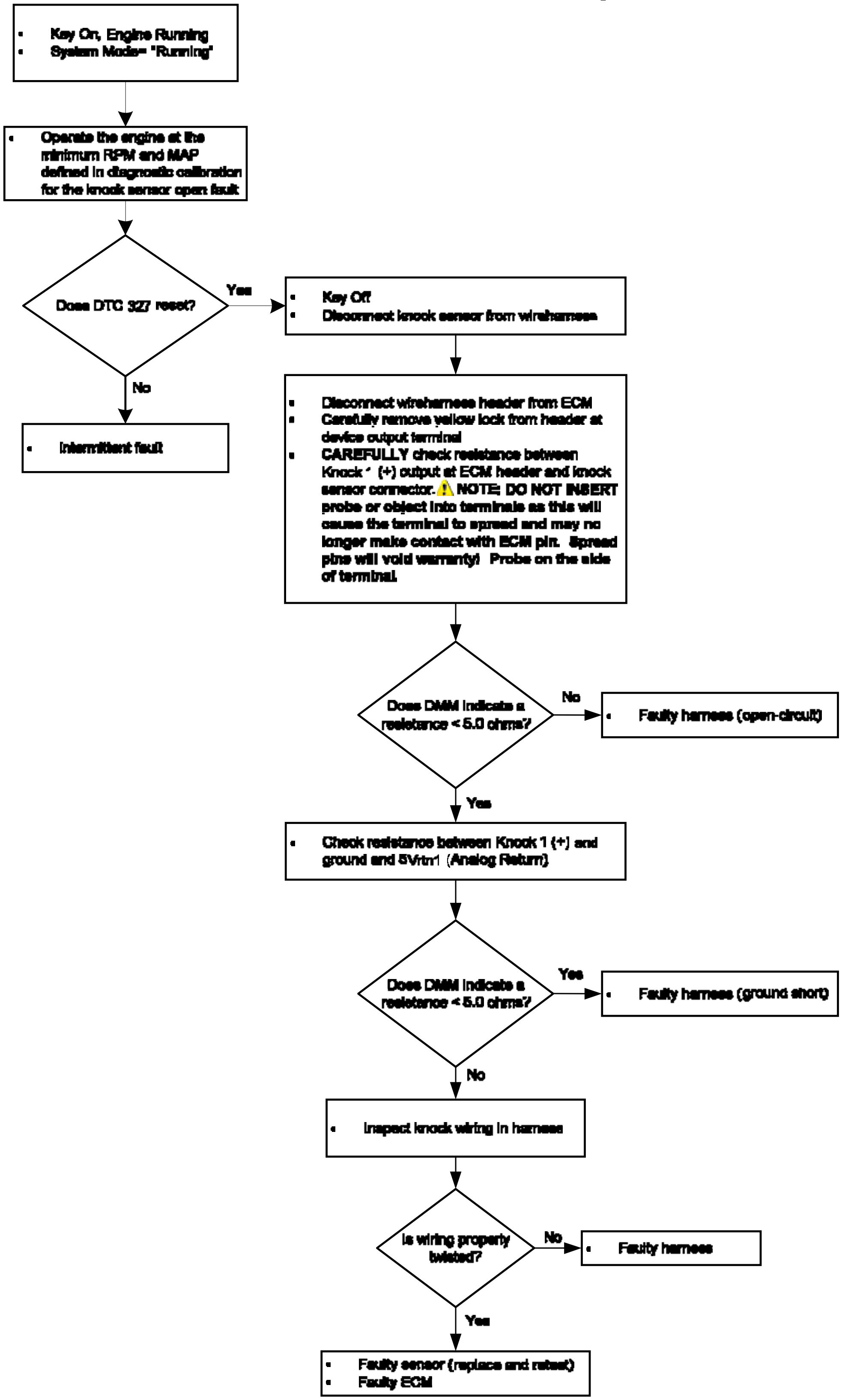


- Knock sensor #1
- Check Condition- Key On, Engine On
- Fault Condition- Knock sensor 1 signal low while engine speed is greater than x RPM and MAP is greater than y psia as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly power derate the engine, and retard spark to *Faulted KNK Retard* level to protect engine from possible damage due to inability to sense detonation
- Emissions related fault

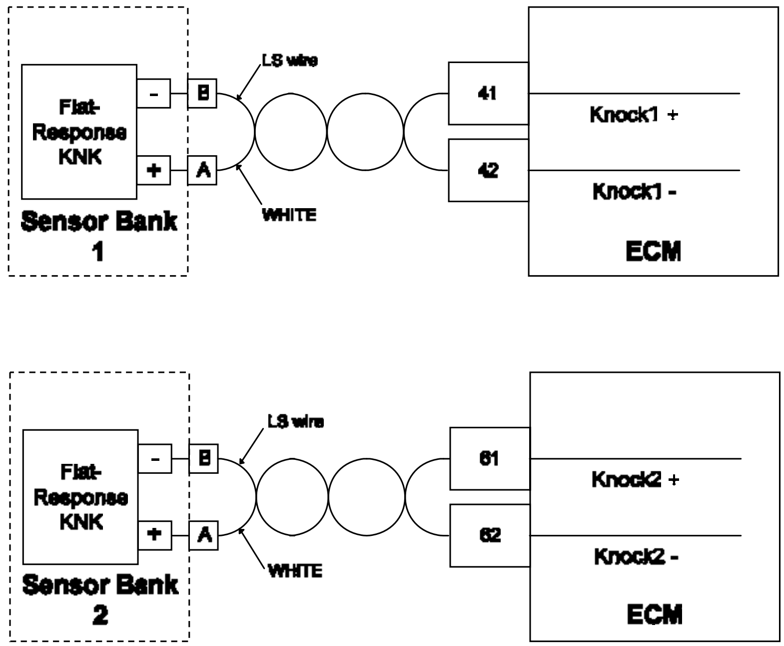
The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused from detonation or knock based on fixed spark advance. In other applications, the knock sensor is used to optimize spark advance and “learn” between spark tables based on fuel quality.

This fault sets if the signal from knock sensor 1 is lower than expected for higher speed and load operation as defined in calibration. If this fault sets, spark is lowered by the amount defined in calibration for *Faulted KNK Retard*.

SPN 731, FMI 4 - Knock 1 Sensor Open or Not Present



SPN 520197, FMI 2 - Knock 2 Excessive or Erratic Signal

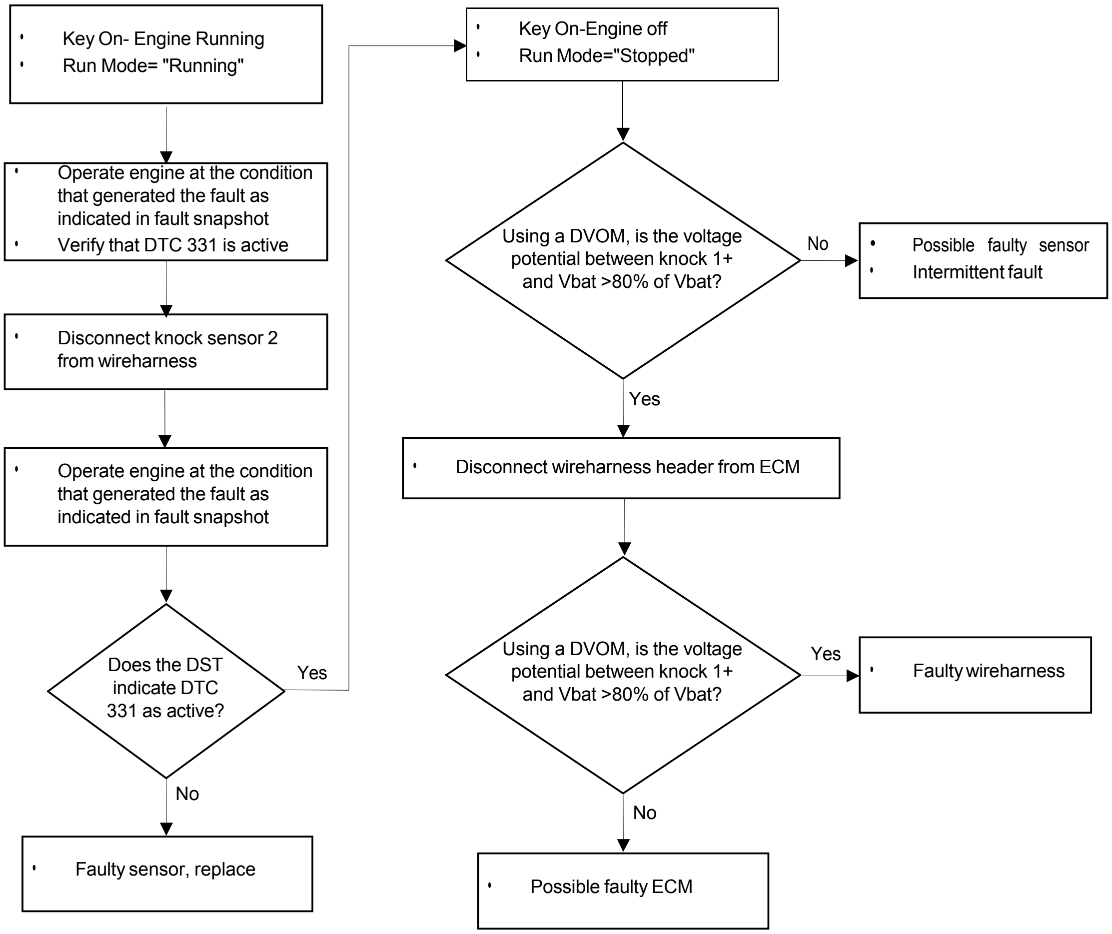


- Knock sensor #2
- Check Condition- Key On, Engine On
- Fault Condition- Knock sensor 2 indicates an excessive signal level
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly power derate the engine, and retard spark to *Faulted KNK Retard* level to protect engine from possible damage due to inability to sense detonation
- Emissions related fault

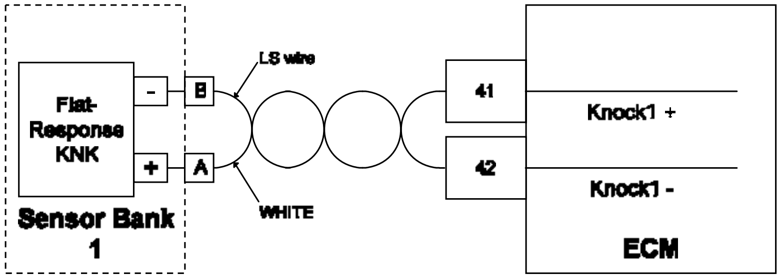
The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused from detonation or knock based on fixed spark advance. In other applications, the knock sensor is used to optimize spark advance and "learn" between spark tables based on fuel quality.

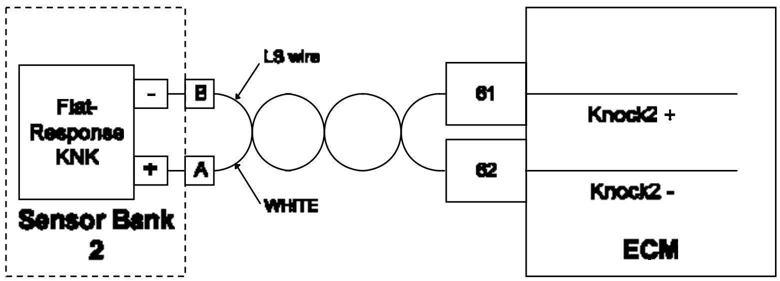
This fault sets if the signal from knock sensor 2 is higher than expected for low load operation as defined in calibration. If this fault sets, spark is lowered by the amount defined in calibration for *Faulted KNK Retard*.

SPN 520197, FMI 2 - Knock 2 Excessive or Erratic Signal



SPN 520197, FMI 4 - Knock 2 Sensor Open or Not Present



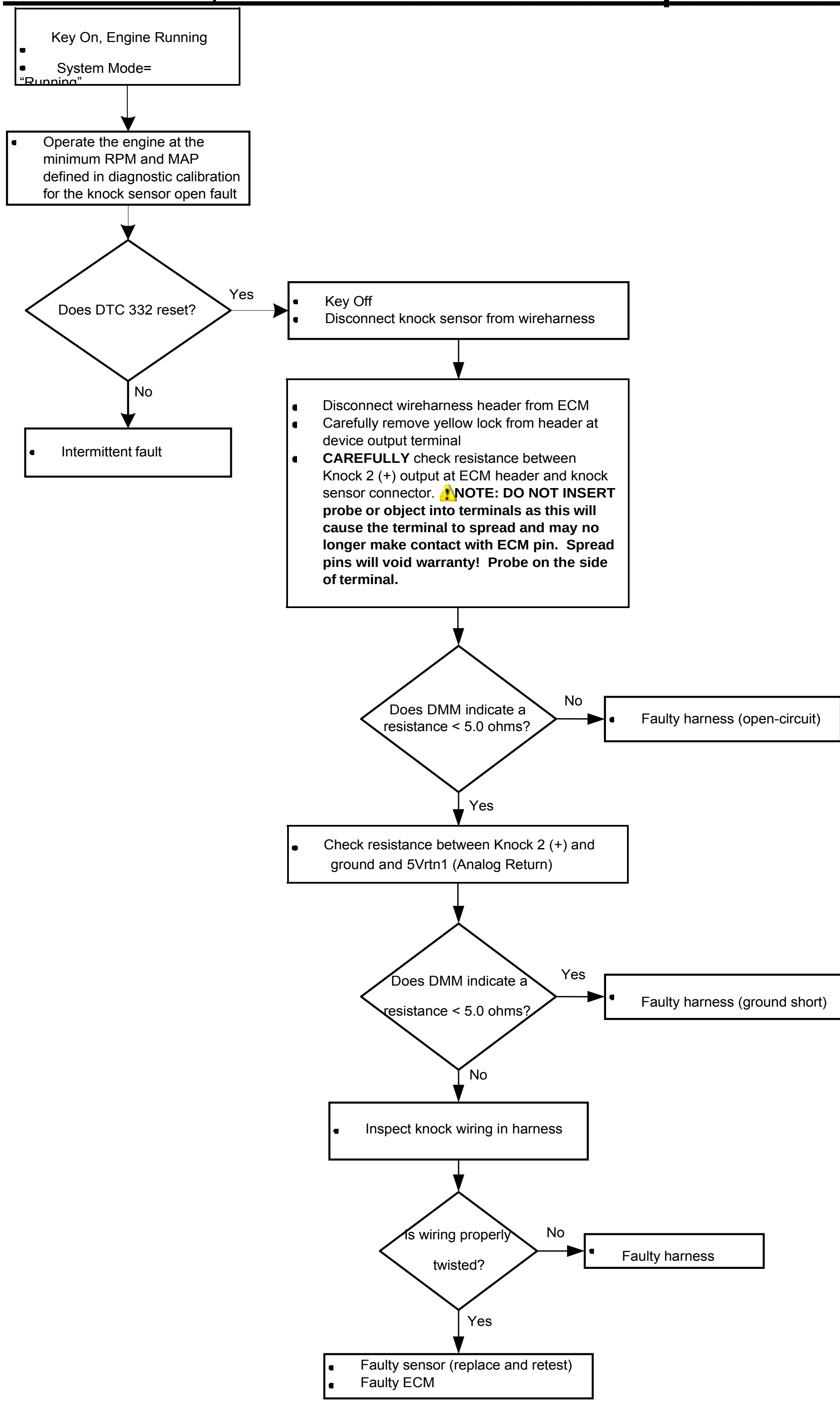


- Knock sensor #2
- Check Condition- Key On, Engine On
- Fault Condition- Knock sensor 2 signal low while engine speed is greater than x RPM and MAP is greater than y psia as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly power derate the engine, and retard spark to *Faulted KNK Retard* level to protect engine from possible damage due to inability to sense detonation
- Emissions related fault

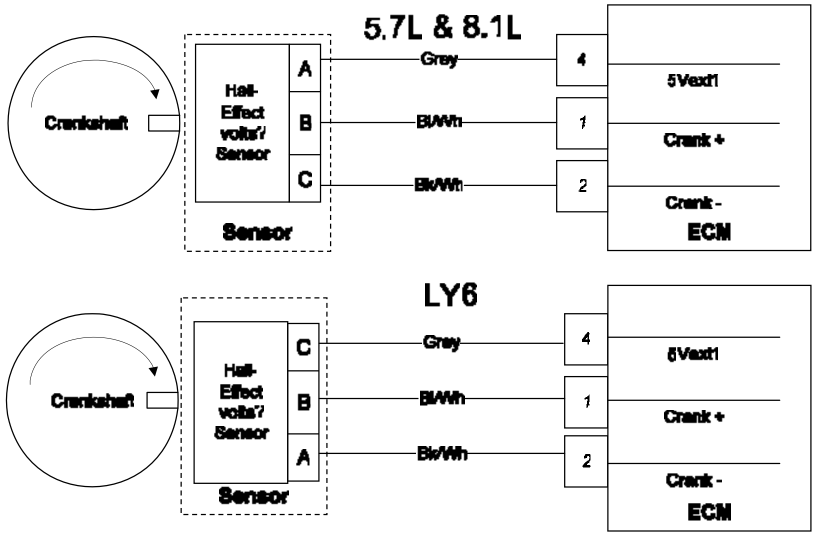
The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused from detonation or knock based on fixed spark advance. In other applications, the knock sensor is used to optimize spark advance and “learn” between spark tables based on fuel quality.

This fault sets if the signal from knock sensor 2 is lower than expected for higher speed and load operation as defined in calibration. If this fault sets, spark is lowered by the amount defined in calibration for *Faulted KNK Retard*.

SPN 520197, FMI 4 - Knock 2 Sensor Open or Not Present



SPN 636, FMI 2 -Crank Input Signal Noise



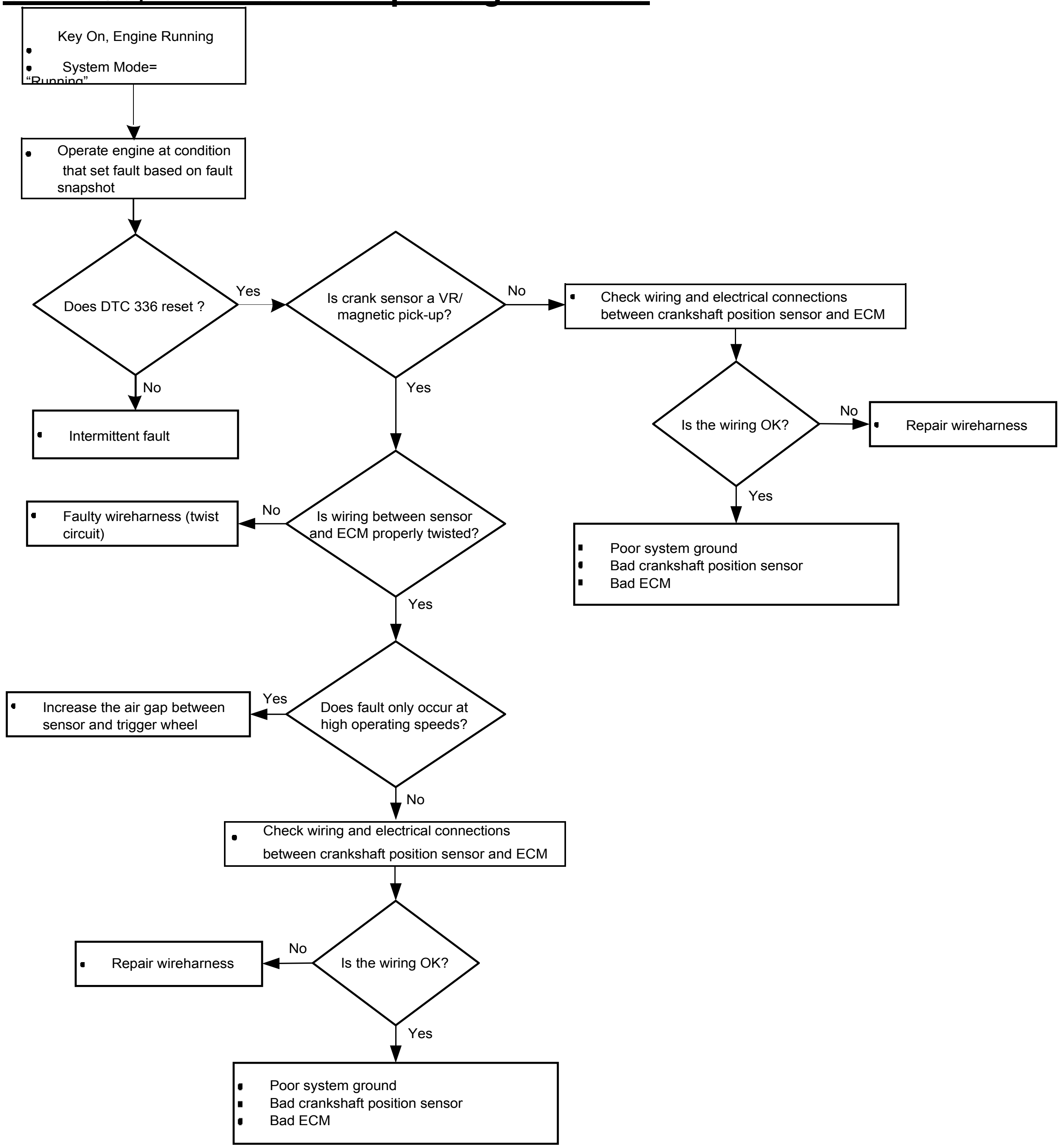
- Crankshaft Position sensor
- Check Condition- Key On, Engine On
- Fault Condition- Electrical noise or irregular crank pattern detected causing x number of crank re-synchronization events as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp and disable adaptive fueling correction for remainder of key-cycle.
- Emissions related fault

The crankshaft position sensor is a magnetic sensor (variable reluctant/magnetic pick-up or hall-effect) installed in the engine block adjacent to a “coded” trigger wheel located on the crankshaft. The sensor-trigger wheel combination is used to determine crankshaft position (with respect to TDC cylinder #1 compression) and the rotational engine speed. Determination of the crankshaft position and speed is necessary to properly activate the ignition, fuel injection, and throttle governing systems for precise engine control.

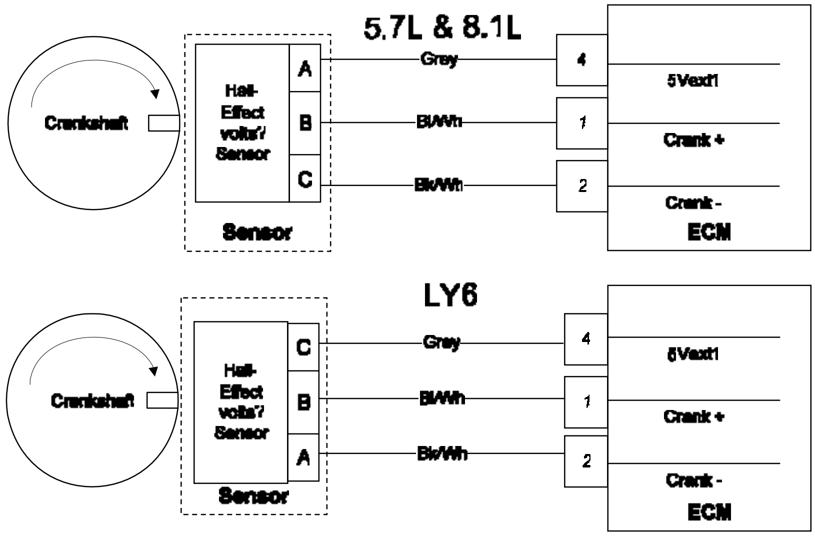
The ECM must see a valid crankshaft position signal while running. If no signal is present, the signal amplitude is too high (due to improper air gap with respect to trigger wheel), or an irregular crank pattern is detected causing the ECM to resynchronize x times for y ms or longer as defined in the diagnostic calibration, this fault will set. Irregular crank patterns can be detected by the ECM due to electrical noise, poor machining of trigger wheel, or trigger wheel runout and/or gear lash.

Ensure crank circuit used with VR/magnetic pick-up sensors are properly twisted.

SPN 636, FMI 2 -Crank Input Signal Noise



SPN 636, FMI 4 -Loss of Crankshaft Input Signal



- Crankshaft Position sensor
- Check Condition- Key On, Engine On
- Fault Condition- Loss of crankshaft position signal while valid camshaft position signals continue for x number of cam pulses as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Emissions related fault

The crankshaft position sensor is a magnetic sensor (variable reluctant/magnetic pick-up or hall-effect) installed in the engine block adjacent to a “coded” trigger wheel located on the crankshaft. The sensor-trigger wheel combination is used to determine crankshaft position (with respect to TDC cylinder #1 compression) and the rotational engine speed. Determination of the crankshaft position and speed is necessary to properly activate the ignition, fuel injection, and throttle governing systems for precise engine control.

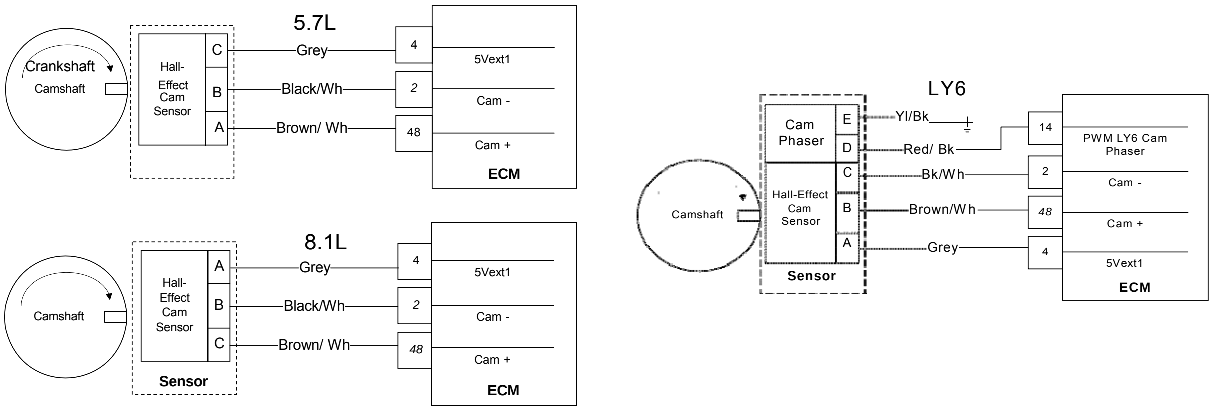
The ECM must see a valid crankshaft position signal while running. If no signal is present while x cam pulses continue the fault will set. The engine typically stalls or dies as a result of this fault condition due to the lack of crankshaft speed input resulting in the inability to control ignition timing.

SPN 636, FMI 4 -Loss of Crankshaft Input Signal

Diagnostic Aids

- ☐ Check that crankshaft position sensor is securely connected to harness
- ☐ Check that crankshaft position sensor is securely installed into engine block
- ☐ Check crankshaft position sensor circuit wiring for open circuit

SPN 723, FMI 2 -Camshaft Input Signal Noise



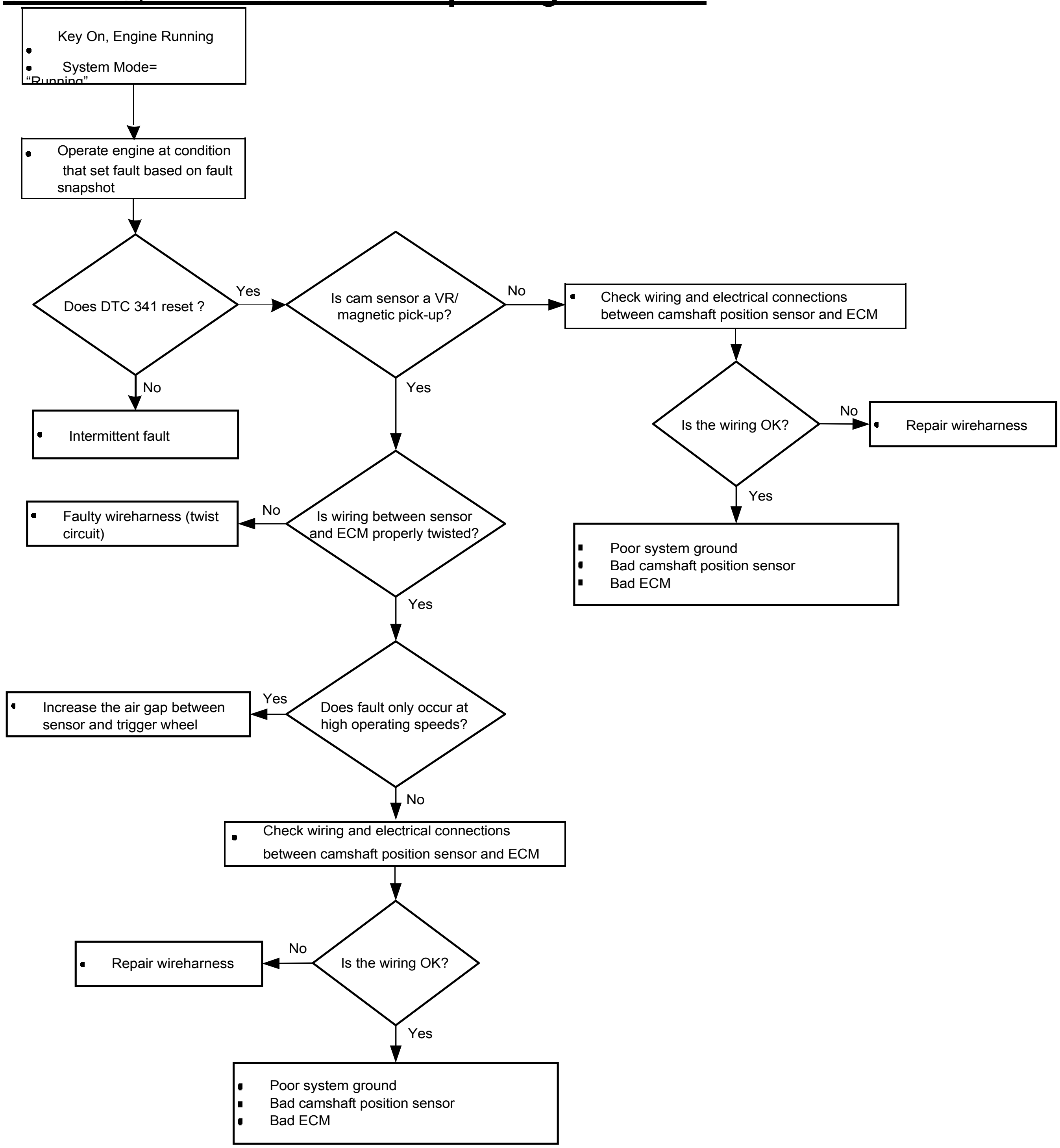
- Camshaft Position sensor
- Check Condition- Key On, Engine On
- Fault Condition- Electrical noise or irregular cam pattern detected causing x number of cam re-synchronization events as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp and disable adaptive fueling correction for remainder of key-cycle.
- Emissions related fault

The camshaft position sensor is a magnetic sensor (variable reluctant/magnetic pick-up or hall-effect) installed in the engine block or valve train adjacent to a “coded” trigger wheel located on or off of the camshaft. The sensor-trigger wheel combination is used to determine cam position (with respect to TDC cylinder #1 compression). Determination of the camshaft position is necessary to identify the stroke (or cycle) of the engine to properly activate the fuel injection system and ignition (for coil-on-plug engines) for precise engine control.

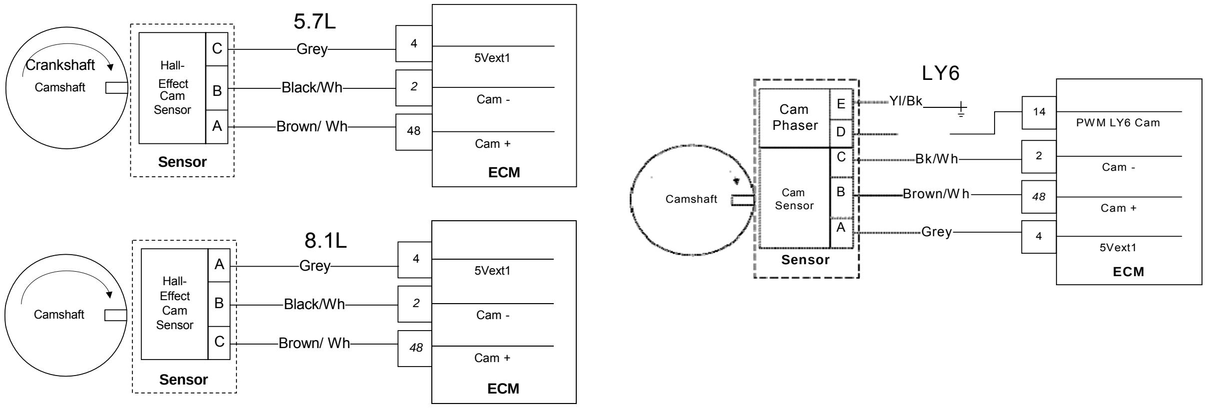
For a cam synchronized engine, the ECM must see a valid camshaft position signal while running. If no signal is present, the signal amplitude is too high (due to improper air gap with respect to trigger wheel), or an irregular cam pattern is detected causing the ECM to resynchronize x times for y ms or longer as defined in the diagnostic calibration, this fault will set. Irregular cam patterns can be detected by the ECM due to electrical noise, poor machining of trigger wheel, or trigger wheel runout and/or gear lash. Normally the engine will continue to run if equipped with a waste-spark or distributor ignition system. In some instances this fault can cause rough engine operation and can cause the engine to stall or die if equipped with coil-on-plug ignition engines.

Ensure cam circuit used with VR/magnetic pick-up sensors are properly twisted.

SPN 723, FMI 2 -Camshaft Input Signal Noise



SPN 723, FMI 4 -Loss of Camshaft Input Signal



- Camshaft Position sensor
- Check Condition- Key On, Engine On
- Fault Condition- Loss of camshaft position signal while valid crankshaft position signals continue for x number of engine cycles while operating at an engine speed > than y RPM as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for the remainder of the key-cycle
- Emissions related fault

The camshaft position sensor is a magnetic sensor (variable reluctant/magnetic pick-up or hall-effect) installed in the engine block or valve train adjacent to a “coded” trigger wheel located on or off of the camshaft. The sensor-trigger wheel combination is used to determine cam position (with respect to TDC cylinder #1 compression). Determination of the camshaft position is necessary to identify the stroke (or cycle) of the engine to properly activate the fuel injection system and ignition (for coil-on-plug engines) for precise engine control.

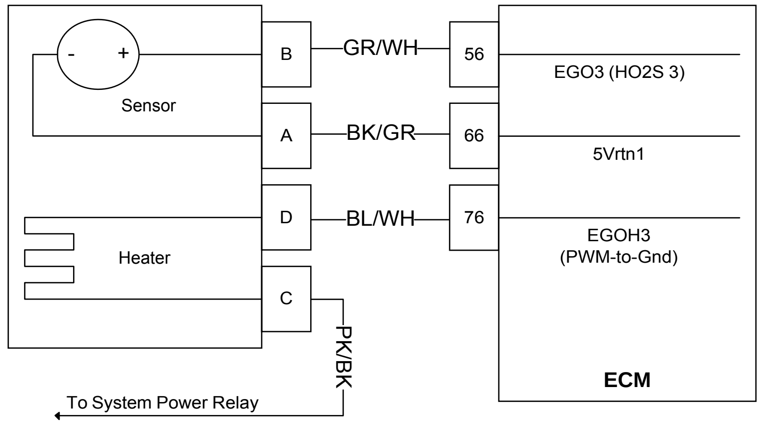
For a cam synchronized engine, the ECM must see a valid camshaft position signal while running. This fault will set if valid crankshaft position data is received for x number of engine cycles while engine speed is greater than y RPM and no camshaft signal is received. Normally the engine will continue to run if equipped with a waste-spark or distributor ignition system. In some instances this fault can cause rough engine operation and can cause the engine to stall or die if equipped with coil-on-plug ignition engines.

SPN 723, FMI 4 -Loss of Camshaft Input Signal

Diagnostic Aids

- ☐ Check that camshaft position sensor is securely connected to harness
- ☐ Check that camshaft position sensor is securely installed into engine block or distributor module
- ☐ Check camshaft position sensor circuit wiring for open circuit

SPN 3050, FMI 11 - Catalyst Inactive on Gasoline (Bank1)



- Bank 1 Catalyst, Heated or Universal Exhaust Gas Oxygen Sensor (Bank 1-Sensor 2-After Catalyst)
- Check Condition- Engine Running
- Fault Condition- Bank 1 catalyst inactive on gasoline
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp.
- Emissions related fault

A catalyst or catalytic converter is a component in the exhaust subsystem used to accelerate/generate chemical reactions within the engine exhaust to convert undesirable gases/pollutants into less harmful gases. In many spark-ignited applications, a three-way catalyst is used to convert hydrocarbons, oxides of nitrogen, and carbon monoxide into nitrogen, water, and carbon dioxide. In addition, many low-emission applications require the use of OBD, which typically require a catalyst monitor to identify whether or not the catalyst is functioning properly. The catalyst monitor diagnostic is typically configured such that exhaust emissions are near compliance-failing levels based on the engines specific regulatory requirement(s). Catalyst monitor techniques typically utilize a HEGO sensor to monitor the amount of oxygen present downstream of the catalyst. This is generally a good indicator of how efficiently the catalyst is using the oxygen entering the catalyst. Some systems also use temperature measurements in the catalyst and compare it to data stored in the ECM for each operating condition to determine if the catalytic reaction is generating the proper amount of heat.

The GCP uses a HEGO/HO2S sensor for catalyst monitor. The HEGO/HO2S is a switching-type sensor around stoichiometry that measures the oxygen content downstream of the catalyst for two main functions: 1) to compare it to the oxygen content upstream of the catalyst to determine how efficiently the catalyst is using oxygen to determine its effectiveness and 2) trim the commanded equivalence ratio target to maximize the catalyst conversion efficiency. The post-catalyst strategy and diagnostic is only active when the system is in either *"CL Active"* or *"CL + Adapt"* control modes.

In theory if the catalyst is operated at a condition that could result in 100 percent conversion efficiency, the catalyst will use all available oxygen present in the exhaust gas to convert the emission pollutants (or reactants) to N_2, CO_2, and H_2O. However, since catalysts generally operate at efficiencies between 85-95% post-catalyst oxygen concentration can be a direct indicator of how efficient the catalyst is. Figure 1 shows an example of a slightly rich biased feed gas or pre-catalyst equivalence ratio versus that of the post-catalyst for a functional catalyst. It can be noticed from this figure that the pre-catalyst equivalence ratio, as identified by '*EGO1_volts*', is varying due to the CL excursions (perturbation) and that the post-catalyst equivalence ratio, as identified by '*EGO2_volts*', is maintained relatively constant rich of stoichimetry. A similar waveform pattern should be expected on properly functioning catalysts.

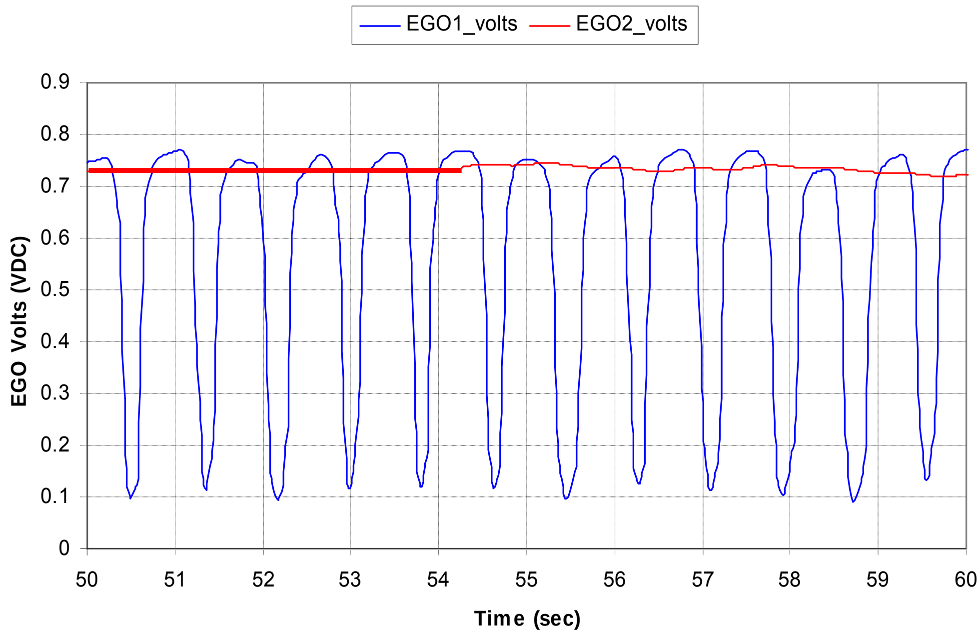


Figure 1: EGO Waveforms (Functional TWC)

Figure 2 shows an example of EGO waveforms for a catalyst with poor conversion efficiency. A significant difference between Figure 1 and Figure 2 is that the post-catalyst EGO feedback oscillates with the same frequency as the pre-catalyst EGO feedback and the amplitude is on the order of 60% of that of EGO1. This indicates that a certain amount of oxygen that is entering into the catalyst is passing through the catalyst unconsumed. Catalyst monitor diagnostics are configured such that if the post-catalyst EGO waveform has an amplitude that is directly proportional to the pre-catalyst EGO waveform and who's waveform similarly matches the closed-loop excursion (perturbation) a fault is generated.

Two metric comparisons that are used to identify the health of the catalyst are:

1) Post-catalyst EGO root-mean square (RMS) > Pre-catalyst EGO RMS x ??? %, where the ??? % is determined based on emissions compliance testing over the application's certified duty-cycle(s).
2) Post-catalyst EGO RMS > CL excursion RMS x ??? %, where the ??? % is determined based on emissions compliance testing over the application's certified duty-cycle(s).

There are a couple of ways in which the limits for diagnostics can be determined. In both cases, the system must be tested with an emissions measurement system to determine when the exhaust emissions are nearly failing emissions compliance.

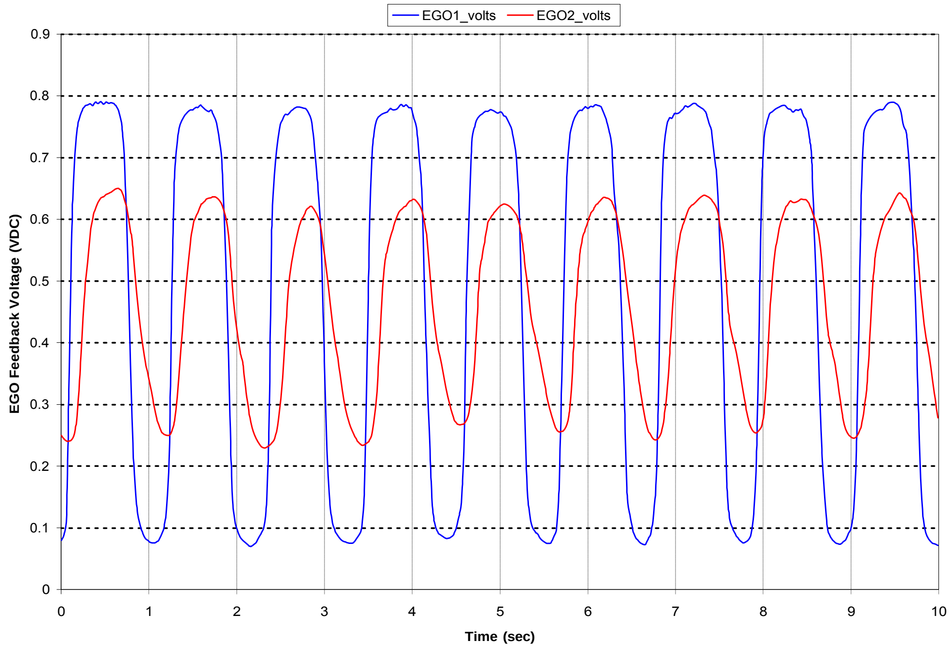


Figure 2: EGO Waveforms (Damaged TWC)

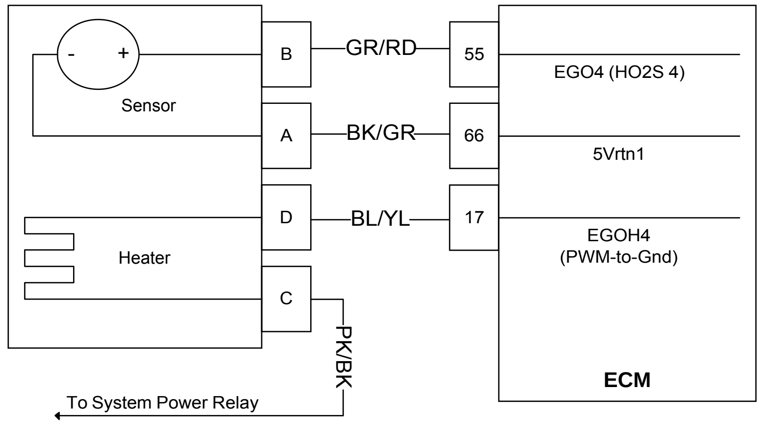
SPN 3050, FMI 11 - Catalyst Inactive on Gasoline (Bank1)

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks upstream and around catalyst and post-catalyst HEGO sensor. Replace gaskets and tighten fasteners if leaks are present.
- ☐ Perform manufacture recommended in-field emissions test.

SPN 3051, FMI 11 - Catalyst Inactive on Gasoline (Bank2)



- Bank 2 Catalyst, Heated or Universal Exhaust Gas Oxygen Sensor (Bank 2-Sensor 2-After Catalyst)
- Check Condition- Engine Running
- Fault Condition- Bank 1 catalyst inactive on gasoline
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp.
- Emissions related fault

A catalyst or catalytic converter is a component in the exhaust subsystem used to accelerate/generate chemical reactions within the engine exhaust to convert undesirable gases/pollutants into less harmful gases. In many spark-ignited applications, a three-way catalyst is used to convert hydrocarbons, oxides of nitrogen, and carbon monoxide into nitrogen, water, and carbon dioxide. In addition, many low-emission applications require the use of OBD, which typically require a catalyst monitor to identify whether or not the catalyst is functioning properly. The catalyst monitor diagnostic is typically configured such that exhaust emissions are near compliance-failing levels based on the engines specific regulatory requirement(s). Catalyst monitor techniques typically utilize a HEGO sensor to monitor the amount of oxygen present downstream of the catalyst. This is generally a good indicator of how efficiently the catalyst is using the oxygen entering the catalyst. Some systems also use temperature measurements in the catalyst and compare it to data stored in the ECM for each operating condition to determine if the catalytic reaction is generating the proper amount of heat.

The GCP uses a HEGO/HO2S sensor for catalyst monitor. The HEGO/HO2S is a switching-type sensor around stoichiometry that measures the oxygen content downstream of the catalyst for two main functions: 1) to compare it to the oxygen content upstream of the catalyst to determine how efficiently the catalyst is using oxygen to determine its effectiveness and 2) trim the commanded equivalence ratio target to maximize the catalyst conversion efficiency. The post-catalyst strategy and diagnostic is only active when the system is in either *"CL Active"* or *"CL + Adapt"* control modes.

In theory if the catalyst is operated at a condition that could result in 100 percent conversion efficiency, the catalyst will use all available oxygen present in the exhaust gas to convert the emission pollutants (or reactants) to N_2, CO_2, and H_2O. However, since catalysts generally operate at efficiencies between 85-95% post-catalyst oxygen concentration can be a direct indicator of how efficient the catalyst is. Figure 3 shows an example of a slightly rich biased feed gas or pre-catalyst equivalence ratio versus that of the post-catalyst for a functional catalyst. It can be noticed from this figure that the pre-catalyst equivalence ratio, as identified by '*EGO1_volts*', is varying due to the CL excursions (perturbation) and that the post-catalyst equivalence ratio, as identified by '*EGO2_volts*', is maintained relatively constant rich of stoichimetry. A similar waveform pattern should be expected on properly functioning catalysts.

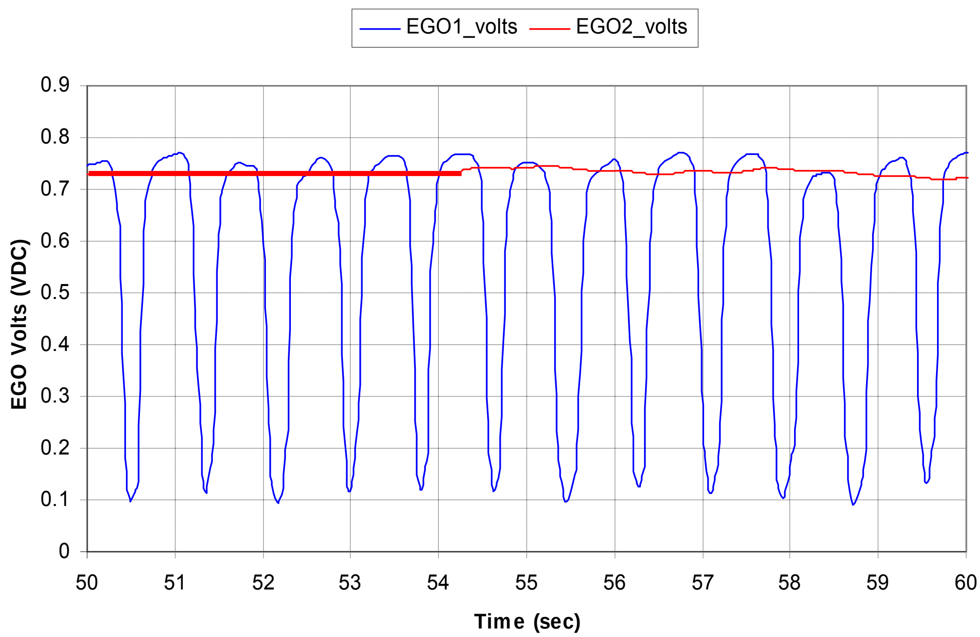


Figure 3: EGO Waveforms (Functional TWC)

Figure 4 shows an example of EGO waveforms for a catalyst with poor conversion efficiency. A significant difference between Figure 3 and Figure 4 is that the post-catalyst EGO feedback oscillates with the same frequency as the pre-catalyst EGO feedback and the amplitude is on the order of 60% of that of EGO1. This indicates that a certain amount of oxygen that is entering into the catalyst is passing through the catalyst unconsumed. Catalyst monitor diagnostics are configured such that if the post-catalyst EGO waveform has an amplitude that is directly proportional to the pre-catalyst EGO waveform and who's waveform similarly matches the closed-loop excursion (perturbation) a fault is generated.

Two metric comparisons that are used to identify the health of the catalyst are:

1) Post-catalyst EGO root-mean square (RMS) > Pre-catalyst EGO RMS x ??? %, where the ??? % is determined based on emissions compliance testing over the application's certified duty-cycle(s).
2) Post-catalyst EGO RMS > CL excursion RMS x ??? %, where the ??? % is determined based on emissions compliance testing over the application's certified duty-cycle(s).

There are a couple of ways in which the limits for diagnostics can be determined. In both cases, the system must be tested with an emissions measurement system to determine when the exhaust emissions are nearly failing emissions compliance.

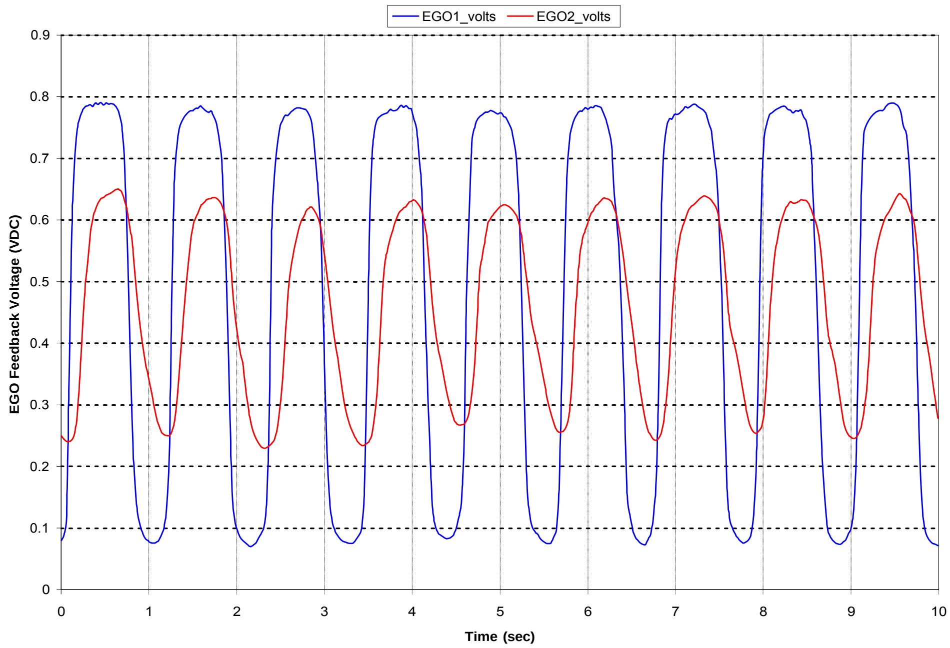


Figure 4: EGO Waveforms (Damaged TWC)

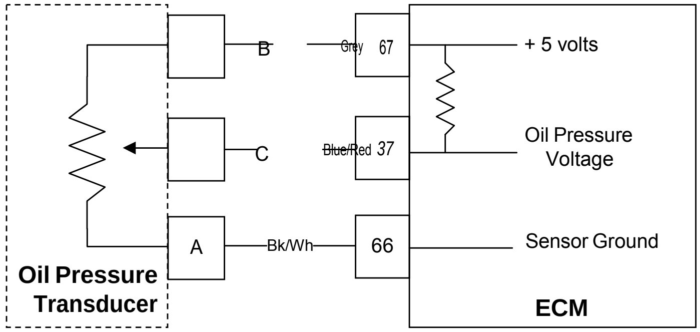
SPN 3051, FMI 11 - Catalyst Inactive on Gasoline (Bank2)

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks upstream and around catalyst and post-catalyst HEGO sensor. Replace gaskets and tighten fasteners if leaks are present.
- ☐ Perform manufacture recommended in-field emissions test.

SPN 100, FMI 0 - Oil Pressure Sender High Pressure

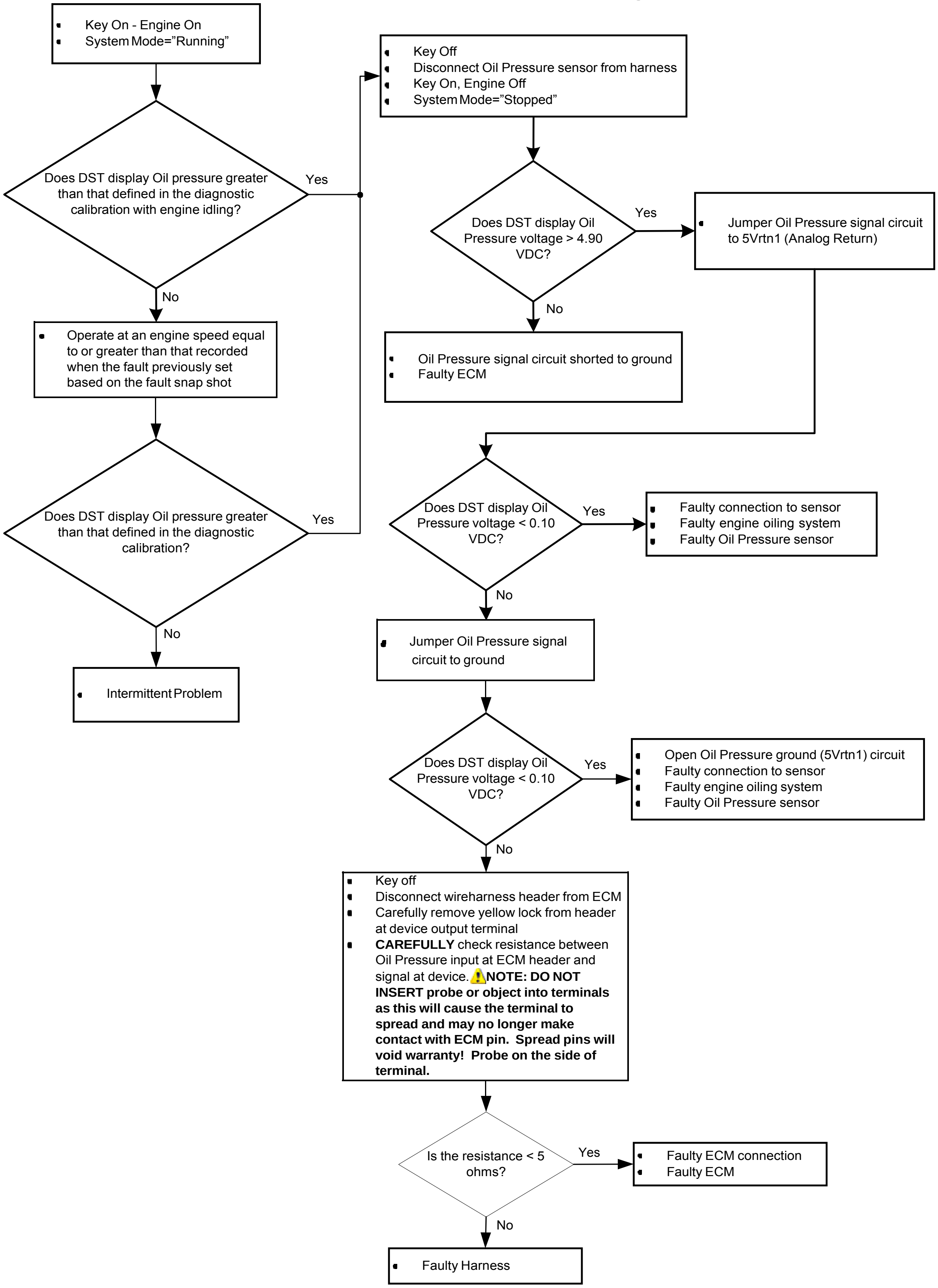


- Engine Oil Pressure
- Check Condition- Key on, Engine on
- Fault Condition- Oil pressure higher than x psia while engine speed is greater that y RPM.
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly configure for power derate 1 or low rev limit
- Non-emissions related fault

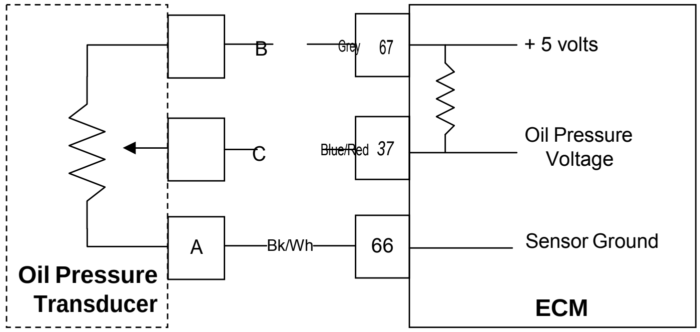
The ECM can be configured to monitor oil pressure through a proportional transducer or through a switch. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and rings, can be a result of a restriction in the oil flow path, or can be a sign of a malfunctioning oiling system.

This fault sets if the engine oil pressure is higher than x psia and engine speed greater than y RPM as defined in the diagnostic calibration. Recommend a power derate and/or low rev limit to help prevent possible engine damage and reduce oil pressure.

SPN 100, FMI 0 - Oil Pressure Sender High Pressure



SPN 100, FMI 4 - Oil Pressure Sender Low Voltage

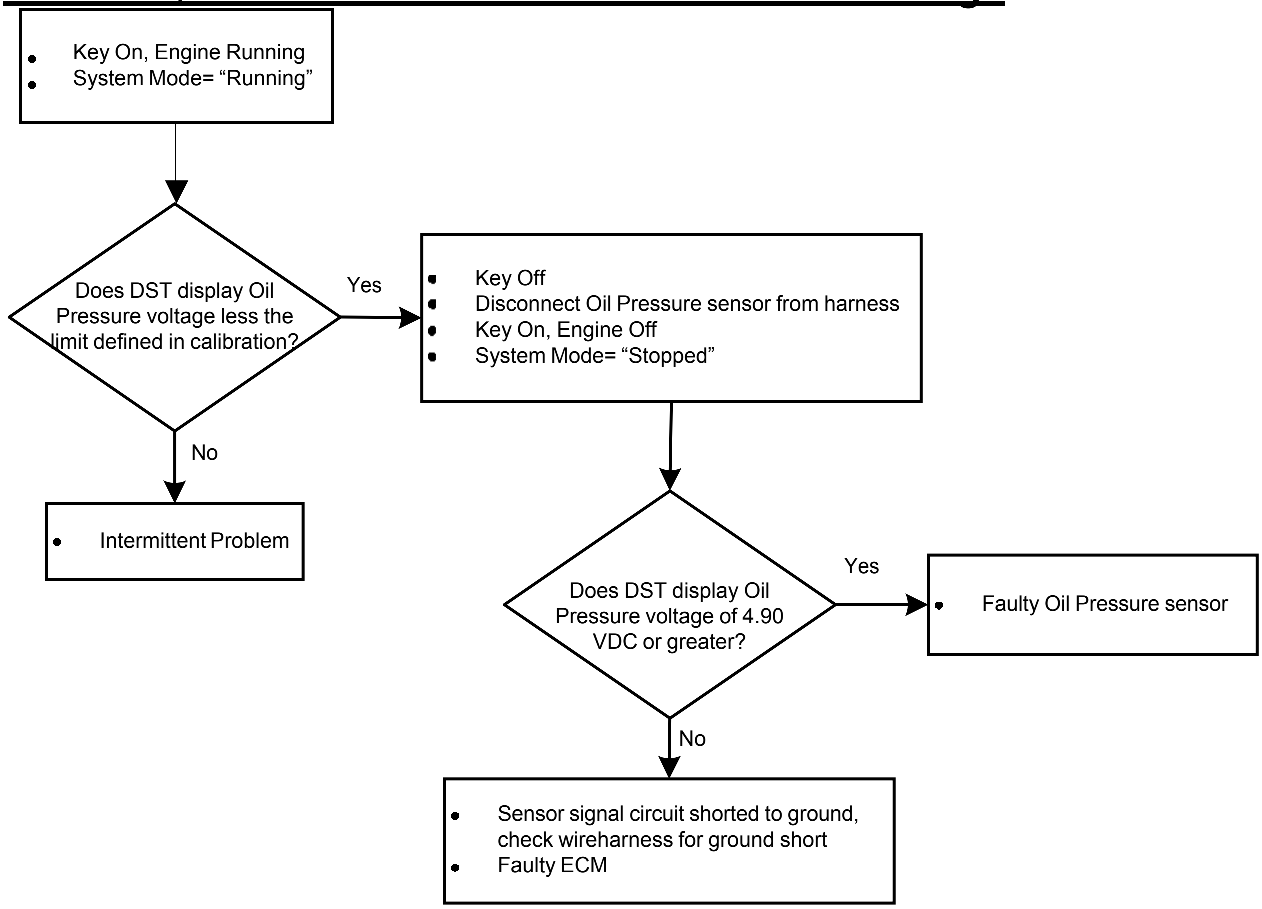


- Engine Oil Pressure
- Check Condition- Key on, Engine on
- Fault Condition- Oil pressure sender voltage lower than defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly configure for power derate 1 or low rev limit due to inability to sense oil pressure
- Non-emissions related fault

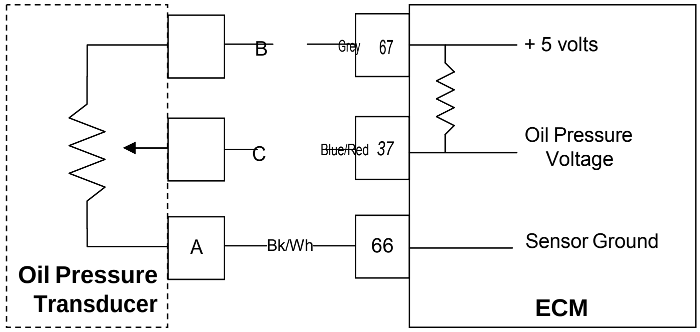
The ECM can be configured to monitor oil pressure through a proportional transducer or through a switch. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and rings, can be a result of a restriction in the oil flow path, or can be a sign of a malfunctioning oiling system.

This fault sets if the engine oil pressure sender/transducer voltage is lower than defined in the diagnostic calibration. Recommend a power derate and/or low rev limit due to the inability to sense oil pressure and to reduce risk of potential engine damage.

SPN 100, FMI 4 - Oil Pressure Sender Low Voltage



SPN 100, FMI 3 - Oil Pressure Sender High Voltage

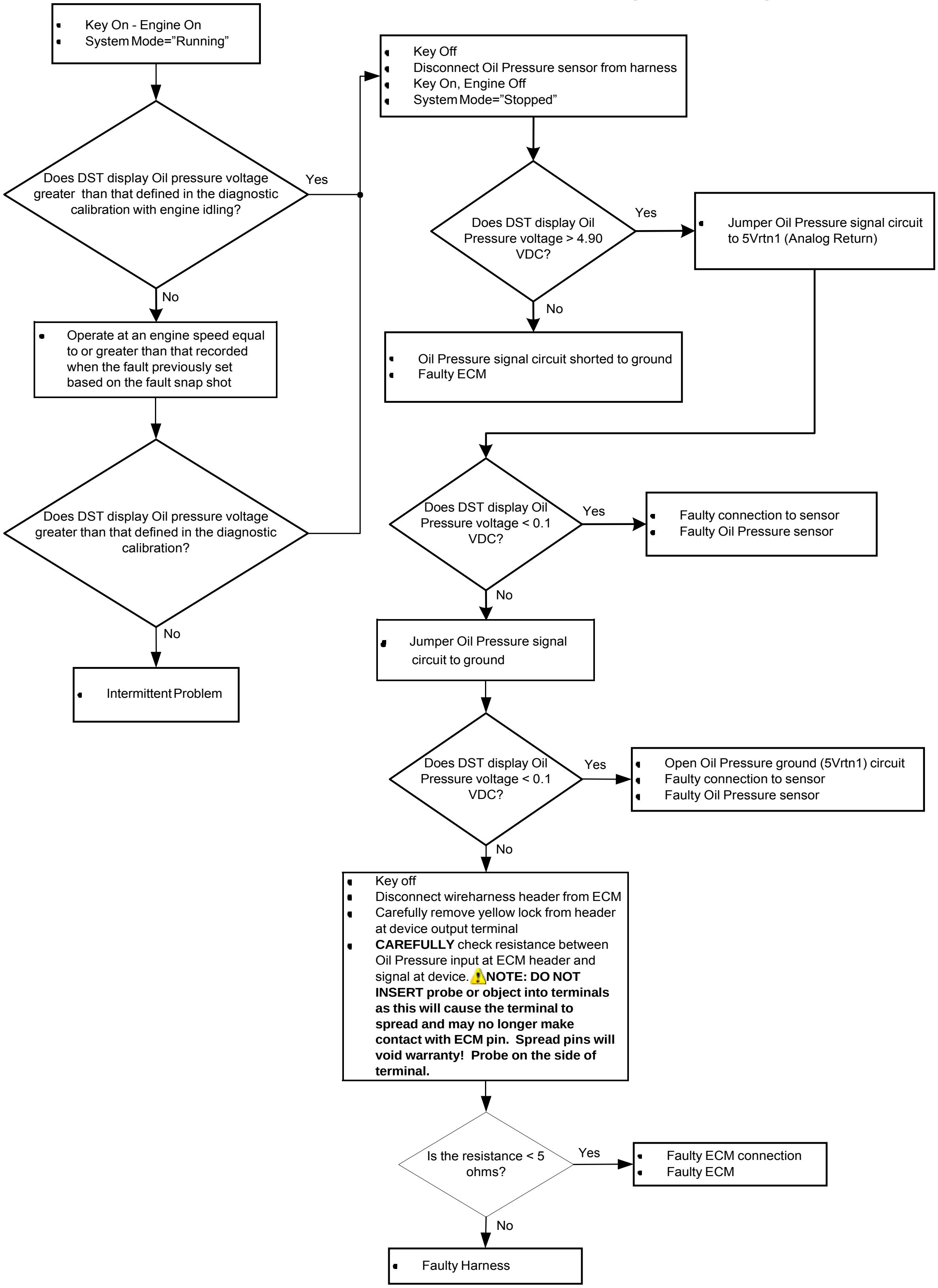


- Engine Oil Pressure
- Check Condition- Key on, Engine on
- Fault Condition- Oil pressure sender voltage higher than defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly configure for power derate 1 or low rev limit due to inability to sense oil pressure
- Non-emissions related fault

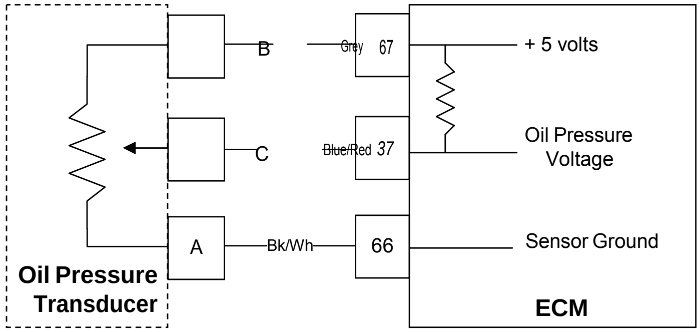
The ECM can be configured to monitor oil pressure through a proportional transducer or through a switch. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and rings, can be a result of a restriction in the oil flow path, or can be a sign of a malfunctioning oiling system.

This fault sets if the engine oil pressure sender/transducer voltage is higher than defined in the diagnostic calibration. Recommend a power derate and/or low rev limit due to the inability to sense oil pressure and to reduce risk of potential engine damage.

SPN 100, FMI 3 - Oil Pressure Sender High Voltage



SPN 100, FMI 1 - Oil Pressure Low



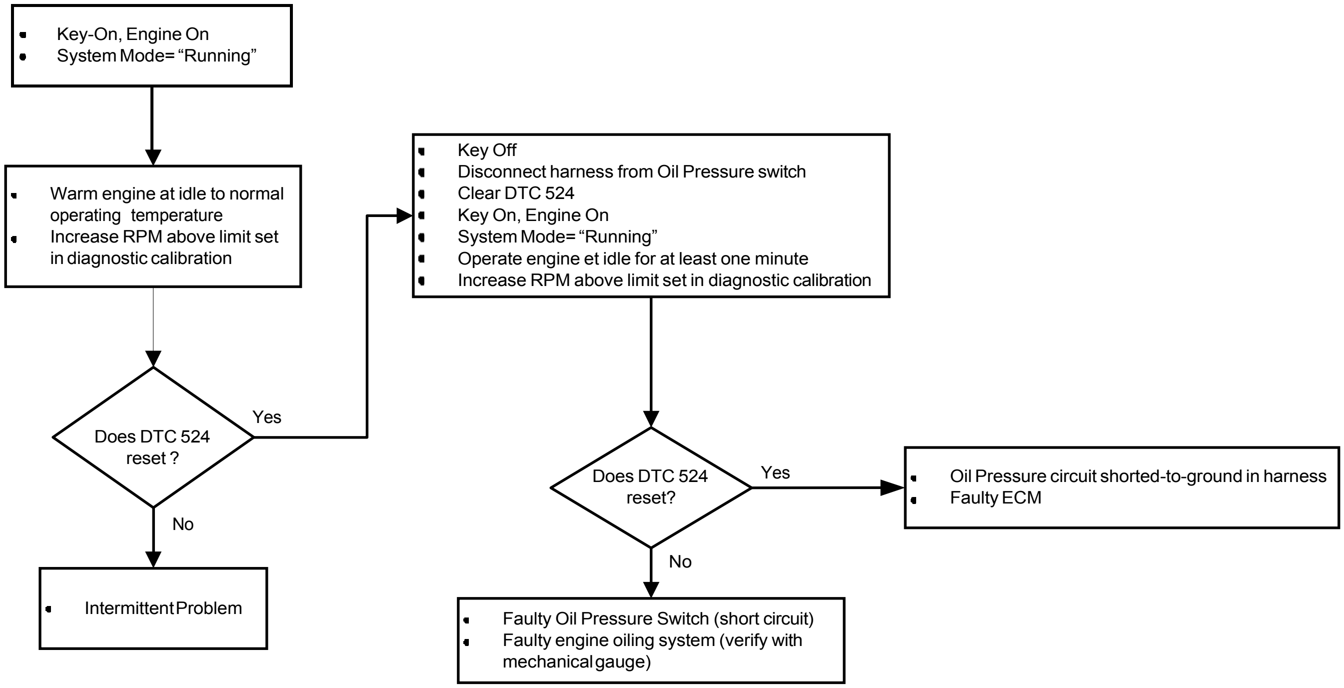
- Engine Oil Pressure
- Check Condition- Key on, Engine on
- Fault Condition- Engine oil pressure lower than expected while engine has been running for a minimum amount of time while engine speed is above some limit as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, generally configured to derate the engine and trigger an engine shutdown
- Non-emissions related fault

The ECM can be configured to monitor oil pressure through a proportional transducer or through a switch. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and rings, can be a result of a restriction in the oil flow path, or can be a sign of a malfunctioning oiling system.

For systems that use a transducer, this fault sets if the engine oil pressure is less than x psia and engine speed is greater than y RPM after the engine has been running for z seconds as defined in the diagnostic calibration. For systems that use a switch this fault can be configured two different ways. It may use a normally closed switch or a normally open switch. If the switch is normally open, the fault will set if the circuit becomes grounded. If the switch is normally closed, the fault will set if the circuit becomes open. Go to the Faults page in EDIS to determine how the input is configured. ("Open=OK" is normally open and "Ground=OK" is normally closed). The engine will should be configured to derate or force idle and/or shut down in the event of this fault to help prevent possible damage.

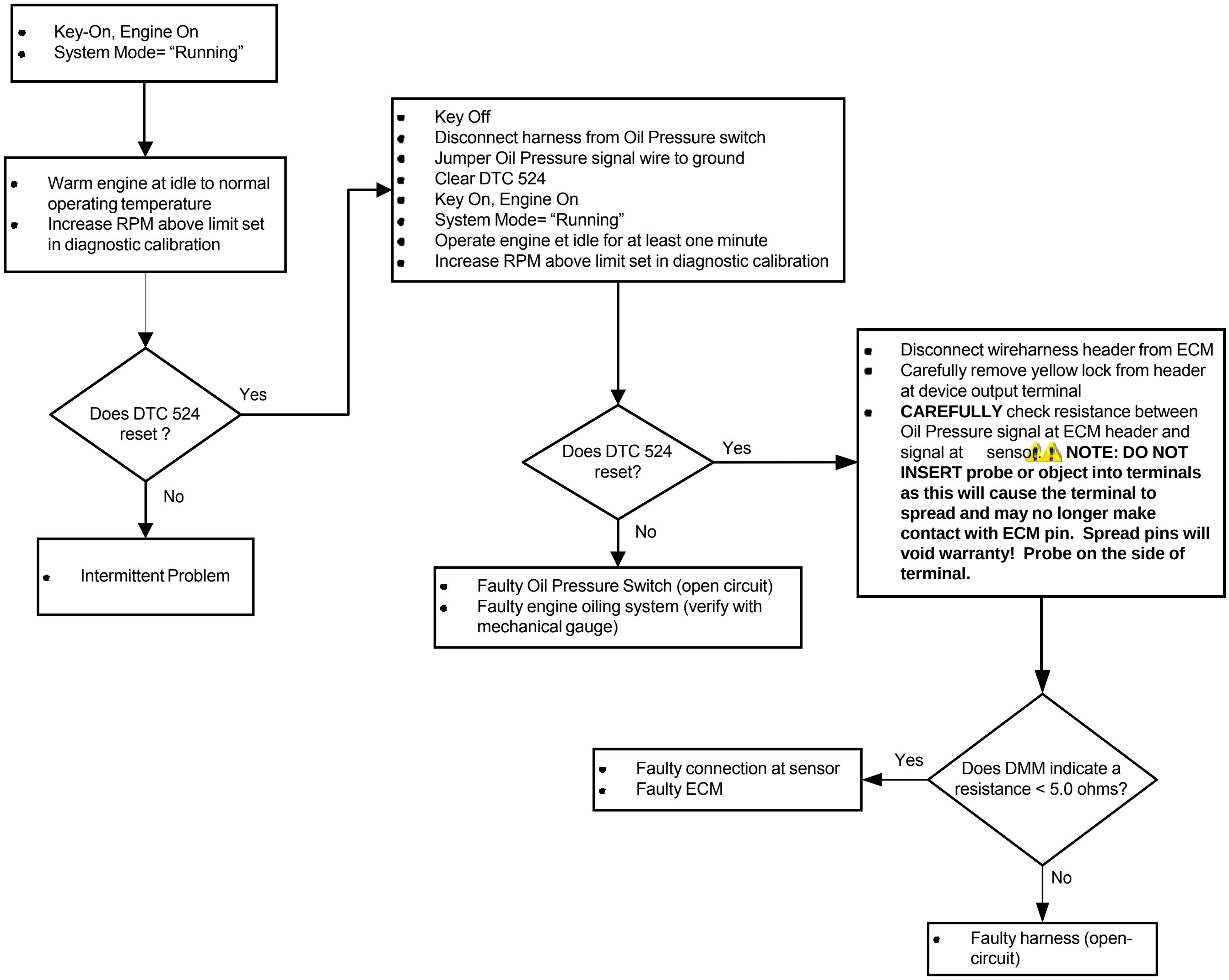
SPN 100, FMI 1 -Oil Pressure Low

Normally-Open Switch



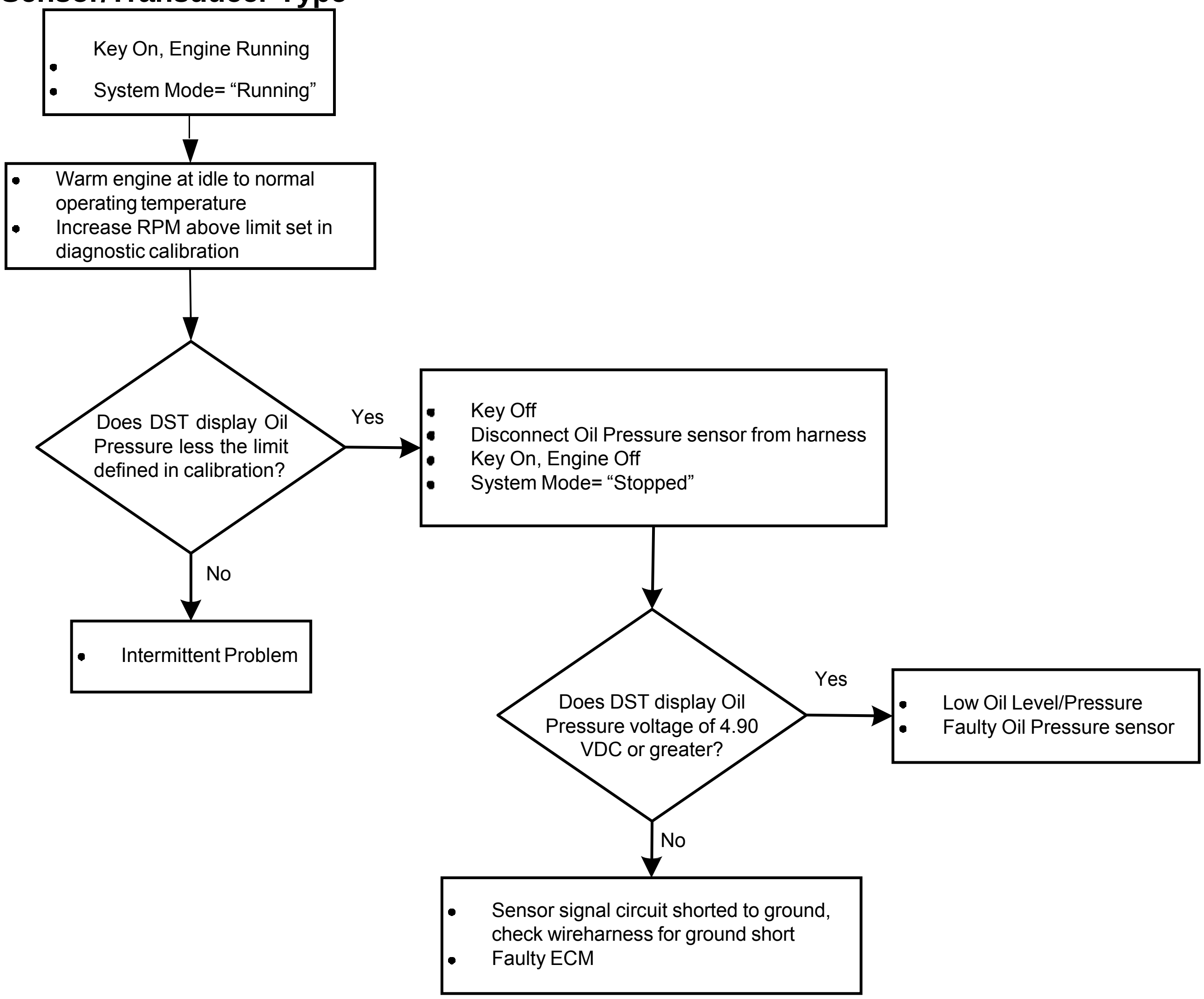
DTC 524-Oil Pressure Low

Normally-Closed Switch

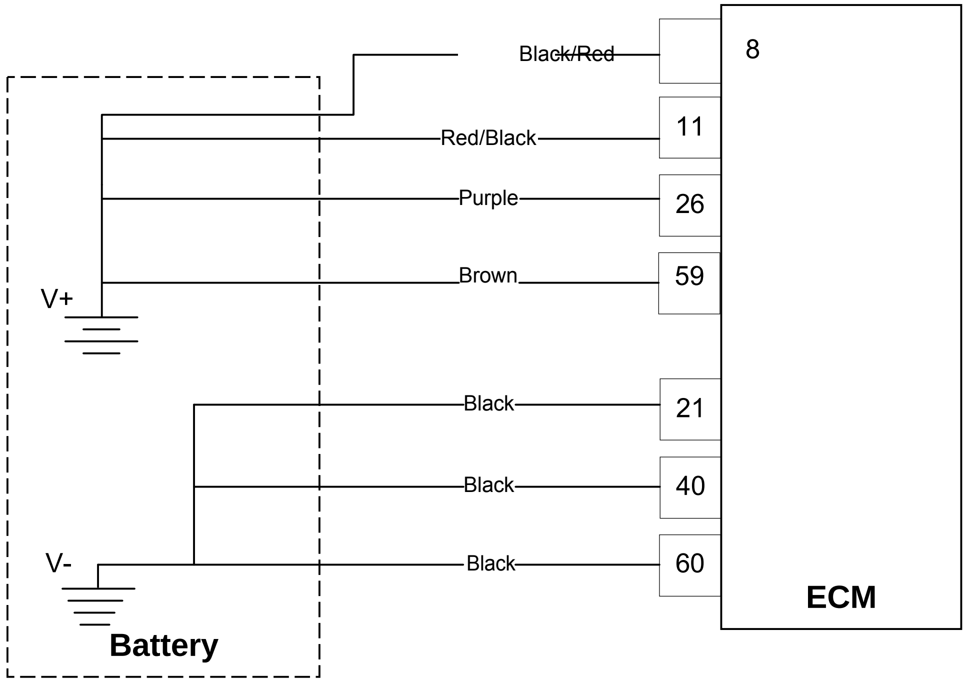


DTC 524-Oil Pressure Low

Sensor/Transducer Type



SPN 168, FMI 17 - Battery Voltage (VBat) Low

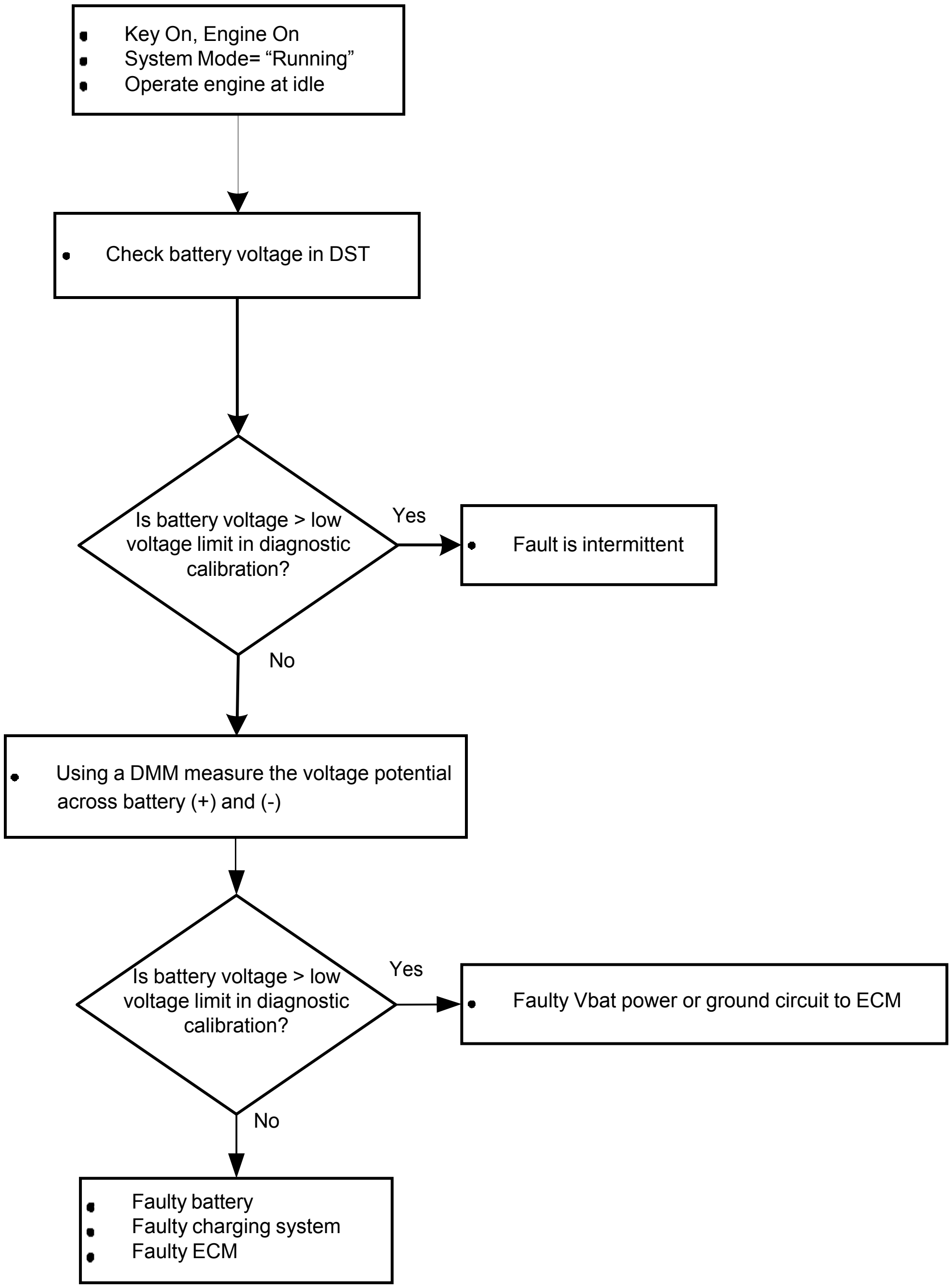


- System voltage to ECM
- Check Condition- Key on, Engine on
- Fault Condition- Battery voltage to ECM less than x volts while the engine is operating at y RPM or greater as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle
- Non-emissions related fault

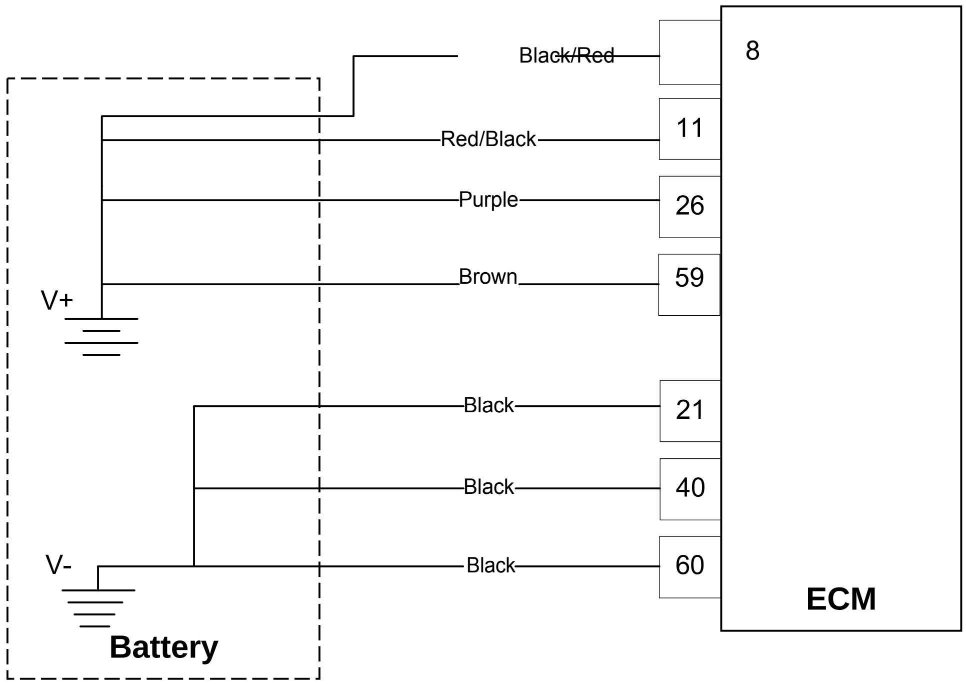
The battery voltage powers the ECM and must be within limits to correctly operate injector drivers, ignition coils, throttle, power supplies, and other powered devices that the ECM controls.

This fault will set if the ECM detects system voltage less than x volts while the engine is operating at y RPM as defined in the diagnostic calibration as the alternator should be charging the system. The adaptive learn is disabled to avoid improper adaptive learning due to the inability to correctly time injector firings.

SPN 168, FMI 17 - Battery Voltage (VBat) Low



SPN 168, FMI 15 - Battery Voltage (VBat) High

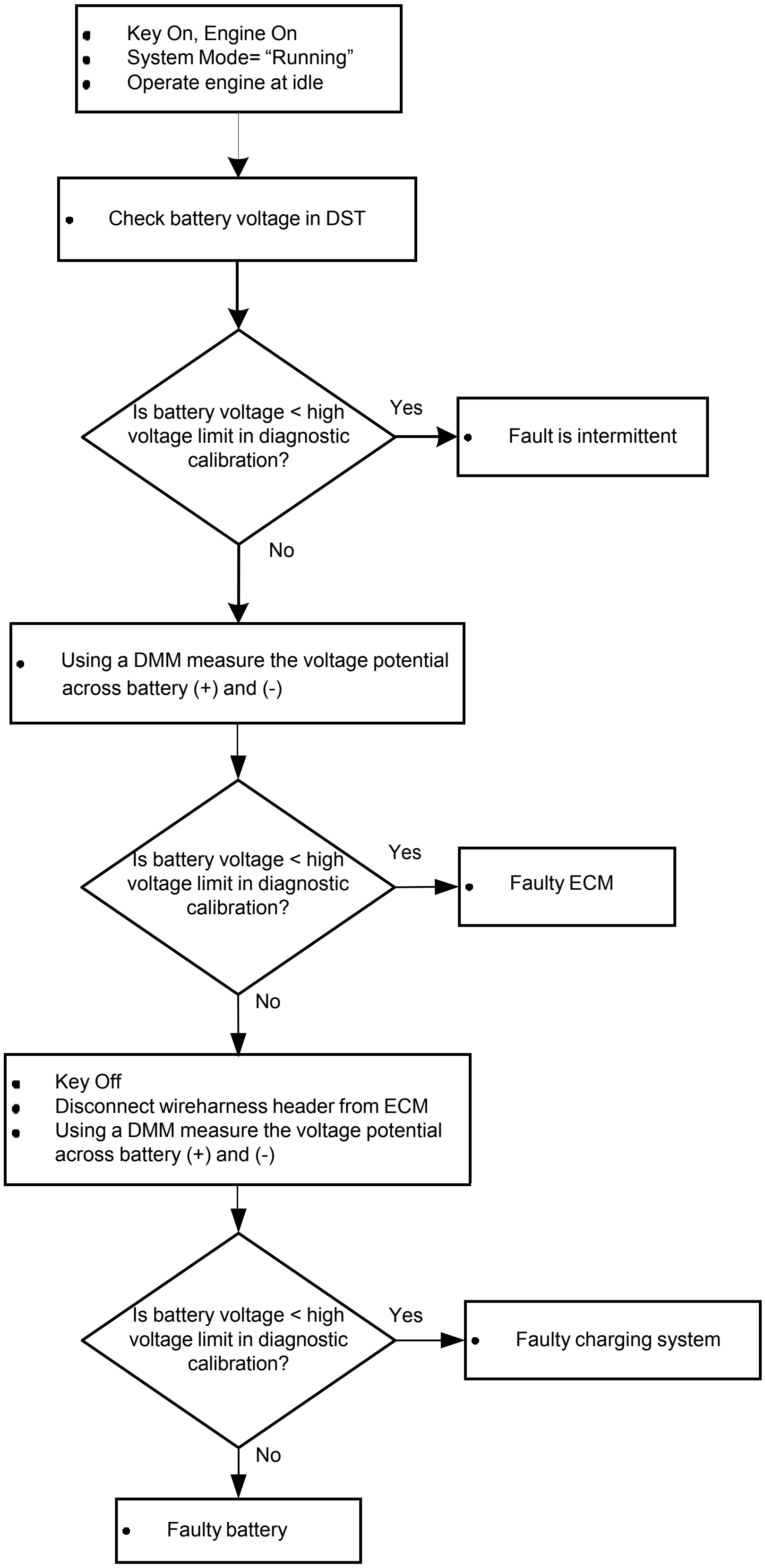


- System voltage to ECM
- Check Condition- Key on, Engine Cranking or Running
- Fault Condition- Battery voltage to ECM greater than x volts while the engine is running as defined in the diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle
- Non-emissions related fault

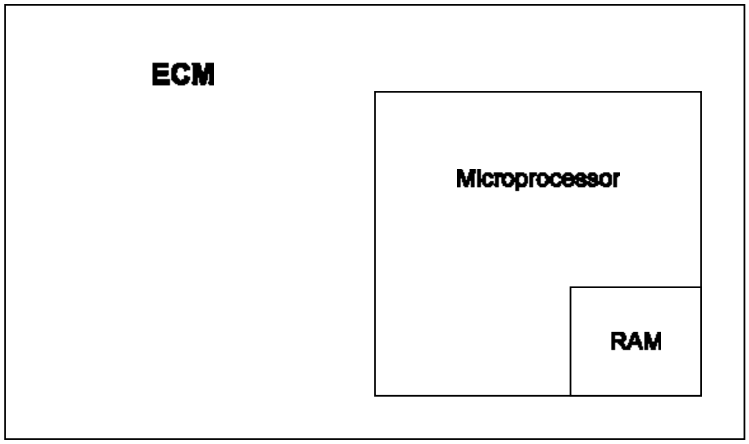
The battery voltage powers the ECM and must be within limits to correctly operate injector drivers, ignition coils, throttle, power supplies, and other powered devices that the ECM controls.

This fault will set if the ECM detects system voltage greater than x volts while the engine is running or cranking as defined in the diagnostic calibration. The adaptive learn is disabled to avoid improper adaptive learning.

SPN 168, FMI 15 - Battery Voltage (VBat) High



SPN 628, FMI 13 - Microprocessor Failure - FLASH

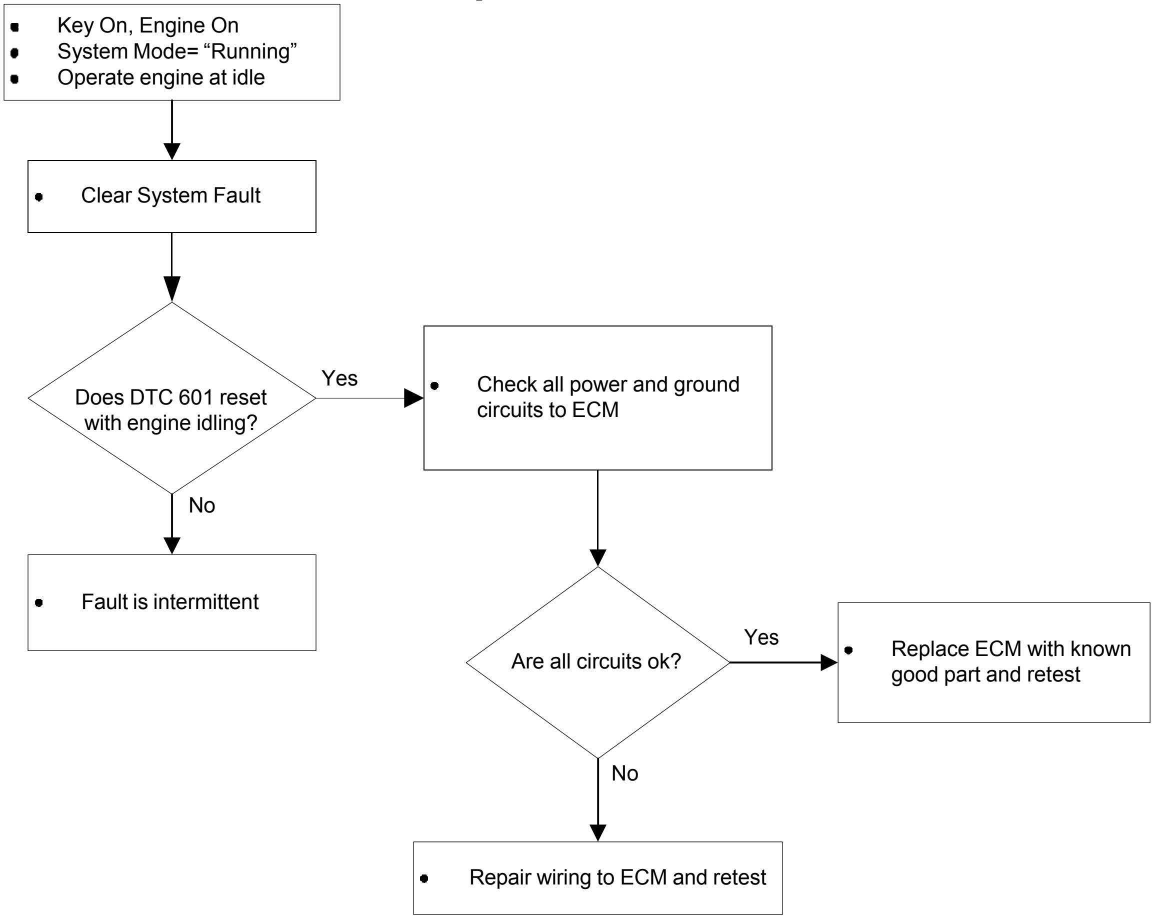


- Engine Control Module- Flash Memory
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle, recommend power derate 2 and low rev limit to reduce possible engine damage and/or overspeed condition
- Non-emissions related fault

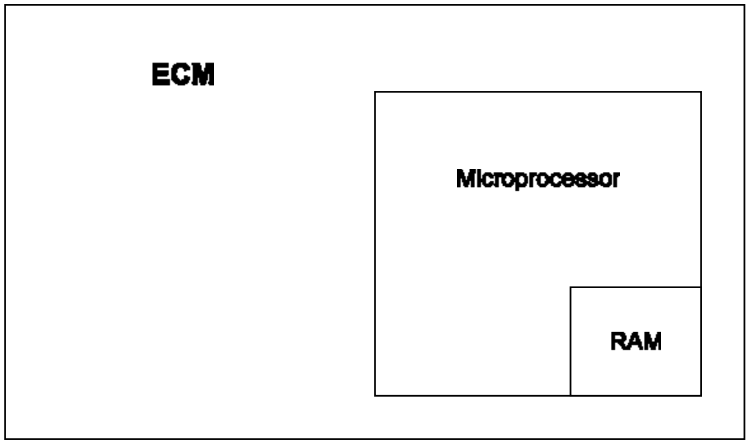
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault.

If this fault sets, the ECM will reset itself and log the code. The fault should be configured to never forget and will not self-erase and will not clear until a technician performs diagnostics and manually clears the code. This fault should be configured to set a power derate 2 and low rev limit to reduce possible engine damage and reduce possibility of an overspeed condition. A fault of flash memory can occur for any calibration variable set and thus could cause undesirable operation.

SPN 628, FMI 13 - Microprocessor Failure - FLASH



SPN 630, FMI 12 - Microprocessor Failure - RAM

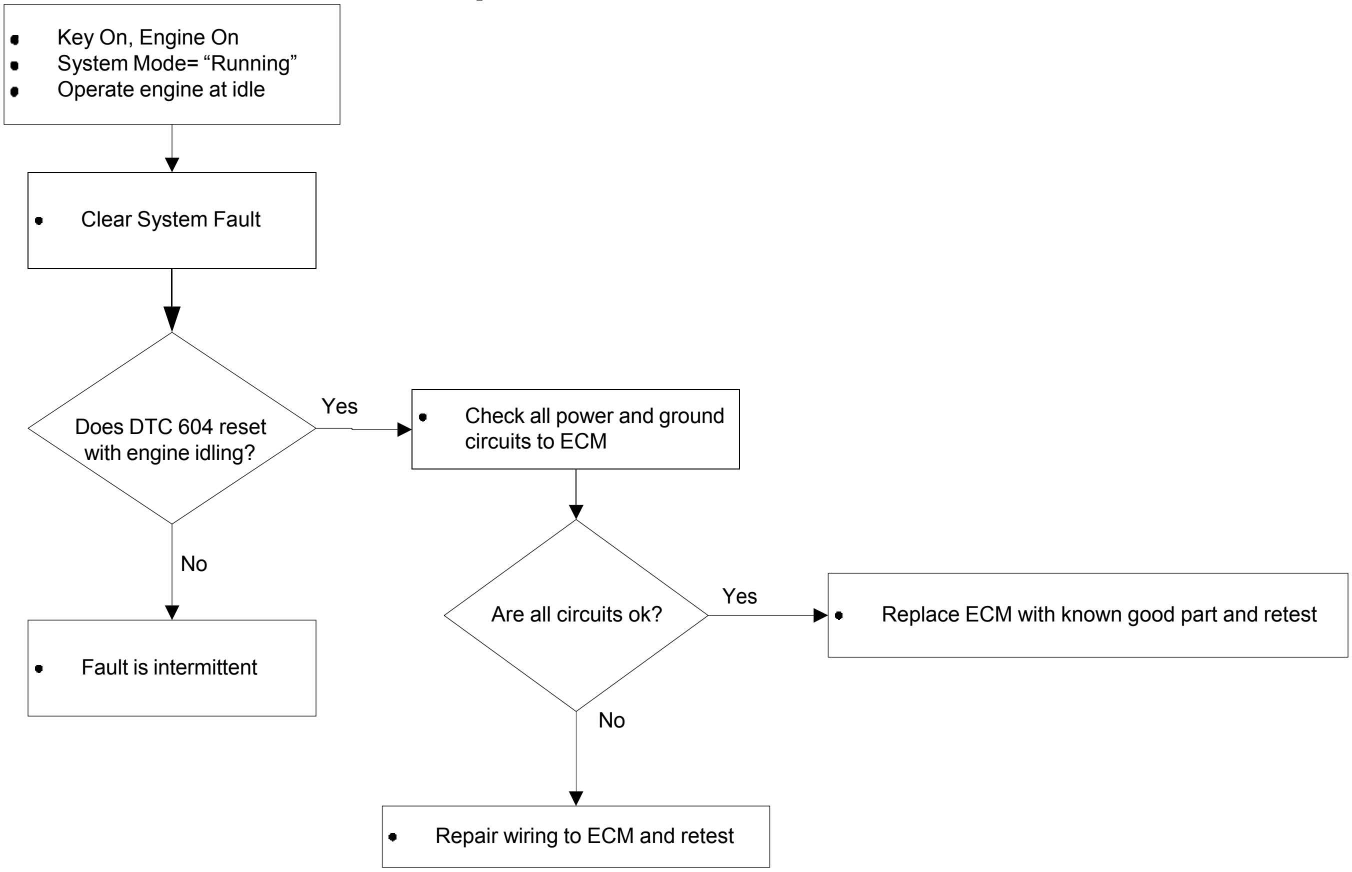


- Engine Control Module- Random Access Memory
- Check Condition- Key on
- Fault Condition- Internal ECM microprocessor memory access failure
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle, recommend power derate 2 and low rev limit to reduce possible engine damage and/or overspeed condition
- Non-emissions related fault

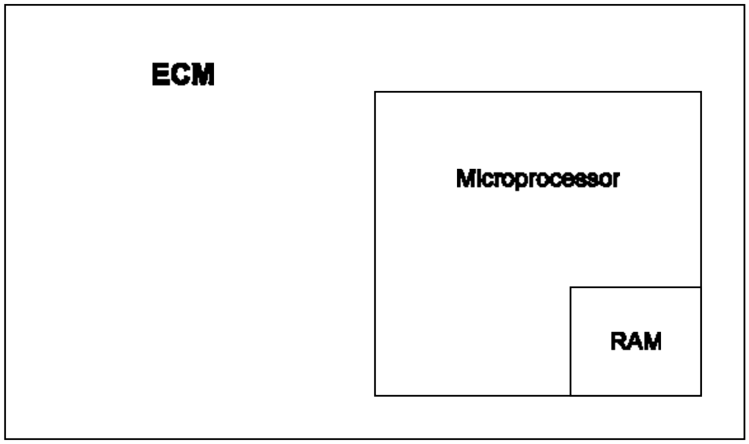
Random Access Memory is located within the microprocessor and can be read from or written to at any time. Data stored in RAM include DTCs (when fault configuration is set to “Battery Power Retained”), adaptive fuel learn tables, octane adaptation table, misfire adaption tables, and closed loop fuel multipliers. The ECM has checks that must be satisfied each time an instruction is executed.

This fault will set if the ECM detects a problem accessing or writing information to RAM and should be configured to set a power derate 2 and low rev limit to reduce possible engine damage and reduce possibility of an overspeed condition. If this fault sets, the ECM will reset itself and log the code. This fault should be erased by a technician after diagnostics are performed. The fault should be configured to never forget and will not self-erase.

SPN 630, FMI 12 - Microprocessor Failure – RAM



SPN 629, FMI 31 - Microprocessor Failure - COP

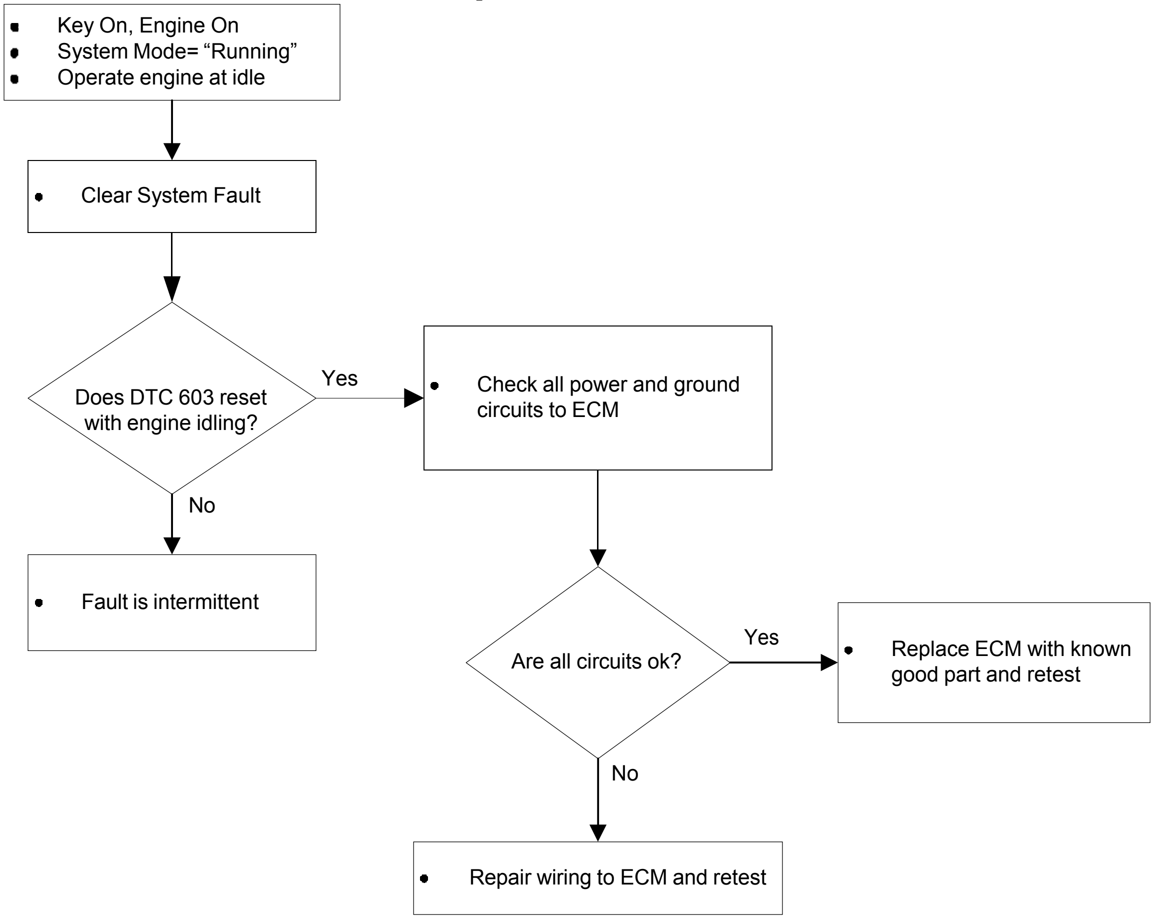


- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle, recommend power derate 2 and low rev limit to reduce possible engine damage and/or overspeed condition
- Non-emissions related fault

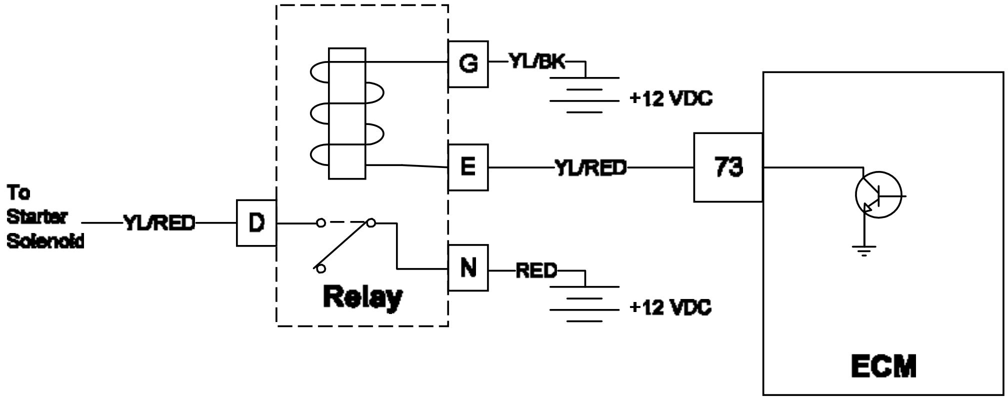
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault.

If this fault sets, the ECM will reset itself and log the code. The fault should be configured to never forget and will not self-erase and will not clear until a technician performs diagnostics and manually clears the code. This fault should be configured to set a power derate 2 and low rev limit to reduce possible engine damage and reduce possibility of an overspeed condition.

SPN 629, FMI 31 - Microprocessor Failure – COP



SPN 1321, FMI 5 - Start Relay Coil Open



- Starter Relay
- Check Condition- Key On, Engine Cranking
- Fault Condition- Starter relay coil output open circuit
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

This fault sets if the output for the starter relay is detected as an open circuit. If this fault is active the starter motor will not receive power and will not engage.

SPN 1321, FMI 5 - Start Relay Coil Open

- Key On, Engine Cranking
- System Mode= "Cranking"
- Verify that DTC 615 is active

- Remove Starter Relay from fuse block/relay module
- Using a DMM, measure the voltage potential from the starter relay output to ground while the engine is trying to crank

Is voltage > 80% of Vbat?

Yes:

- Key Off
- Connect test lamp to Vbat and Starter Relay output
- Key On, Engine Cranking
- System Mode= "Cranking"

No:

- Faulty Starter Relay

Does test lamp stay lit?

Yes:

- Faulty Starter Relay
- Faulty Relay connection/ wiring

No:

- Disconnect wireharness header from ECM
- Carefully remove yellow lock from header at
- device output terminal
- CAREFULLY check resistance between Starter Relay output at ECM header and at relay. ⚠ NOTE: DO NOT INSERT probe or object into terminals as this will cause the terminal to spread and may no longer make contact with ECM pin. Spread pins will void warranty! Probe on the side of terminal.

Does DMM indicate a resistance < 5.0 ohms?

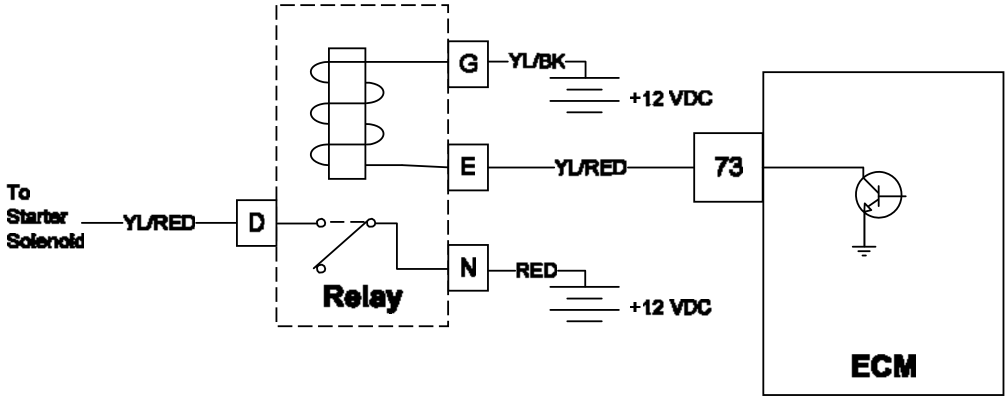
Yes:

- Faulty ECM

No:

- Faulty harness (open-circuit)

SPN 1321, FMI 4 - Start Relay Ground Short

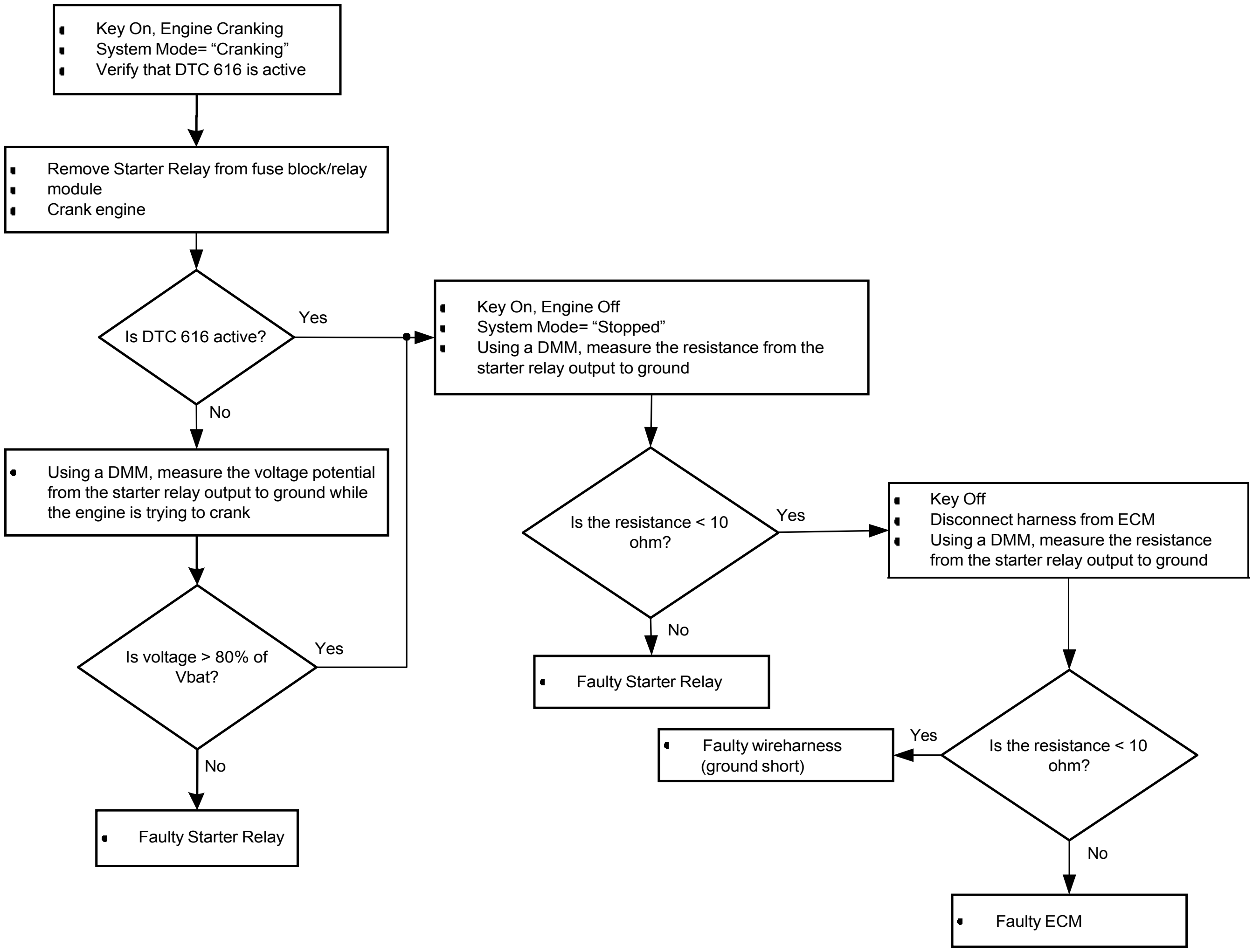


- Starter Relay
- Check Condition- Key On, Engine Cranking
- Fault Condition- Starter relay coil output shorted to ground
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

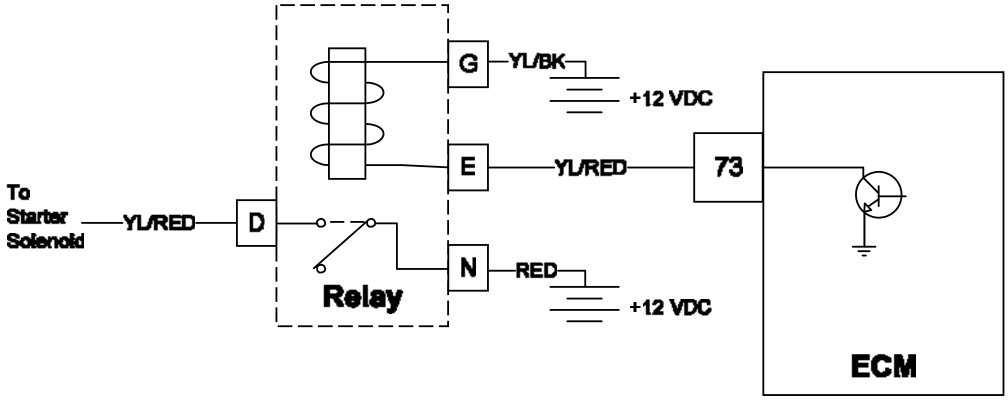
The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

This fault sets if the output for the starter relay is detected as being shorted to ground. If this fault is active and the high-side of the starter relay is supplied, the starter motor will crank until the relay or high-side power is removed.

SPN 1321, FMI 4 - Start Relay Ground Short



SPN 1321, FMI 3 - Start Relay Coil Short-To-Power

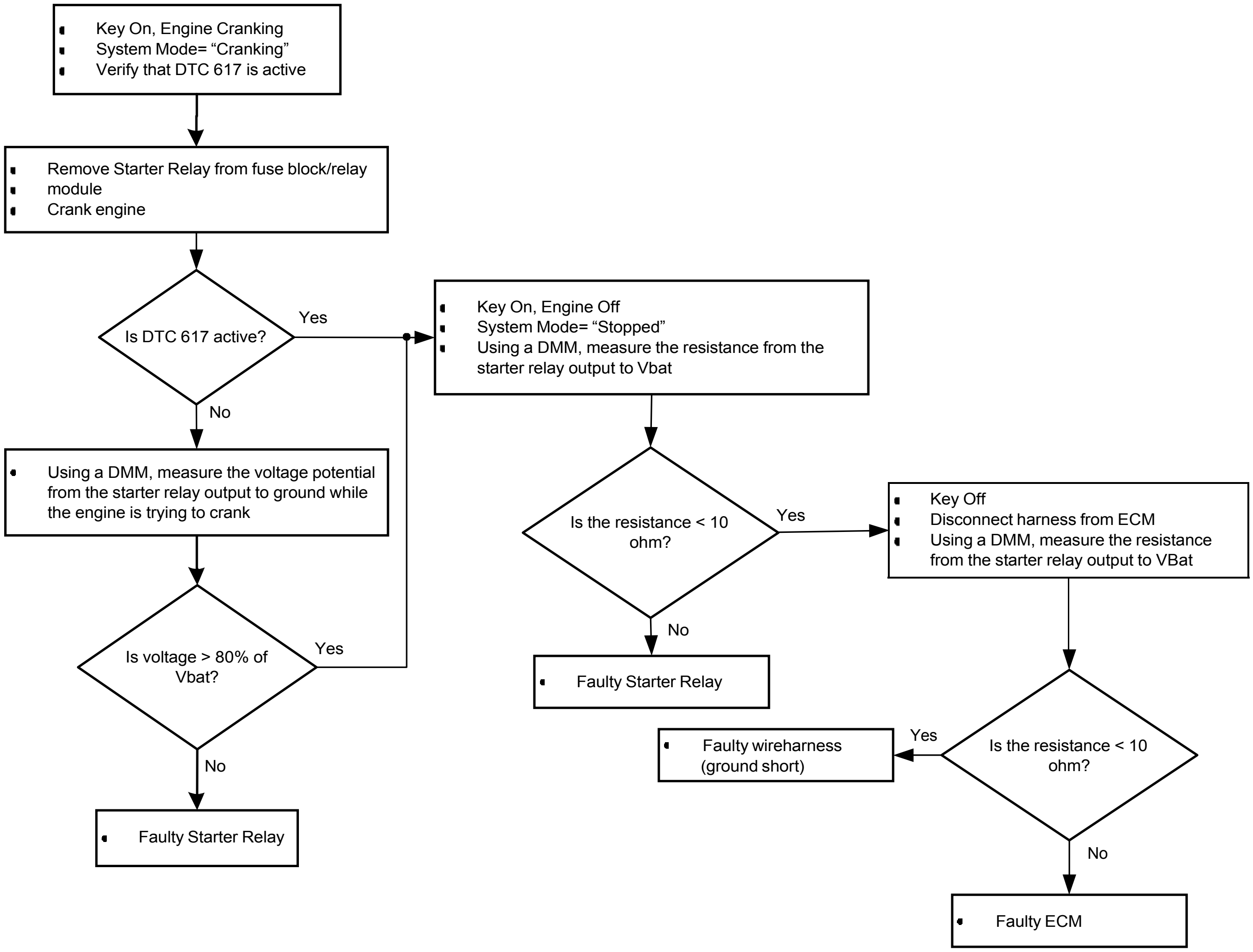


- Starter Relay
- Check Condition- Key On, Engine Cranking
- Fault Condition- Starter relay coil output short to power/voltage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

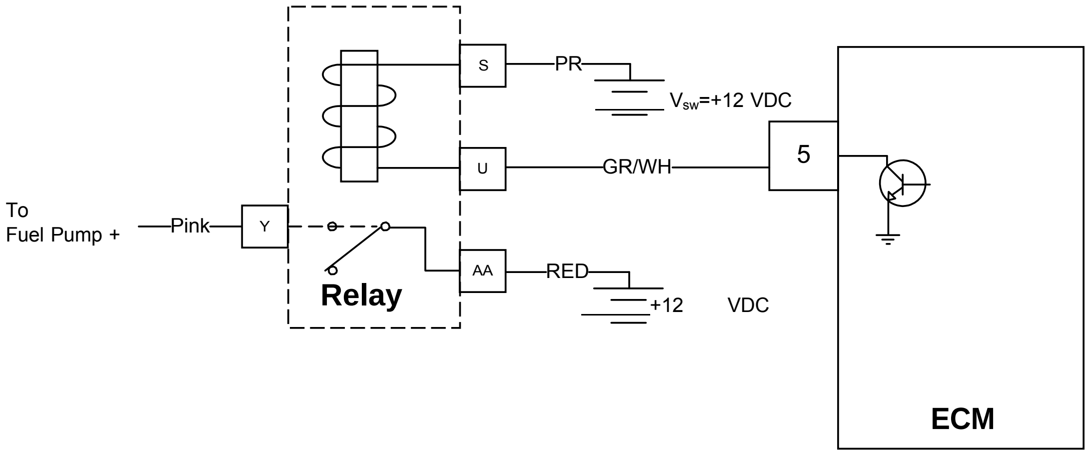
The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

This fault sets if the output for the starter relay is detected as shorted to power. If this fault is active the starter motor will not receive power and will not engage.

SPN 1321, FMI 3 - Start Relay Coil Short-To-Power



SPN 1348, FMI 5 - Fuel Pump Relay Coil Open

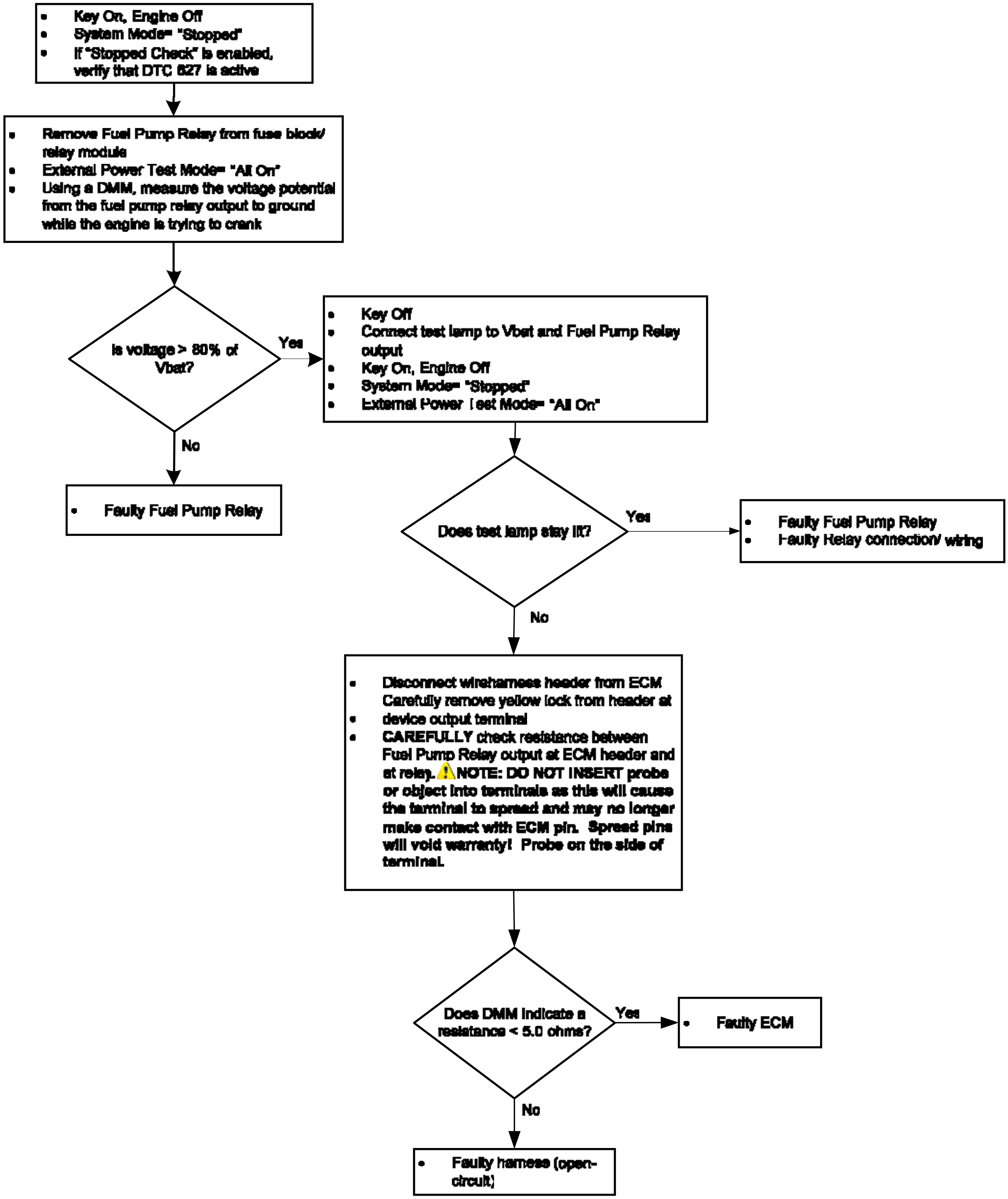


- Fuel Pump Relay
- Check Condition- Key On, Engine Off
- Fault Condition- Fuel Pump relay coil output open circuit
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

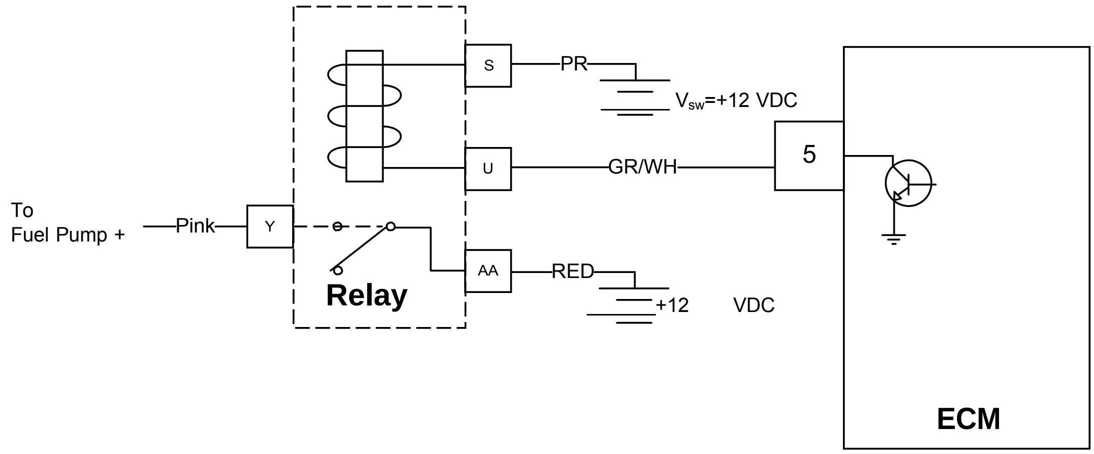
The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

This fault sets if the output for the fuel pump relay is detected as an open circuit. If this fault is active the fuel pump will not receive power and the engine will not run on gasoline.

SPN 1348, FMI 5 - Fuel Pump Relay Coil Open



SPN 1347, FMI 5 - Fuel Pump Relay Ground Short

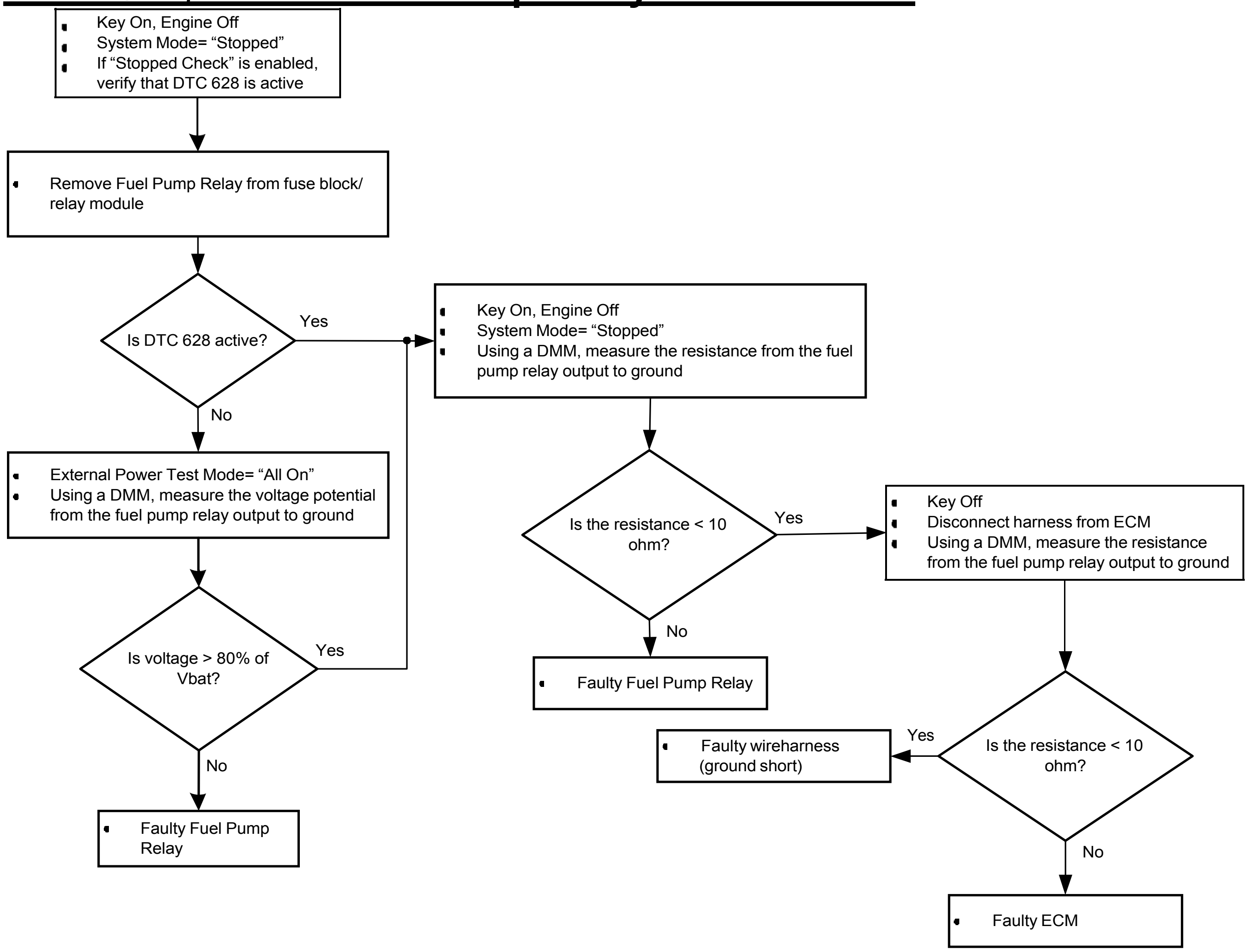


- Fuel Pump Relay
- Check Condition- Key On, Engine Off
- Fault Condition- Fuel Pump relay coil output shorted to ground
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

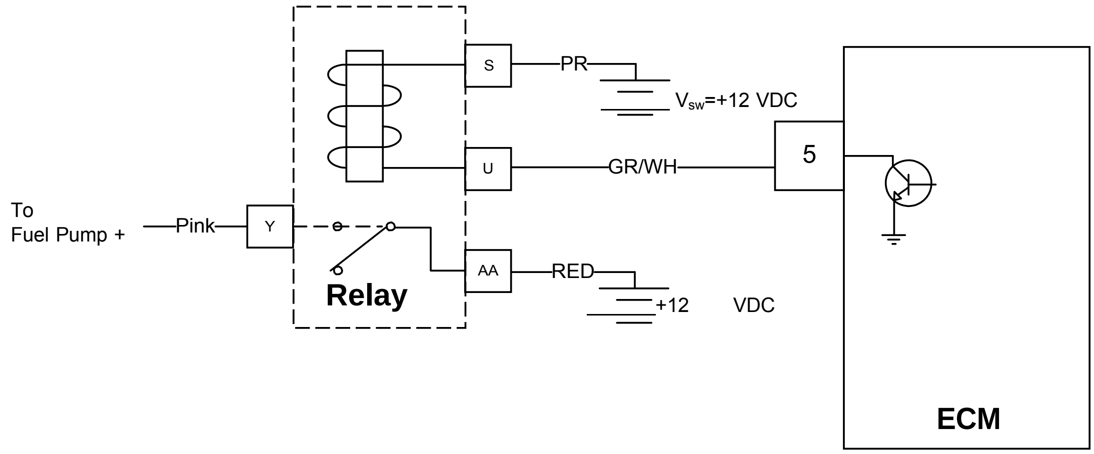
The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

This fault sets if the output for the fuel pump relay is detected as being shorted to ground. If this fault is active and the high-side of the fuel pump relay is supplied, the fuel pump will run until the relay or high-side power is removed.

SPN 1347, FMI 5 - Fuel Pump Relay Ground Short



SPN 1347, FMI 6 - Fuel Pump Relay Coil Short-To-Power

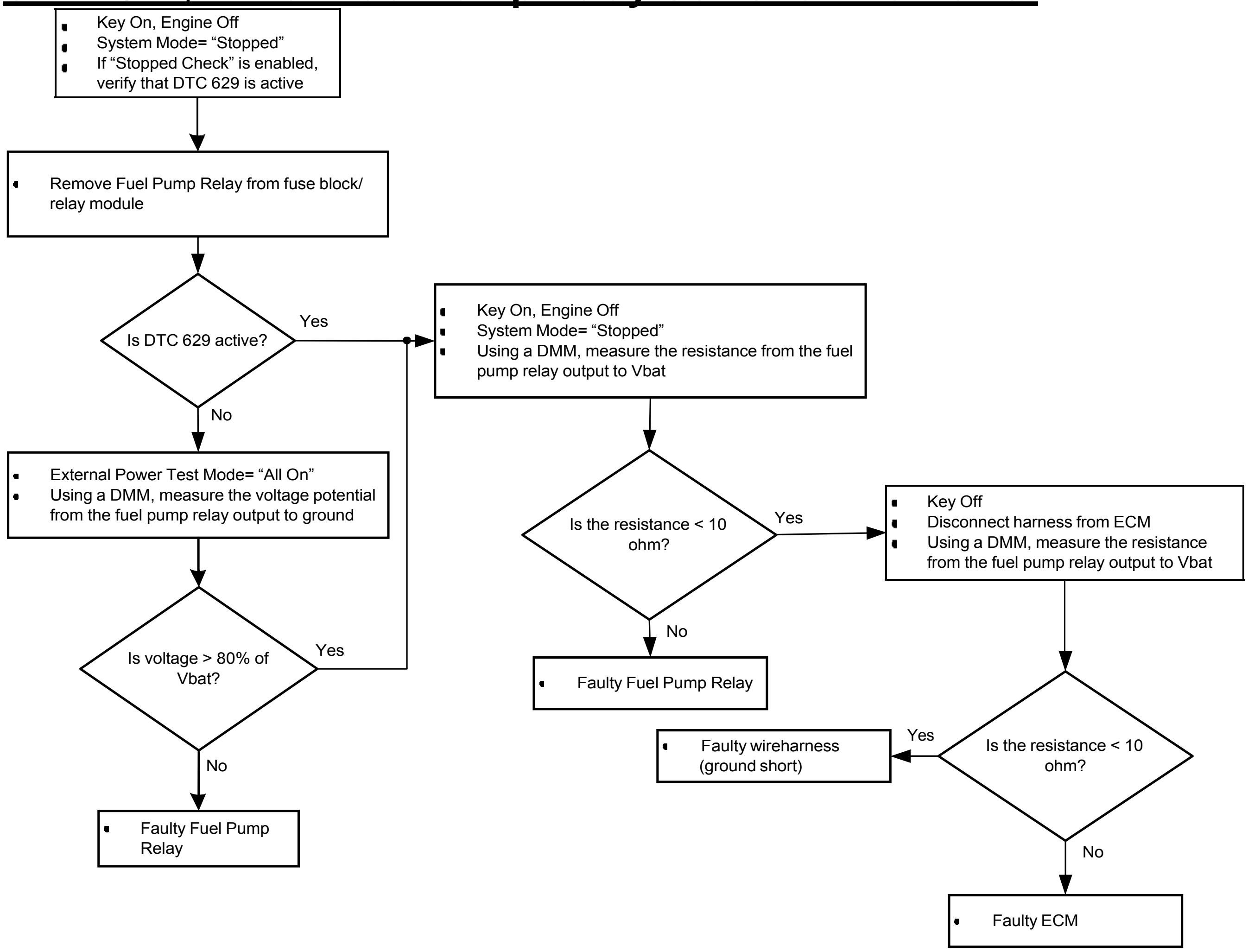


- Fuel Pump Relay
- Check Condition- Key On, Engine Off
- Fault Condition- Fuel Pump relay coil output short to power/voltage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

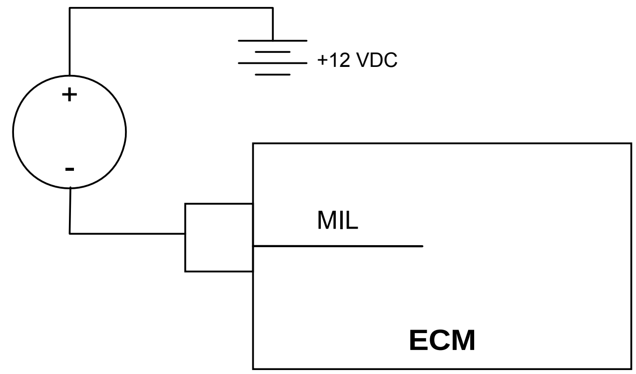
The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

This fault sets if the output for the fuel pump relay is detected as shorted to power. If this fault is active the fuel pump will not receive power and will not run.

SPN 1347, FMI 6 - Fuel Pump Relay Coil Short-To-Power



SPN 1213, FMI 5 - MIL Open

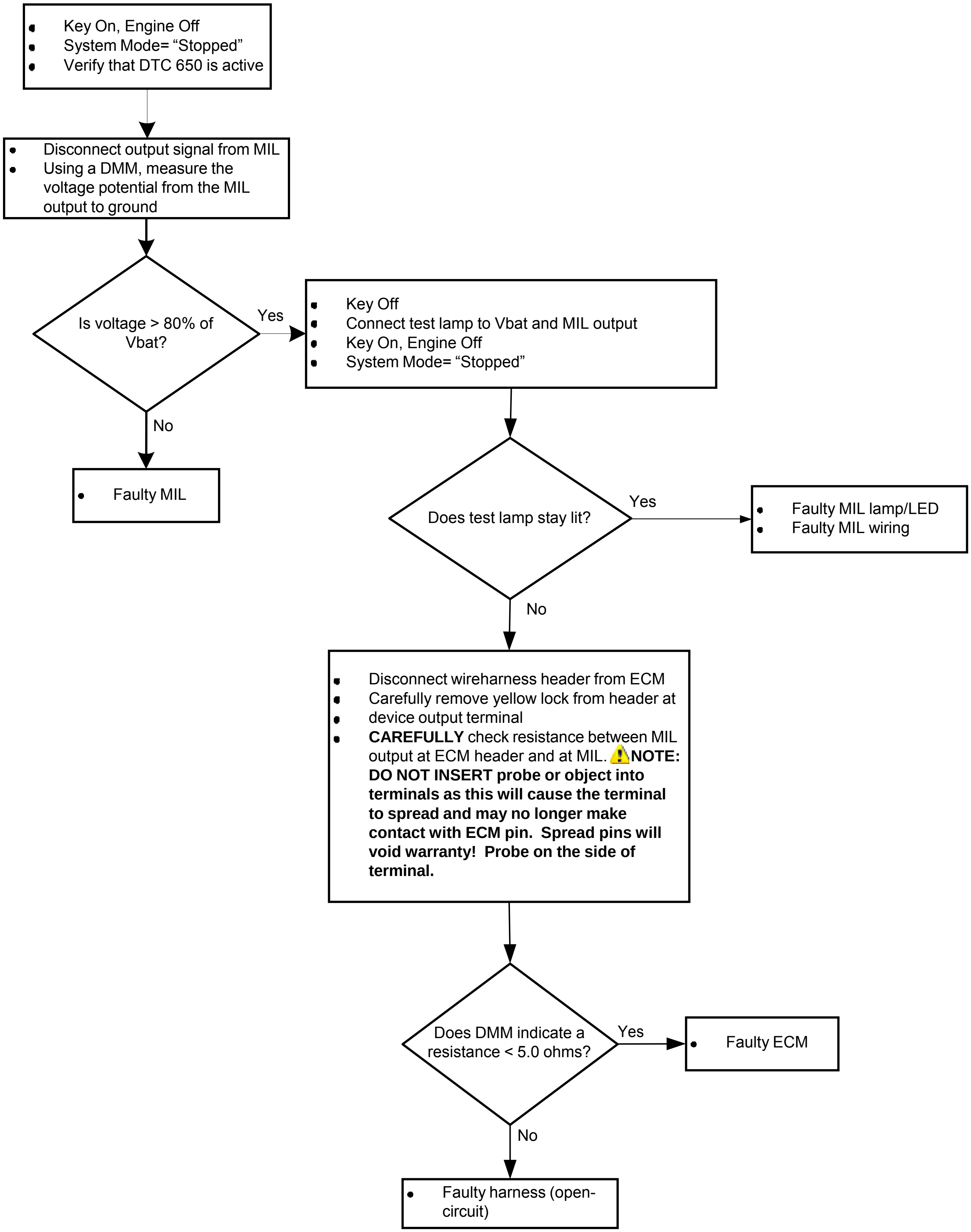


- MIL
- Check Condition- Key On, Engine Off or Running
- Fault Condition- ECM MIL output open circuit
- Corrective Action(s)- Sound audible warning or illuminate secondary warning lamp
-
- Non-emissions related fault

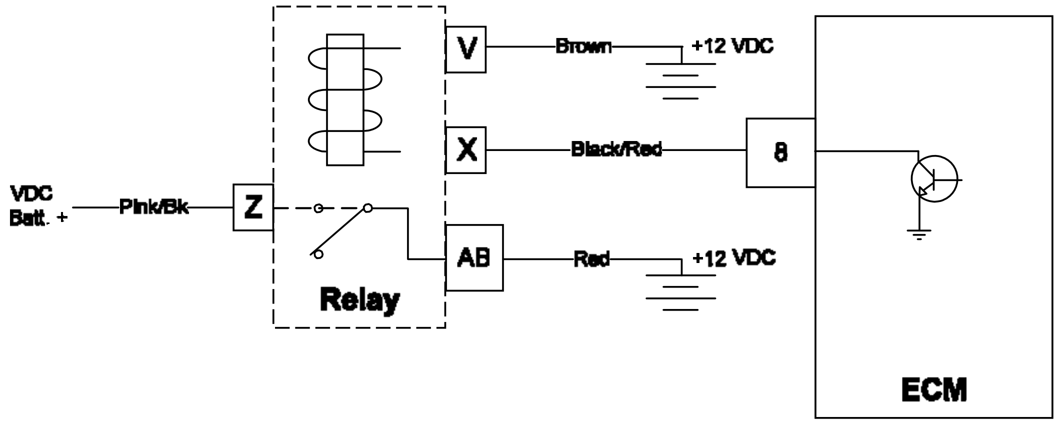
This ECM output is used to provide a low-side switch to a MIL that is used to indicate that an emission related fault has been set.

This fault will set if the ECM detects that there is no load connected to the MIL output.

SPN 1213, FMI 5 - MIL Open



SPN 1485, FMI 5 - Power Relay Coil Open

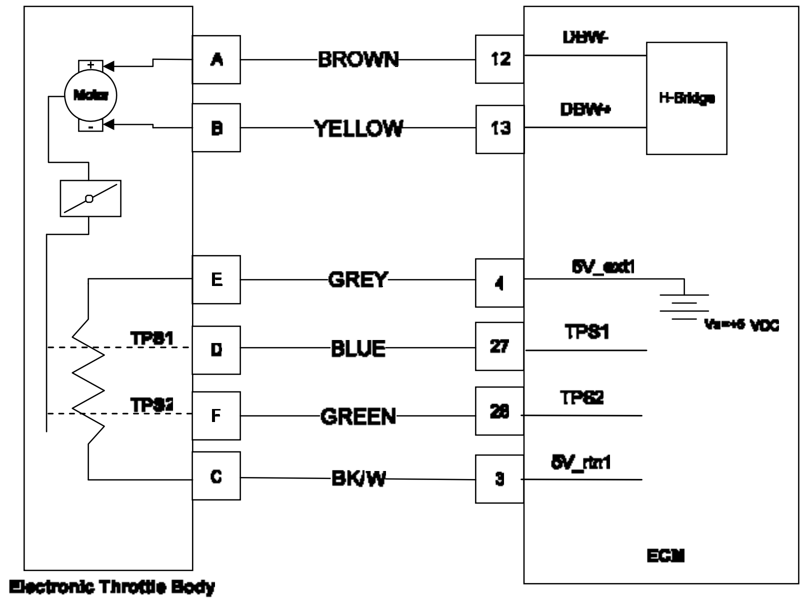


- Power Relay
- Check Condition- Key On, Engine Off
- Fault Condition- Power relay coil output open circuit
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

This fault sets if the output for the power relay is detected as an open circuit. If this fault is active the injector and ignition coil high-side will not receive power and the engine will not run.

SPN 515, FMI 16 - RPM Above Fuel Rev Limit Level



- Fuel Rev Limit- Crankshaft Position Sensor
- Check Condition-Engine Running
- Fault Condition-Engine speed greater than the Fuel Rev Limit speed as defined in the diagnostic calibration
- Corrective Action(s): Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable fuel injectors or gaseous fuel control actuator to limit speed. Recommend disabling closed loop and adaptive learn fueling corrections while fault is active
- Non-emissions related fault

This fault will set anytime the engine RPM exceeds the limit set in the diagnostic calibration for the latch time or more. This speed overrides any higher max governor speeds programmed by the user. This fault is designed to help prevent engine or equipment damage and will disable fuel injectors or gaseous fuel actuator to reduce engine speed. The throttle will also be lowered in order to govern the engine to the speed set in the diagnostic calibration for Max Gov Override.

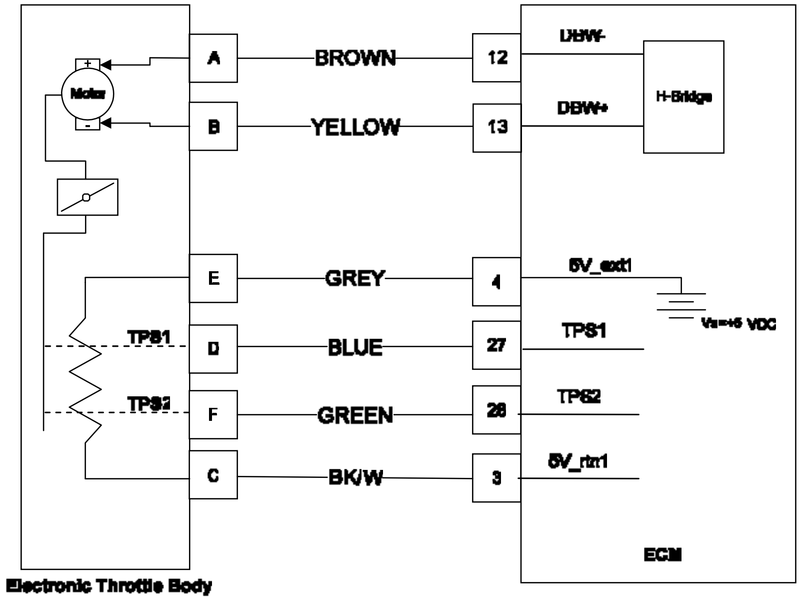
SPN 515, FMI 16 - RPM Above Fuel Rev Limit Level

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Ensure that no programmed governor speeds exceed the limit set in the diagnostic calibration for Max Gov Override Speed
- ☐ Check mechanical operation of the throttle
- ☐ Check the engine intake for large air leaks downstream of the throttle body

SPN 515, FMI 0 - RPM Above Spark Rev Limit Level



- Spark Rev Limit- Crankshaft Position Sensor
- Check Condition-Engine Running
- Fault Condition-Engine speed greater than the Spark Rev Limit speed as defined in the diagnostic calibration
- Corrective Action(s): Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable ignition coils. Recommend disabling closed loop and adaptive learn fueling corrections while fault is active
- Non-emissions related fault

This fault will set anytime the engine RPM exceeds the limit set in the diagnostic calibration for the latch time or more. This speed overrides any higher max governor speeds programmed by the user. This fault is designed to help prevent engine or equipment damage and will disable the ignition coils to reduce engine speed. In addition, the throttle will be lowered in order to govern the engine to the speed set in the diagnostic calibration for Max Gov Override and the fuel injectors or gaseous fuel control actuator will be disabled to reduce the engine speed below the speed set in the diagnostic calibration for Fuel Rev Limit.

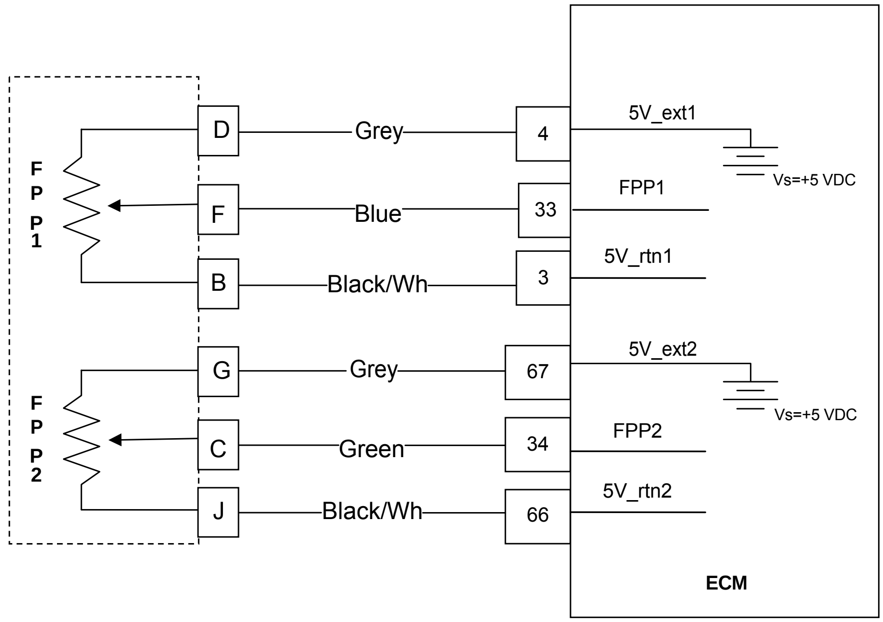
SPN 515, FMI 0 - RPM Above Spark Rev Limit Level

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Ensure that no programmed governor speeds exceed the limit set in the diagnostic calibration for Max Gov Override Speed
- ☐ Check mechanical operation of the throttle
- ☐ Check the engine intake for large air leaks downstream of the throttle body

SPN 91, FIM 31 - FPP1/2 Simultaneous Voltages Out-of-Range



- Electronic foot pedal/throttle control sensor
- Check Condition- Key On, Engine Off
- Fault Condition- FPP1 and FPP2 VDC out-of-range
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp, and forced idle
- Non-emissions related fault

The FPP sensor is an electronic device that is coupled to a mechanically driven input as commanded by the vehicle/engine operator. A FPP sensor may be, but is not limited to a foot pedal assembly, a cable-lever-sensor assembly, or a rotary potentiometer. General sensor configurations consist of single potentiometer with IVS, two potentiometers, or two potentiometers with IVS. The FPP sensor outputs are proportional to the commanded input. The ECM uses the FPP sensor inputs to control the throttle and adjust the engine's load in order to achieve the requested power. Since the FPP sensor inputs directly affect the engine's power output, redundant sensors are generally used to ensure safe, reliable operation.

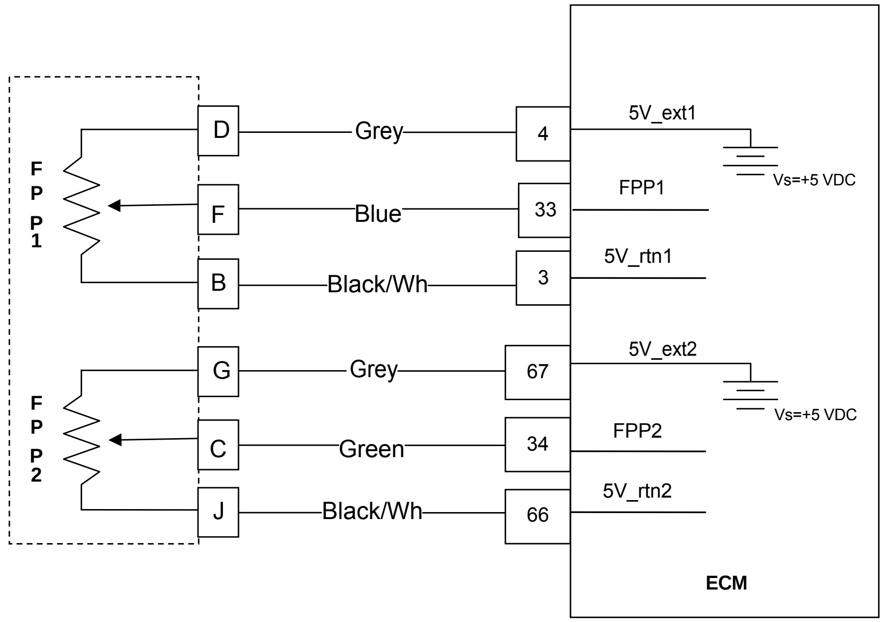
This fault is only applicable with sensors that incorporate dual potentiometer and indicates that FPP1 and FPP2 voltages are out-of-range resulting in a loss of redundancy. As a result, the engine is commanded to a forced idle.

SPN 91, FIM 31 - FPP1/2 Simultaneous Voltages Out-of-Range

Diagnostic Aids

- ☐ Troubleshoot according to *FPP1 voltage out-of-range* following DTC 2122 and 2123 procedures.
- ☐ Troubleshoot according to *FPP2 voltage out-of-range* following DTC 2127 and 2128 procedures.

SPN 520199, FMI 11 - FPP1 & FPP2 Do Not Match Each Other or IVS



- Electronic foot pedal/throttle control sensor
- Check Condition- Key On, Engine Off
- Fault Condition- FPP1 and FPP2 %'s do not correlate and neither correlate with IVS state
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp, and forced idle
- Non-emissions related fault

The FPP sensor is an electronic device that is coupled to a mechanically driven input as commanded by the vehicle/engine operator. A FPP sensor may be, but is not limited to a foot pedal assembly, a cable-lever-sensor assembly, or a rotary potentiometer. General sensor configurations consist of single potentiometer with IVS, two potentiometers, or two potentiometers with IVS. The FPP sensor outputs are proportional to the commanded input. The ECM uses the FPP sensor inputs to control the throttle and adjust the engine's load in order to achieve the requested power. Since the FPP sensor inputs directly affect the engine's power output, redundant sensors are generally used to ensure safe, reliable operation.

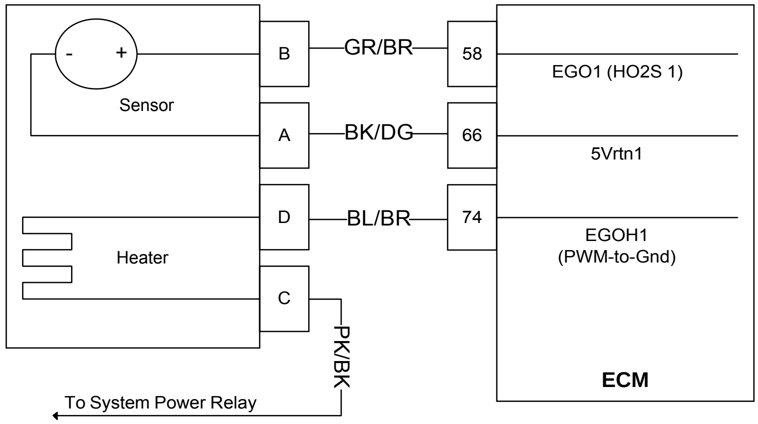
This fault is only applicable for dual potentiometer/single IVS sensors and indicates that FPP1 and FPP2 percentages do not correlate with each other and neither of the two potentiometers correlate with the IVS.

SPN 520199, FMI 11 - FPP1 & FPP2 Do Not Match Each Other or IVS

Diagnostic Aids

- ☐ Troubleshoot according to *FPP1 & FPP2 Do Not Match* following DTC 2121 and 2126 procedures.
- ☐ Troubleshoot according to *FPP1 & FPP2 Do Not Match IVS* following DTC 2115, 2116, 2139, and 2140 procedures.

SPN 4236, FMI 0 -Closed Loop Bank 1 High (Gasoline)



- Heated or Universal Exhaust Gas Oxygen Sensor (Bank 1-Sensor 1/Bank 1-Before Catalyst)
- Check Condition- Engine Running
- Fault Condition- Bank 1 closed loop fuel multiplier higher than defined in diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO/HO2S sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to lambda/equivalence ratio/air-fuel ratio. In either case, if there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either *“CL Active”* or *“CL + Adapt”* control modes. The purpose of the closed loop fuel multiplier is to quickly adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation prior to adaptive learn fueling correction “learning” the fueling deviation.

This fault sets if the closed loop multiplier exceeds the high limit of normal operation indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near the HEGO sensor, 2) reduced fuel supply pressure to the fuel injection system, 3) a non-responsive HEGO/UEGO sensor, and/or 3) an injector that is stuck closed. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

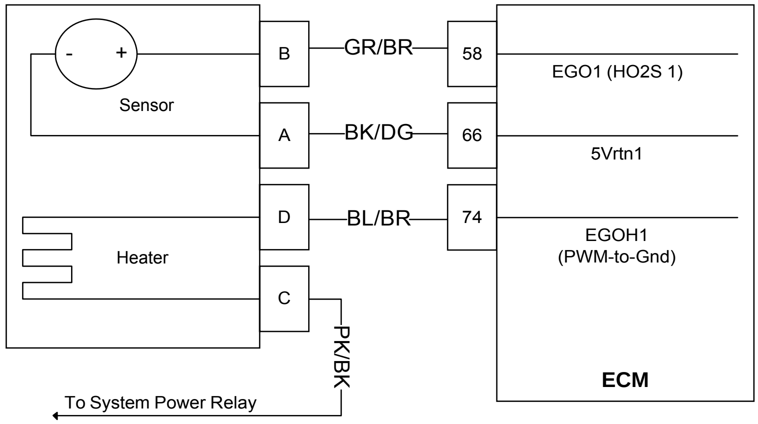
SPN 4236, FMI 0 -Closed Loop Bank 1 High (Gasoline)

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ☐ Vacuum Leaks - Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at light load.
- ☐ Injectors - System will be lean if an injector driver or driver circuit fails. The system will also be lean if an injector fails in a closed manner or is dirty.
- ☐ Fuel Pressure - System will be lean if fuel pressure is too low. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- ☐ Air in Fuel - If the fuel return hose/line is too close to the fuel supply pickup in the fuel tank, air may become entrapped in the pump or supply line causing a lean condition and driveability problems.
- ☐ Exhaust Leaks - If there is an exhaust leak, outside air can be pulled into the exhaust and past the O2 sensor causing a false lean condition.
- ☐ Fuel Quality - A drastic variation in fuel quality may cause the system to be lean including oxygenated fuels.
- ☐ System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- ☐ If all tests are OK, replace the HO2S sensor with a known good part and retest.

SPN 4236, FMI 1 - Closed Loop Bank 1 Low (Gasoline)



- Heated or Universal Exhaust Gas Oxygen Sensor (Bank 1-Sensor 1/Bank 1-Before Catalyst)
- Check Condition- Engine Running
- Fault Condition- Bank 1 closed loop fuel multiplier lower than defined in diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO/HO2S sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to lambda/equivalence ratio/air-fuel ratio. In either case, if there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either *“CL Active”* or *“CL + Adapt”* control modes. The purpose of the closed loop fuel multiplier is to quickly adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation prior to adaptive learn fueling correction “learning” the fueling deviation.

This fault sets if the closed loop multiplier exceeds the low limit of normal operation indicating that the engine is operating rich (excess fuel) and requires less fuel than allowed by corrections. Often high negative fueling corrections are a function of one or more of the following conditions: 1) high fuel supply pressure to the fuel injection system, 2) a non-responsive HEGO/UEGO sensor, and/or 3) an injector that is stuck open. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

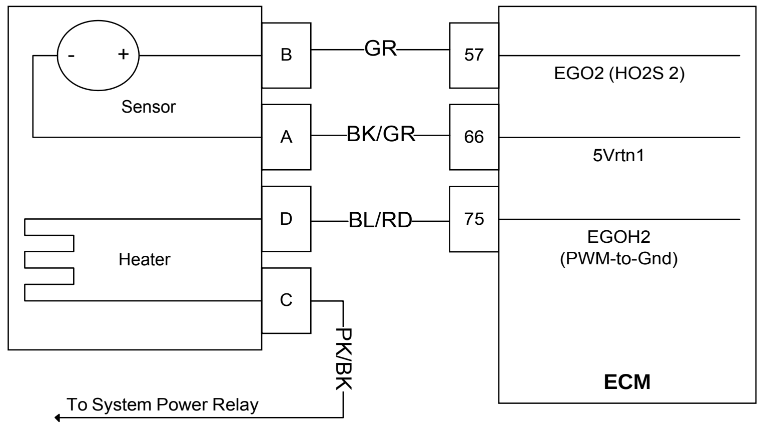
SPN 4236, FMI 1 - Closed Loop Bank 1 Low (Gasoline)

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ☐ Injectors - System will be rich if an injector driver or driver circuit fails shorted-to-ground. The system will also be rich if an injector fails in an open.
- ☐ Fuel Pressure - System will be rich if fuel pressure is too high. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- ☐ System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- ☐ If all tests are OK, replace the HO2S sensor with a known good part and retest.

SPN 4236, FMI 0 - Closed Loop Bank 2 High (Gasoline)



- Heated or Universal Exhaust Gas Oxygen Sensor (Bank 2-Sensor 1/Bank 1-Before Catalyst)
- Check Condition- Engine Running
- Fault Condition- Bank 2 closed loop fuel multiplier higher than defined in diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO/HO2S sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to lambda/equivalence ratio/air-fuel ratio. In either case, if there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either *“CL Active”* or *“CL + Adapt”* control modes. The purpose of the closed loop fuel multiplier is quickly adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation prior to adaptive learn fueling correction “learning” the fueling deviation.

This fault sets if the closed loop multiplier exceeds the high limit of normal operation indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near the HEGO sensor, 2) reduced fuel supply pressure to the fuel injection system, 3) a non-responsive HEGO/UEGO sensor, and/or 3) an injector that is stuck closed. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

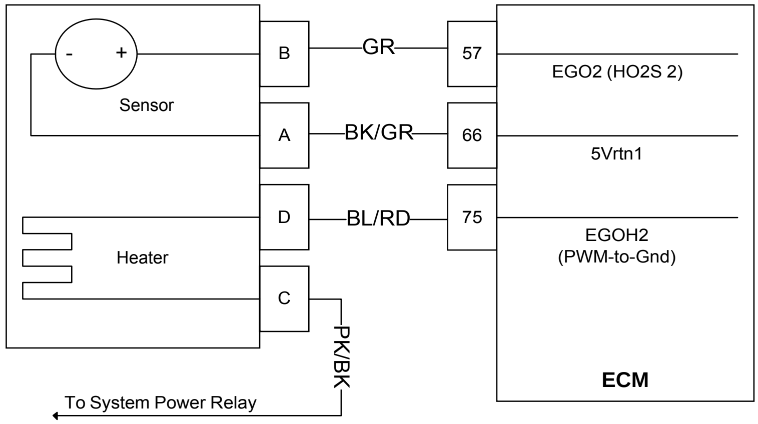
SPN 4236, FMI 0 -Closed Loop Bank 2 High (Gasoline)

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ☐ Vacuum Leaks - Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at light load.
- ☐ Injectors - System will be lean if an injector driver or driver circuit fails. The system will also be lean if an injector fails in a closed manner or is dirty.
- ☐ Fuel Pressure - System will be lean if fuel pressure is too low. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- ☐ Air in Fuel - If the fuel return hose/line is too close to the fuel supply pickup in the fuel tank, air may become entrapped in the pump or supply line causing a lean condition and driveability problems.
- ☐ Exhaust Leaks - If there is an exhaust leak, outside air can be pulled into the exhaust and past the O2 sensor causing a false lean condition.
- ☐ Fuel Quality - A drastic variation in fuel quality may cause the system to be lean including oxygenated fuels.
- ☐ System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- ☐ If all tests are OK, replace the HO2S sensor with a known good part and retest.

SPN 4236, FMI 1 - Closed Loop Bank 2 Low (Gasoline)



- Heated or Universal Exhaust Gas Oxygen Sensor (Bank 2-Sensor 1/Bank 1-Before Catalyst)
- Check Condition- Engine Running
- Fault Condition- Bank 2 closed loop fuel multiplier lower than defined in diagnostic calibration
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO/HO2S sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to lambda/equivalence ratio/air-fuel ratio. In either case, if there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either *“CL Active”* or *“CL + Adapt”* control modes. The purpose of the closed loop fuel multiplier is quickly adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation prior to adaptive learn fueling correction “learning” the fueling deviation.

This fault sets if the closed loop multiplier exceeds the low limit of normal operation indicating that the engine is operating rich (excess fuel) and requires less fuel than allowed by corrections. Often high negative fueling corrections are a function of one or more of the following conditions: 1) high fuel supply pressure to the fuel injection system, 2) a non-responsive HEGO/UEGO sensor, and/or 3) an injector that is stuck open. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

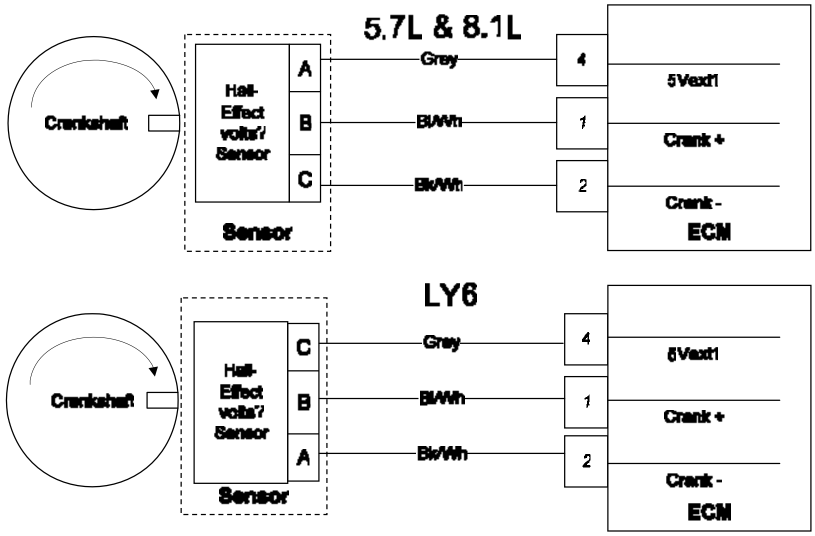
SPN 4236, FMI 1 - Closed Loop Bank 2 Low (Gasoline)

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ☐ Injectors - System will be rich if an injector driver or driver circuit fails shorted-to-ground. The system will also be rich if an injector fails in an open.
- ☐ Fuel Pressure - System will be rich if fuel pressure is too high. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- ☐ System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- ☐ If all tests are OK, replace the HO2S sensor with a known good part and retest.

SPN 1323, FMI 11 - Misfire Detected Cylinder #1



- Cylinder #1 Misfire Detected-Driveability/Performance
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

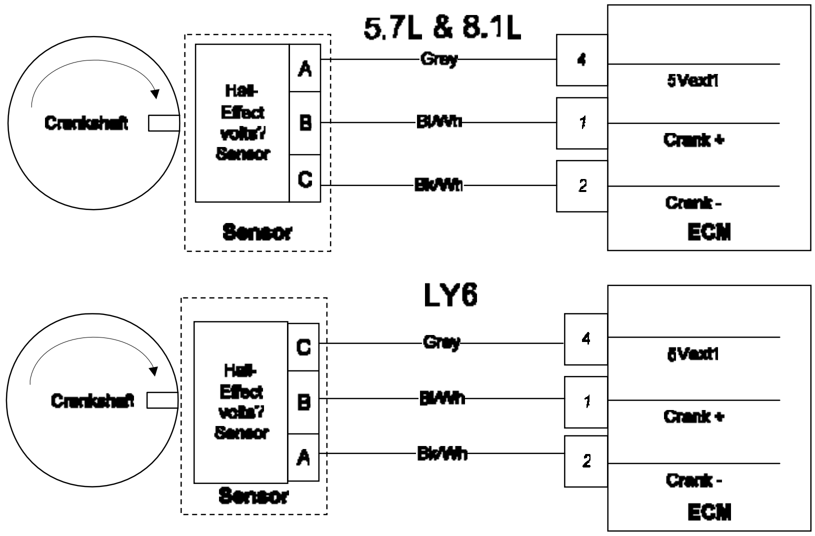
SPN 1323, FMI 11 - Misfire Detected Cylinder #1

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
    - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
    - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
    - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1324, FMI 11 - Misfire Detected Cylinder #2



- Cylinder #2 Misfire Detected-Driveability/Performance
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #2 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

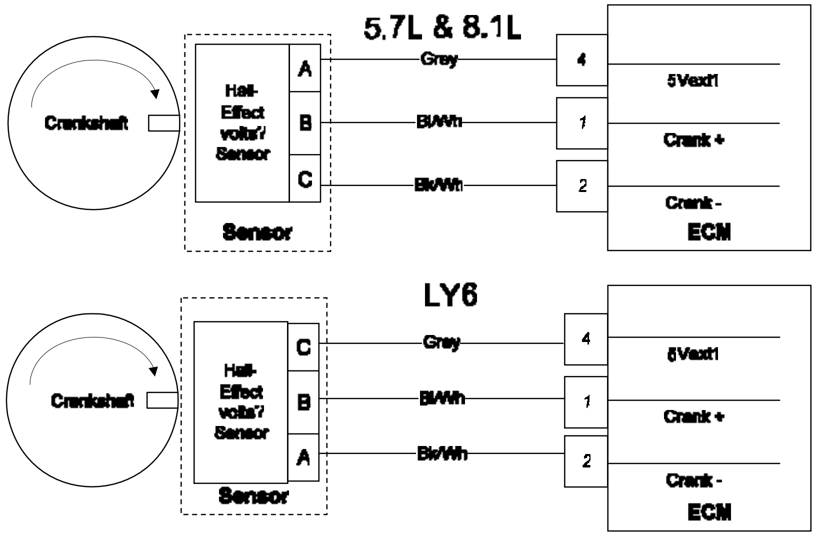
SPN 1324, FMI 11 - Misfire Detected Cylinder #2

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
  - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
  - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
  - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1325, FMI 11 - Misfire Detected Cylinder #3



- Cylinder #3 Misfire Detected-Driveability/Performance
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #3 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

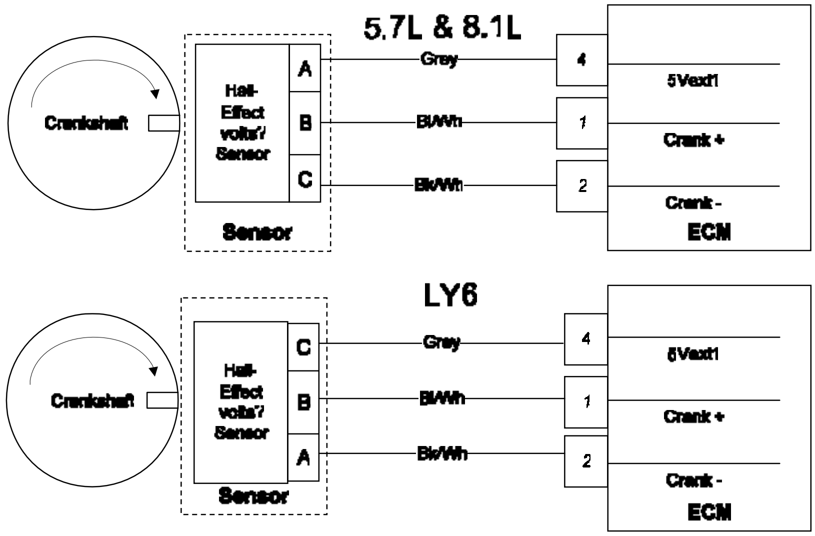
SPN 1325, FMI 11 - Misfire Detected Cylinder #3

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
  - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
  - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
  - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1326, FMI 11 - Misfire Detected Cylinder #4



- Cylinder #4 Misfire Detected-Driveability/Performance
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #4 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

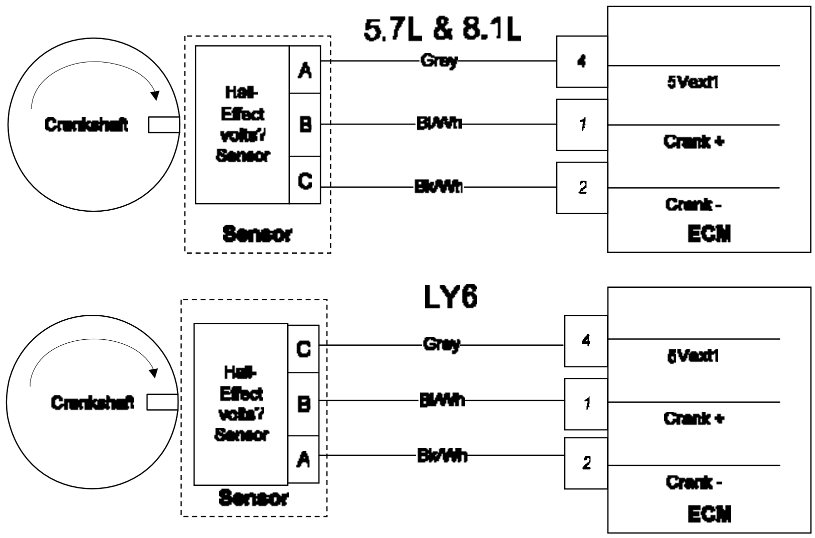
SPN 1326, FMI 11 - Misfire Detected Cylinder #4

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
    - Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
    - Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
    - Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1327, FMI 11 - Misfire Detected Cylinder #5



- Cylinder #5 Misfire Detected-Driveability/Performance
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #5 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

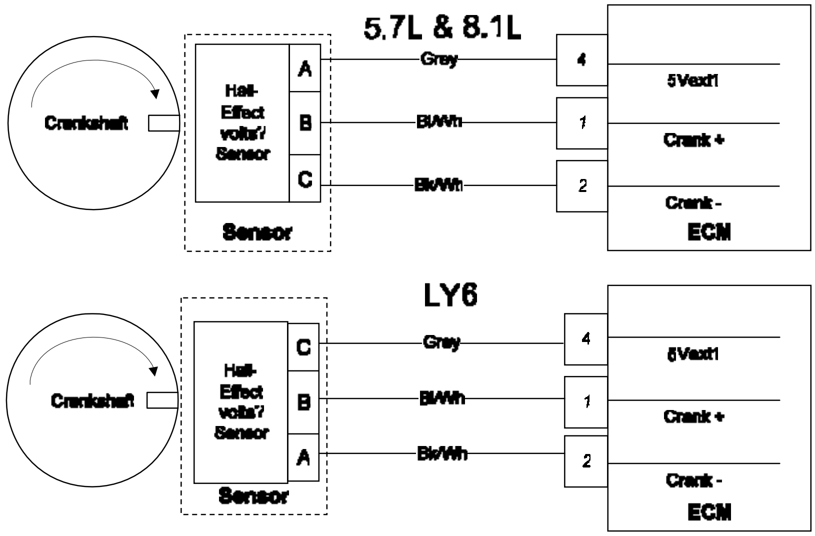
SPN 1327, FMI 11 - Misfire Detected Cylinder #5

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
  - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
  - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
  - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1328, FMI 11 - Misfire Detected Cylinder #6



- Cylinder #6 Misfire Detected-Driveability/Performance
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #6 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

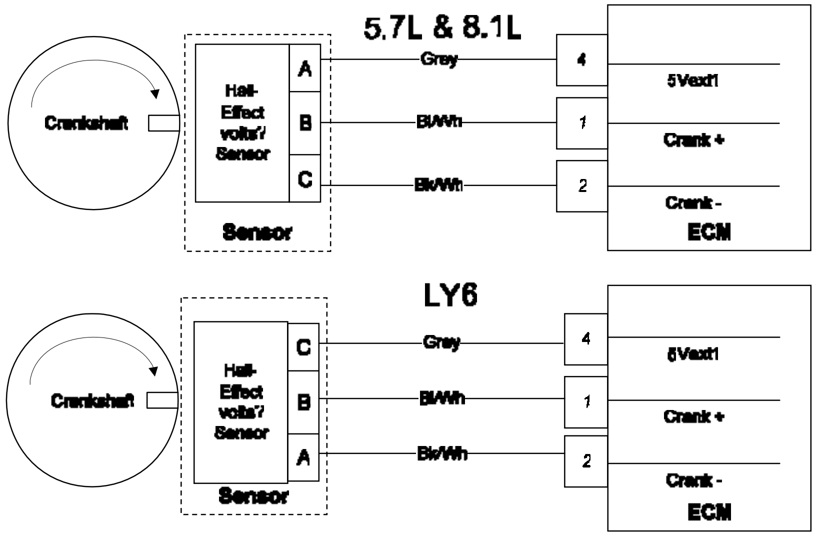
SPN 1328, FMI 11 - Misfire Detected Cylinder #6

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
    - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
    - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
    - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1329, FMI 11 - Misfire Detected Cylinder #7



- Cylinder #7 Misfire Detected-Driveability/Performance
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #7 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

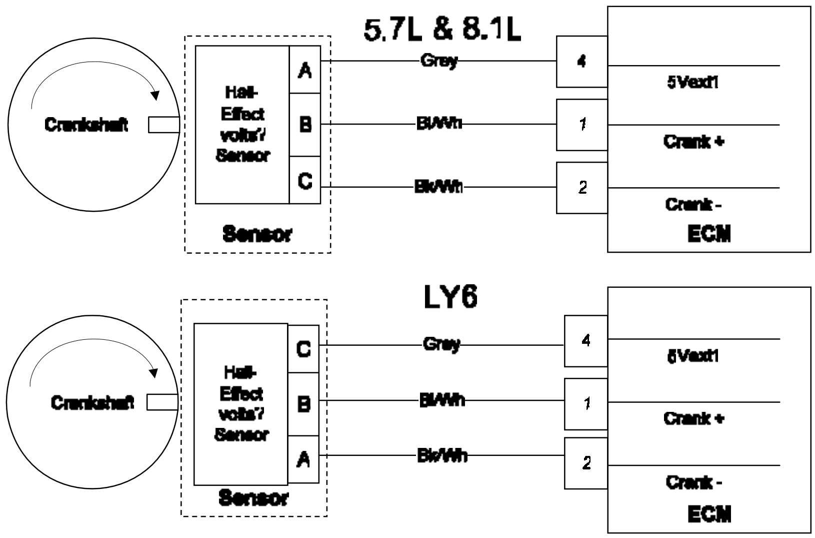
SPN 1329, FMI 11 - Misfire Detected Cylinder #7

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
    - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
    - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
    - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 1330, FMI 11 - Misfire Detected Cylinder #8



- Cylinder #8 Misfire Detected-Driveability/Performance
- Check Condition- Key On, Engine Running
- Fault Condition- Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that banks aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #8 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

SPN 1330, FMI 11 - Misfire Detected Cylinder #8

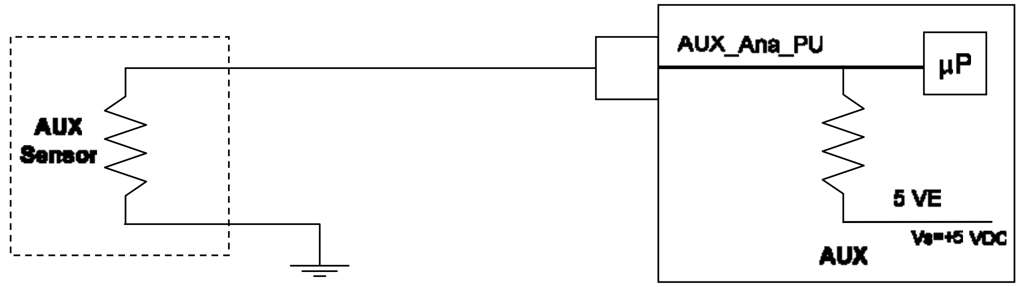
Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

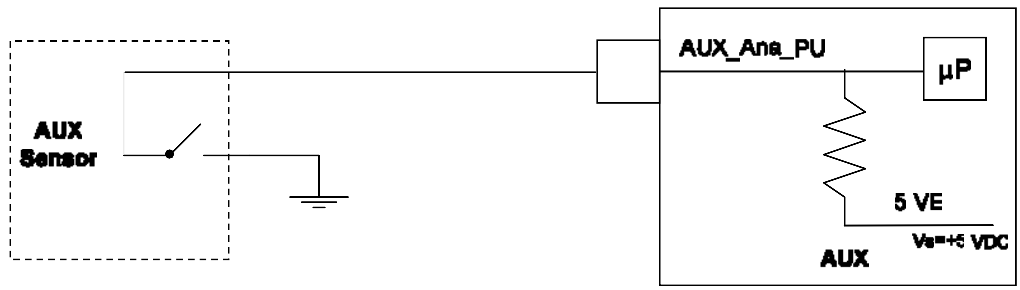
- ☐ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ☐ Fuel Level- Misfire can occur due to intermittent or prolonged loss of fuel pressure due to a lack of fuel supply. If misfire counts or faults set and a fuel pressure fault is not recorded, question the operator(s) about the possibility of running out of fuel before replacing components.
- ☐ Ignition System- Wear or damage to ignition system components (spark plugs, spark plug wires, distributor or ignition coils) can result in weak or misplaced spark causing partial combustion and thus partial misfire.
  - o Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
  - o Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
  - o Distributor modules- Check distributor for oxidized or corroded spark distribution conductors including the distributor rotor and distributor cap poles.
- ☐ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ☐ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ☐ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

SPN 701, FMI 3 - AUX Analog Pull-Up 1 High Voltage Fault

Configuration #1



Configuration #2

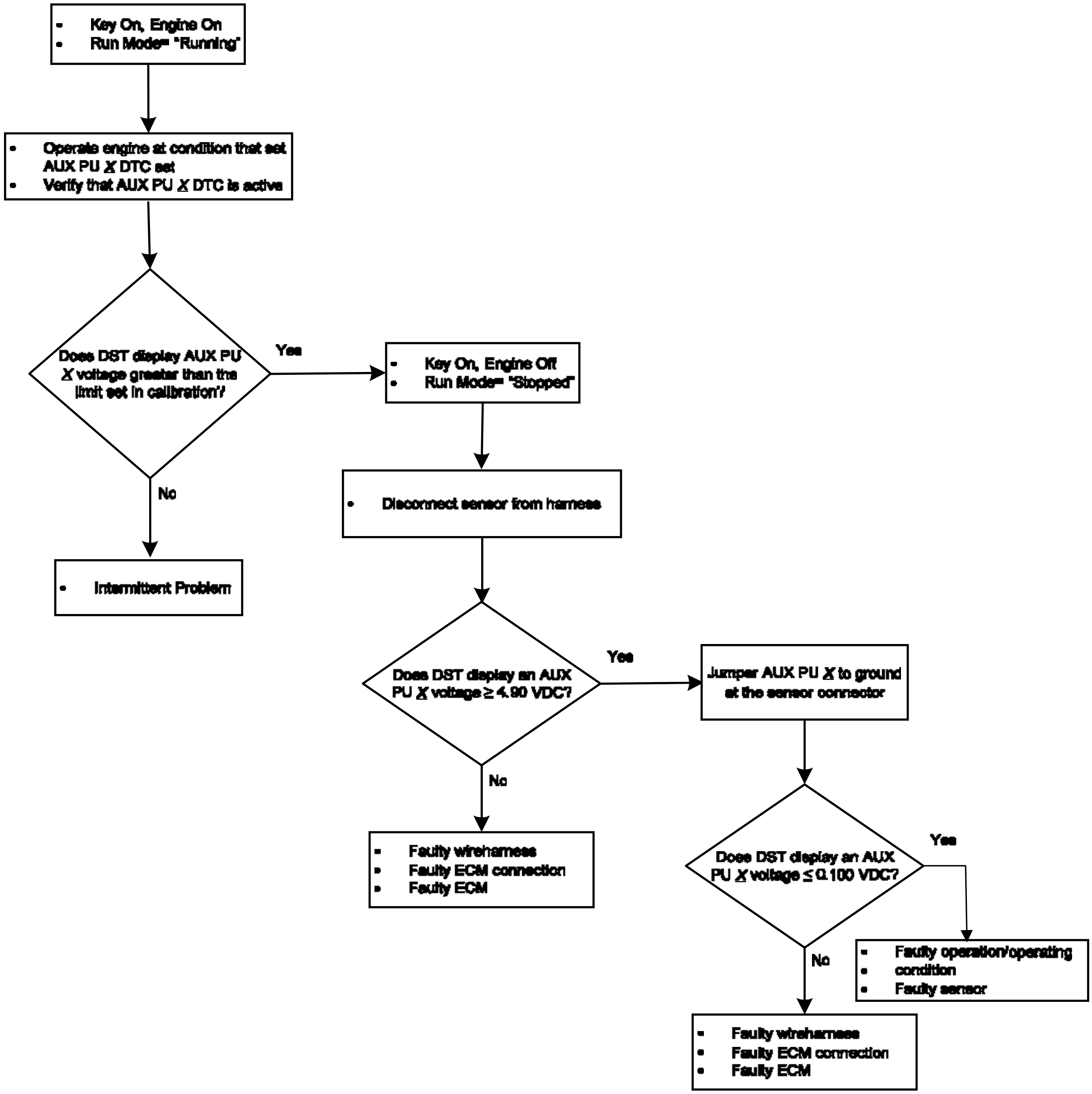


- Configuration #1- Auxiliary Sensor (proportional voltage type), Configuration #2- Auxiliary Sensor (switch-type)
- Check Condition- Key On, Engine On
- Fault Condition- AUX_ana_PU1 voltage higher than expected
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp, power derate, force idle, shutdown, or any combination thereof as defined in calibration.
- Non-emissions related fault

The auxiliary analog input circuit is customer specific and can be used to perform an action based on a sensor that switches to ground or a sensor that outputs a proportional voltage. Typical uses of the auxiliary circuit includes switches that activate particular software strategies, switches that act as vehicle safeties to trigger derate or shutdown conditions, or auxiliary senders used to drive gauges. The circuit internal to the ECM is connected in parallel with the regulated 5 VDC power supply so that when no load is connected to the circuit the feedback voltage is equal to 5 VDC.

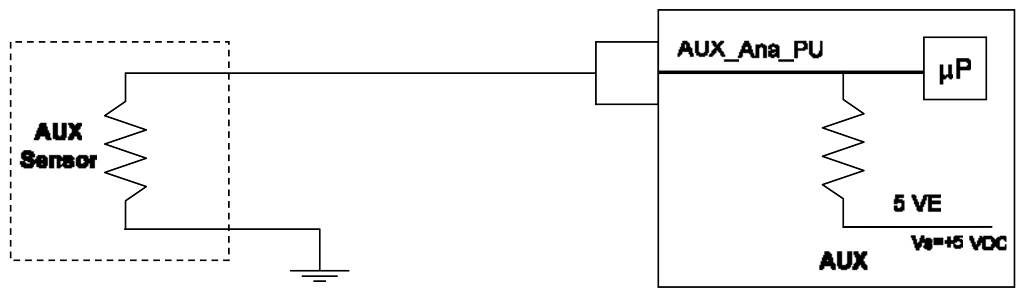
This fault is active when the voltage feedback from the sensor is above the limit defined in calibration.

SPN 701, FMI 3 - AUX Analog Pull-Up 1 High Voltage Fault

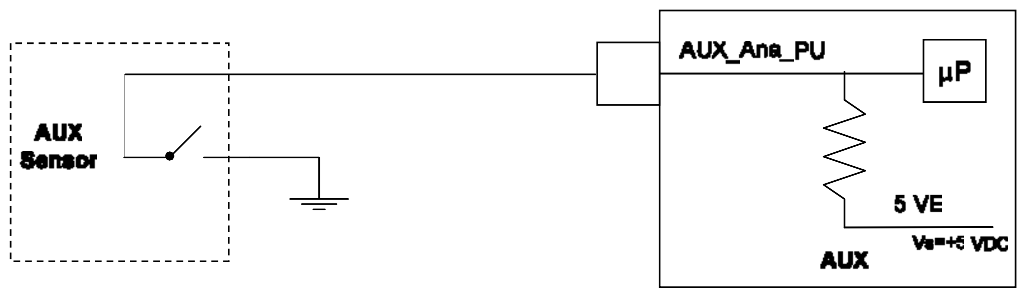


SPN 701, FMI 4 - AUX Analog Pull-Up 1 Low Voltage Fault

Configuration #1



Configuration #2

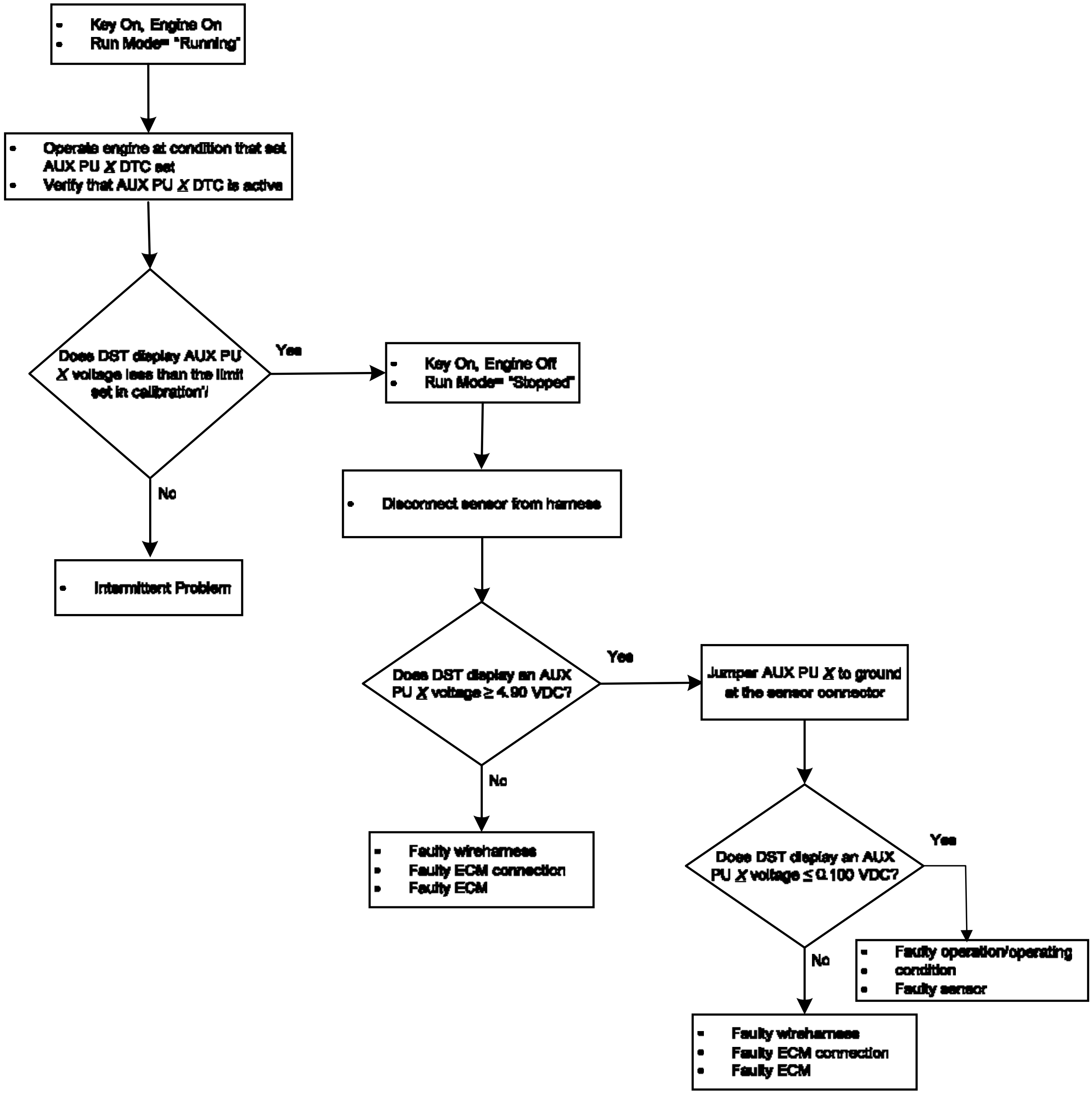


- Configuration #1- Auxiliary Sensor (proportional voltage type), Configuration #2- Auxiliary Sensor (switch-type)
- Check Condition- Key On, Engine On
- Fault Condition- AUX_ana_PU1 voltage lower than expected
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp, power derate, force idle, shutdown, or any combination thereof as defined in calibration.
- Non-emissions related fault

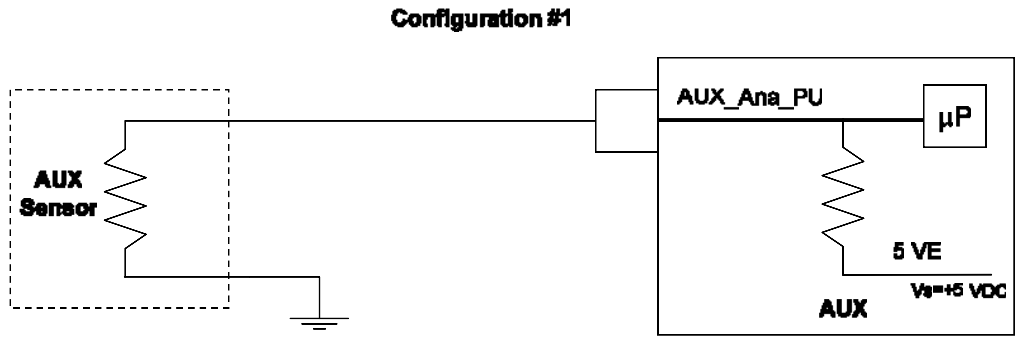
The auxiliary analog input circuit is customer specific and can be used to perform an action based on a sensor that switches to ground or a sensor that outputs a proportional voltage. Typical uses of the auxiliary circuit includes switches that activate particular software strategies, switches that act as vehicle safeties to trigger derate or shutdown conditions, or auxiliary senders used to drive gauges. The circuit internal to the ECM is connected in parallel with the regulated 5 VDC power supply so that when no load is connected to the circuit the feedback voltage is equal to 5 VDC.

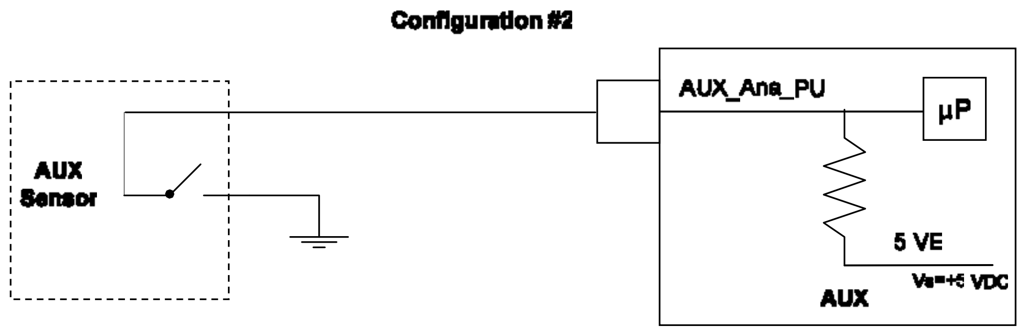
This fault is active when the voltage feedback from the sensor is below the limit defined in calibration.

SPN 701, FMI 4 - AUX Analog Pull-Up 1 Low Voltage Fault



SPN 702, FMI 3 - AUX Analog Pull-Up 2 High Voltage Fault



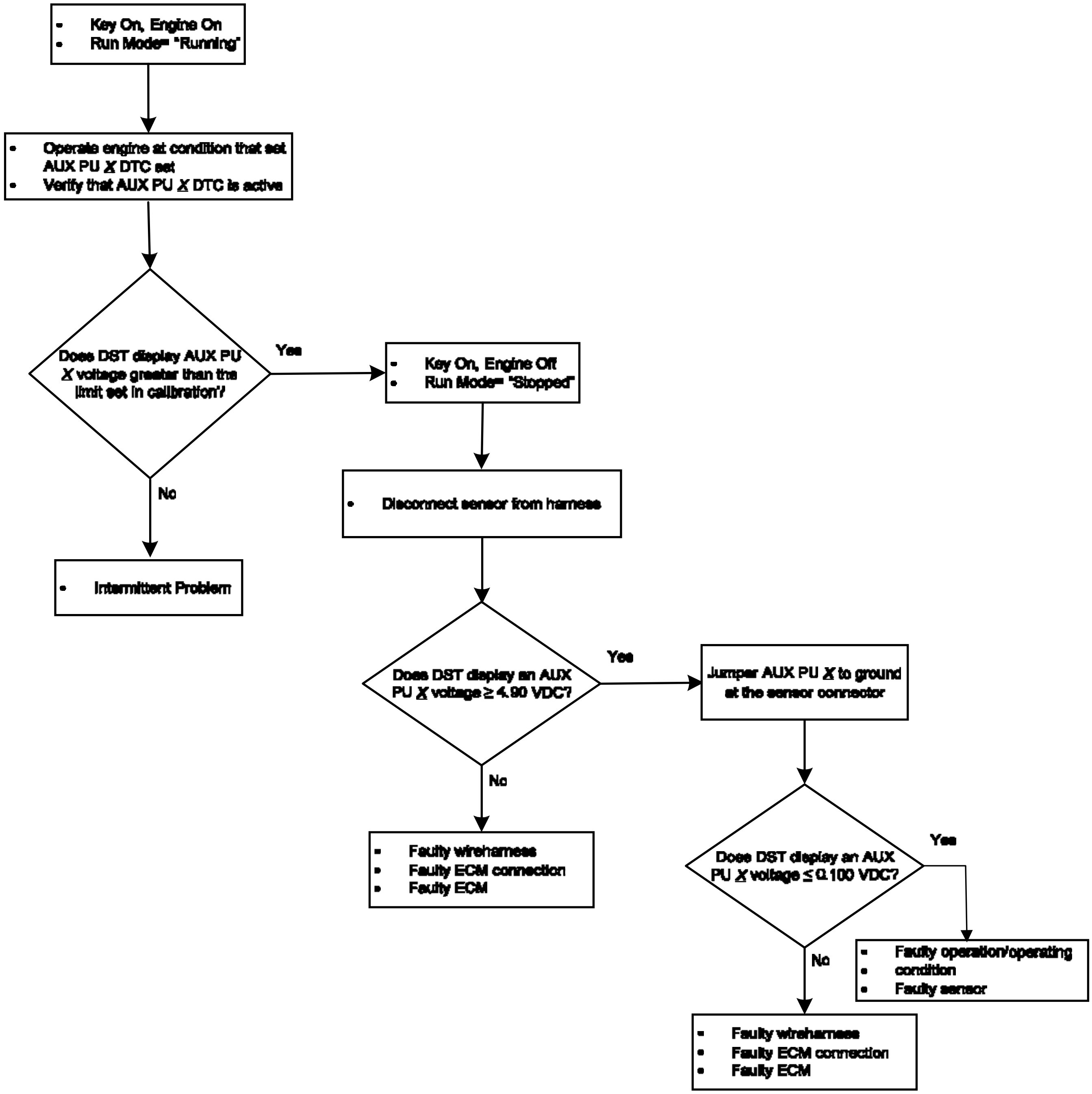


- Configuration #1- Auxiliary Sensor (proportional voltage type), Configuration #2- Auxiliary Sensor (switch-type)
- Check Condition- Key On, Engine On
- Fault Condition- AUX_ana_PU2 voltage higher than expected
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp, power derate, force idle, shutdown, or any combination thereof as defined in calibration.
- Non-emissions related fault

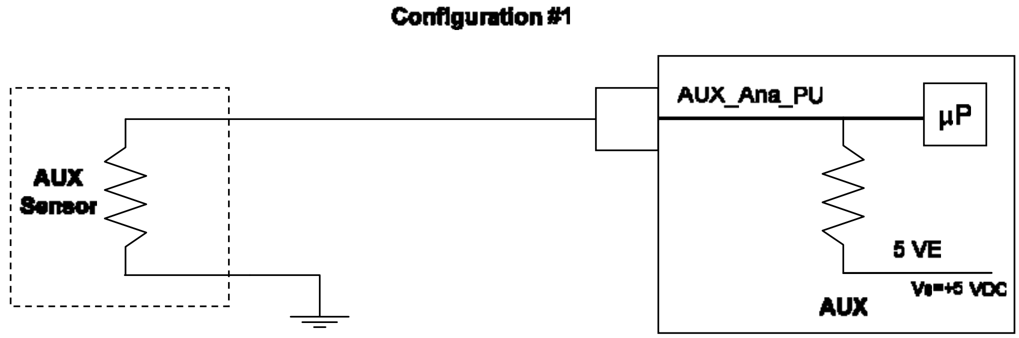
The auxiliary analog input circuit is customer specific and can be used to perform an action based on a sensor that switches to ground or a sensor that outputs a proportional voltage. Typical uses of the auxiliary circuit includes switches that activate particular software strategies, switches that act as vehicle safeties to trigger derate or shutdown conditions, or auxiliary senders used to drive gauges. The circuit internal to the ECM is connected in parallel with the regulated 5 VDC power supply so that when no load is connected to the circuit the feedback voltage is equal to 5 VDC.

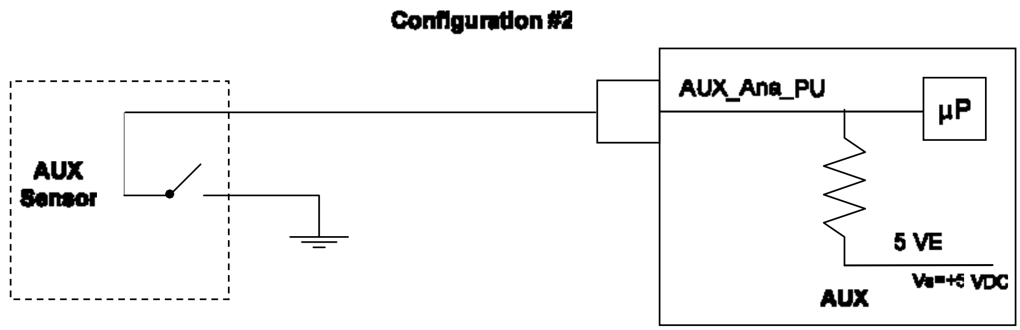
This fault is active when the voltage feedback from the sensor is above the limit defined in calibration.

SPN 702, FMI 3 - AUX Analog Pull-Up 2 High Voltage Fault



SPN 702, FMI 4 - AUX Analog Pull-Up 2 Low Voltage Fault



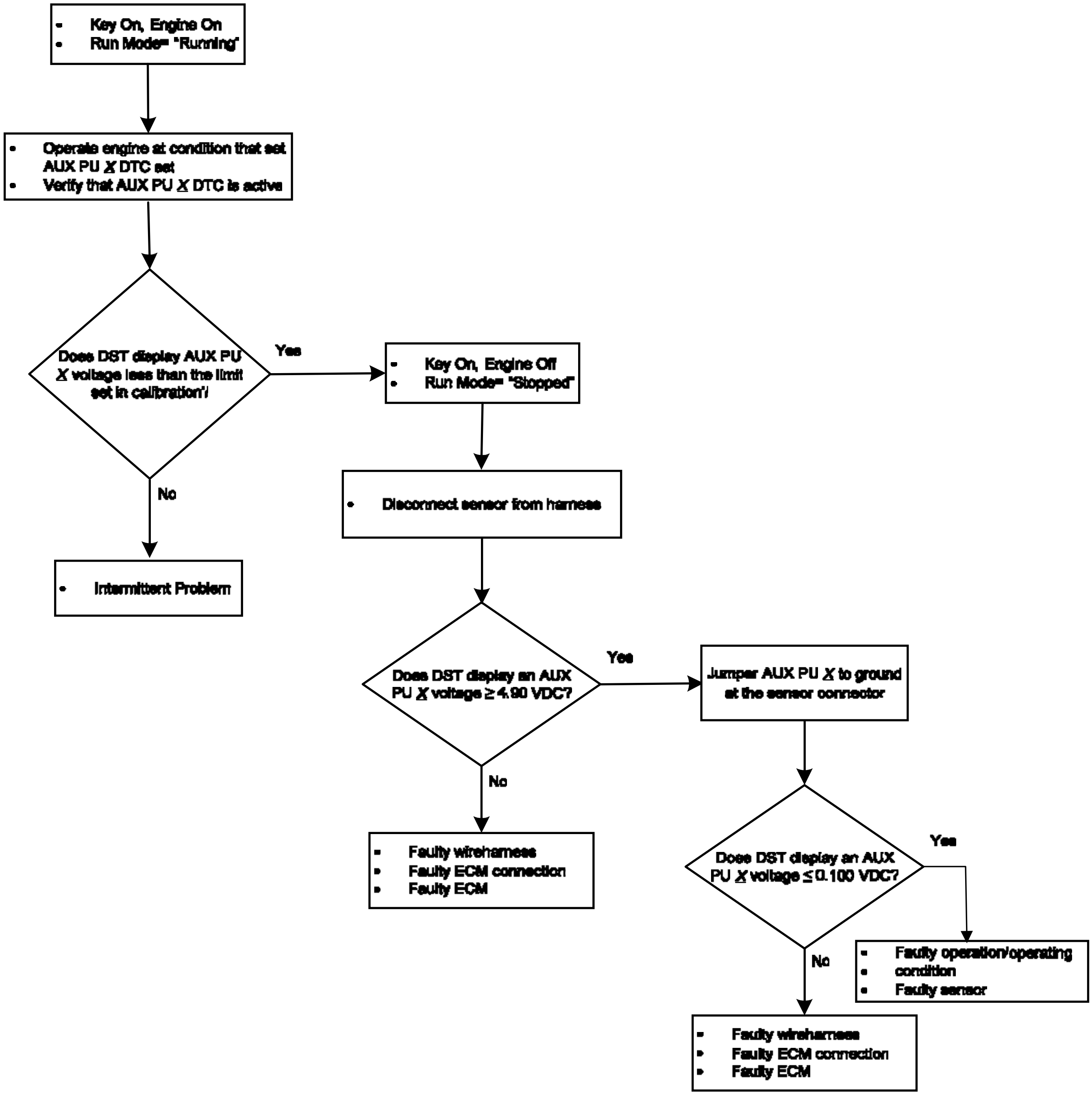


- Configuration #1- Auxiliary Sensor (proportional voltage type), Configuration #2- Auxiliary Sensor (switch-type)
- Check Condition- Key On, Engine On
- Fault Condition- AUX_ana_PU2 voltage lower than expected
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp, power derate, force idle, shutdown, or any combination thereof as defined in calibration.
- Non-emissions related fault

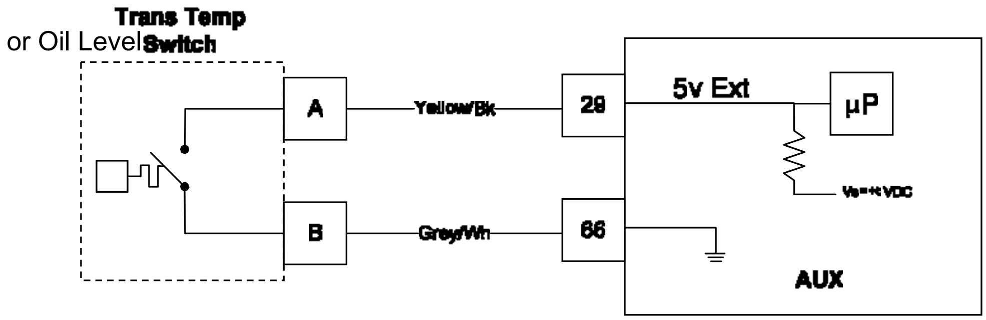
The auxiliary analog input circuit is customer specific and can be used to perform an action based on a sensor that switches to ground or a sensor that outputs a proportional voltage. Typical uses of the auxiliary circuit includes switches that activate particular software strategies, switches that act as vehicle safeties to trigger derate or shutdown conditions, or auxiliary senders used to drive gauges. The circuit internal to the ECM is connected in parallel with the regulated 5 VDC power supply so that when no load is connected to the circuit the feedback voltage is equal to 5 VDC.

This fault is active when the voltage feedback from the sensor is below the limit defined in calibration.

SPN 702, FMI 4 - AUX Analog Pull-Up 2 Low Voltage Fault



SPN 703/707, FMI 3 - AUX Analog Pull-Up 3 High Voltage Fault

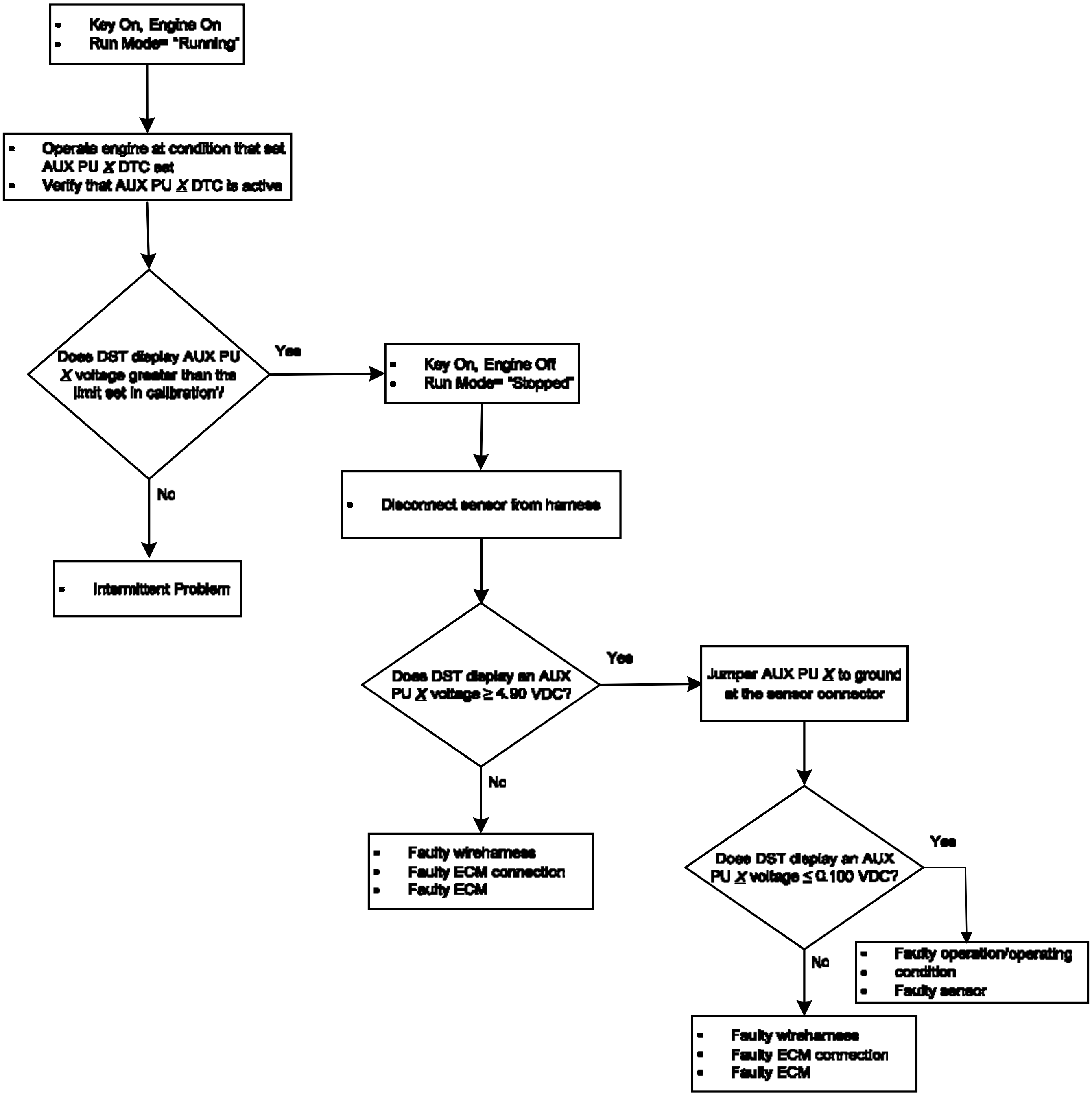


- Configuration #1- Auxiliary Sensor (proportional voltage type), Configuration #2- Auxiliary Sensor (switch-type)
- Check Condition- Key On, Engine On
- Fault Condition- AUX_ana_PU3 voltage higher than expected
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp, power derate, force idle, shutdown, or any combination thereof as defined in calibration.
- Non-emissions related fault

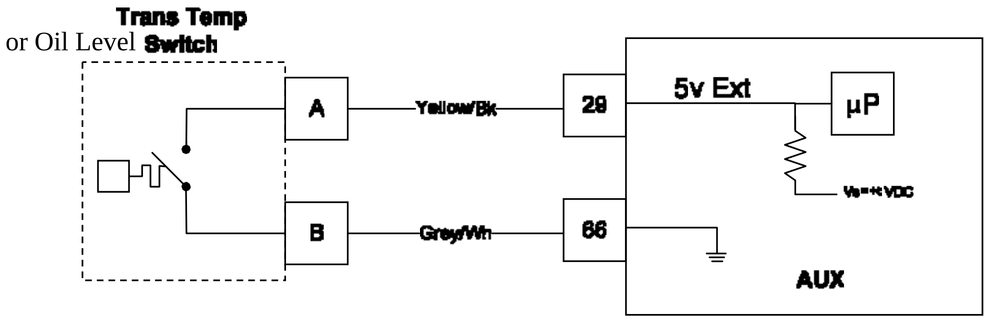
The auxiliary analog input circuit is customer specific and can be used to perform an action based on a sensor that switches to ground or a sensor that outputs a proportional voltage. Typical uses of the auxiliary circuit includes switches that activate particular software strategies, switches that act as vehicle safeties to trigger derate or shutdown conditions, or auxiliary senders used to drive gauges. The circuit internal to the ECM is connected in parallel with the regulated 5 VDC power supply so that when no load is connected to the circuit the feedback voltage is equal to 5 VDC.

This fault is active when the voltage feedback from the sensor is above the limit defined in calibration.

SPN 703/707, FMI 3 - AUX Analog Pull-Up 3 High Voltage Fault



SPN 703/707, FMI 4 - AUX Analog Pull Up 3 Low Voltage Fault

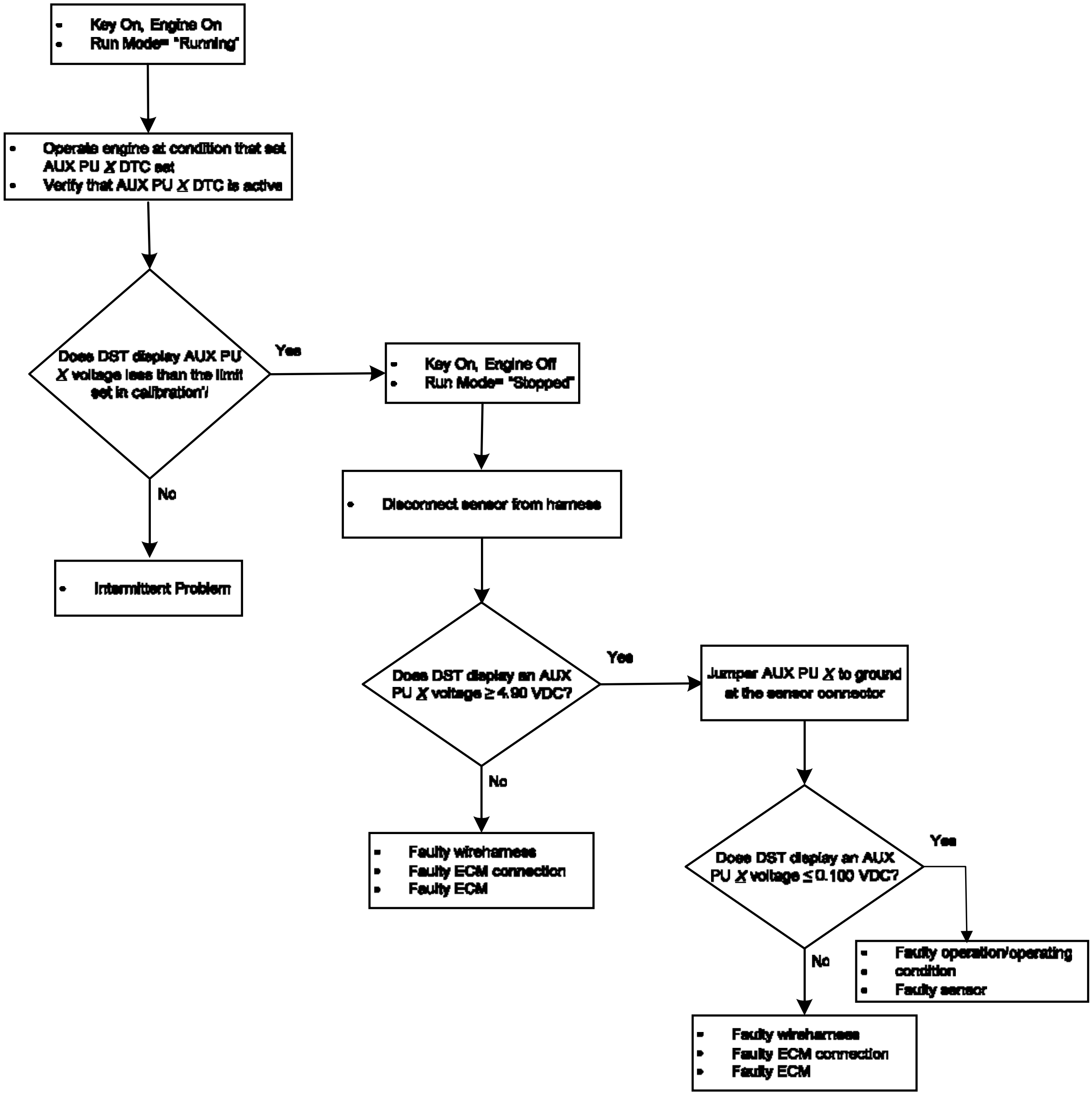


- Configuration #1- Auxiliary Sensor (proportional voltage type), Configuration #2- Auxiliary Sensor (switch-type)
- Check Condition- Key On, Engine On
- Fault Condition- AUX_ana_PU3 voltage lower than expected
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp, power derate, force idle, shutdown, or any combination thereof as defined in calibration.
- Non-emissions related fault

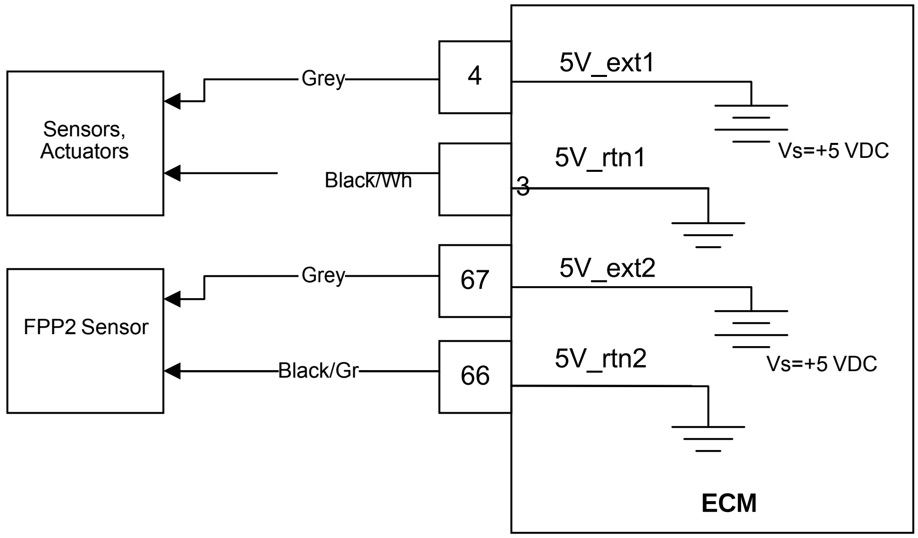
The auxiliary analog input circuit is customer specific and can be used to perform an action based on a sensor that switches to ground or a sensor that outputs a proportional voltage. Typical uses of the auxiliary circuit includes switches that activate particular software strategies, switches that act as vehicle safeties to trigger derate or shutdown conditions, or auxiliary senders used to drive gauges. The circuit internal to the ECM is connected in parallel with the regulated 5 VDC power supply so that when no load is connected to the circuit the feedback voltage is equal to 5 VDC.

This fault is active when the voltage feedback from the sensor is below the limit defined in calibration.

SPN 703/707, FMI 4 - AUX Analog Pull Up 3 Low Voltage Fault



SPN 1079, FMI 31 - Sensor Supply Voltage (5Vext 1/2) Simultaneous Out-of-Range

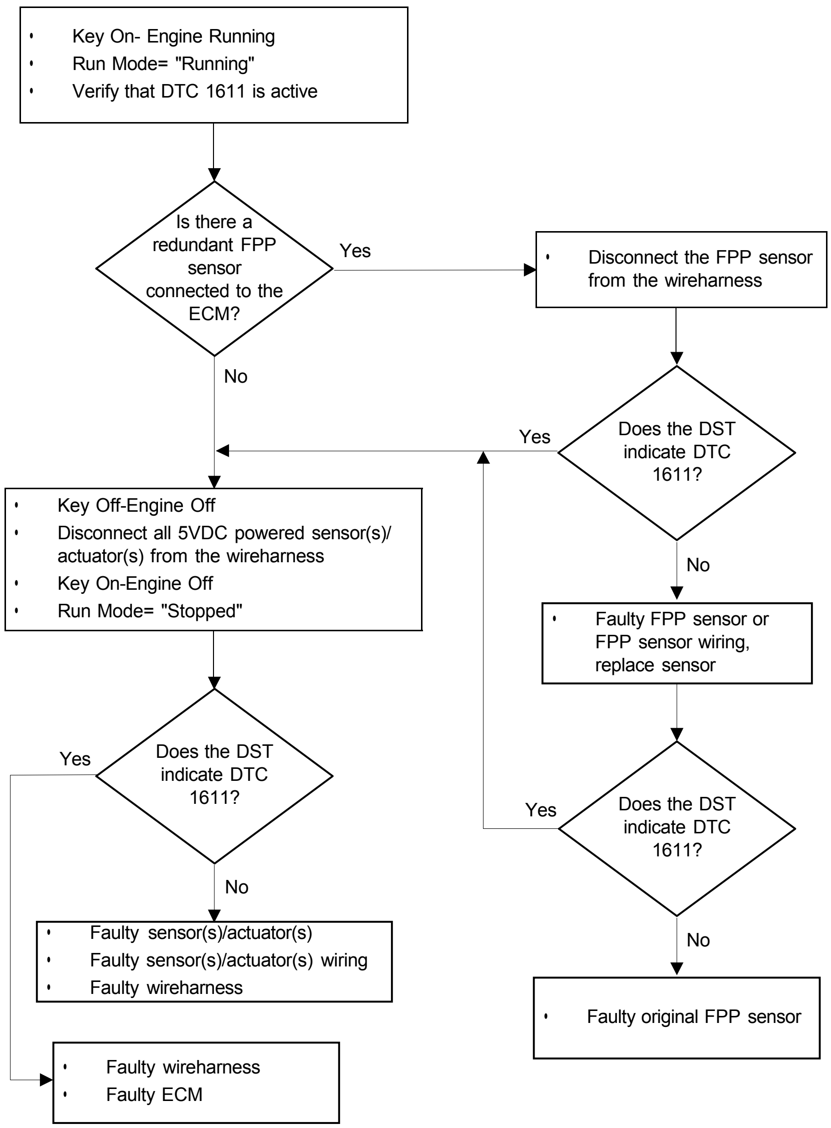


- Powered sensors/actuators and FPP2
- Check Condition- Engine on
- Fault Condition- high or low voltage feedback on both 5V_ext1 and 5V_ext2
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp, and forced idle
- Non-emissions related fault

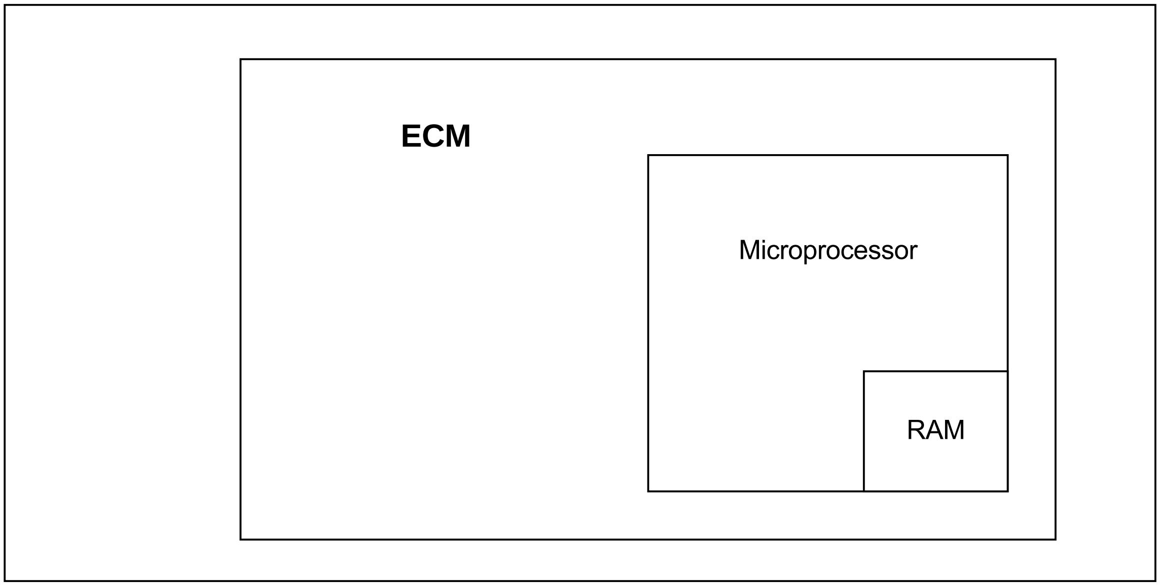
5V_ext1 is a regulated 5 VDC output that supplies power to sensors and actuators. This power is generally supplied, but is not limited to hall-effects, potentiometers, switches, and pressure transducers. 5V_ext2 is a low-current 5 VDC power supply intended solely for powering a second potentiometer used for electronic throttle control in configurations where high redundancy is required. High accuracy of the power supplies are required in order to ensure proper signal scaling. Both power supplies have a feedback voltage that is monitored by the ECM to determine if the output is overloaded, shorted, or otherwise out of specification.

This fault indicates that both power supply feedback voltages are out-of-range as defined in the calibration. In configurations where the crank and/or camshaft position sensors are powered hall-effect sensors, the engine may stall due to loss of synchronization.

SPN 1079, FMI 31 - Sensor Supply Voltage (5Vext 1/2) Simultaneous Out-of-Range



DTC 1612- Microprocessor Failure - RTI 1

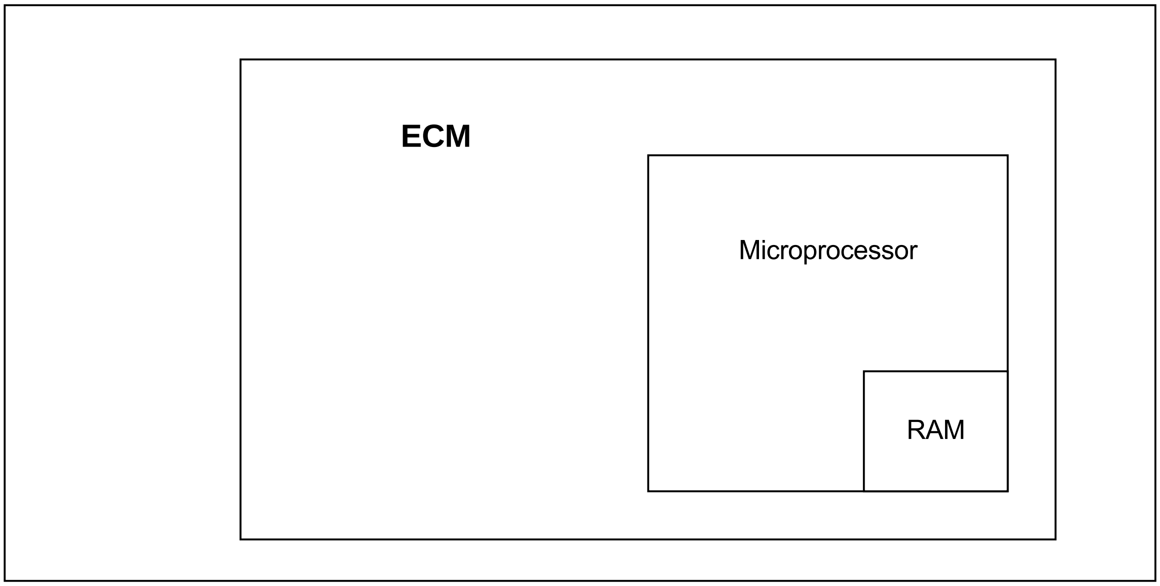


- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 1613- Microprocessor Failure - RTI 2

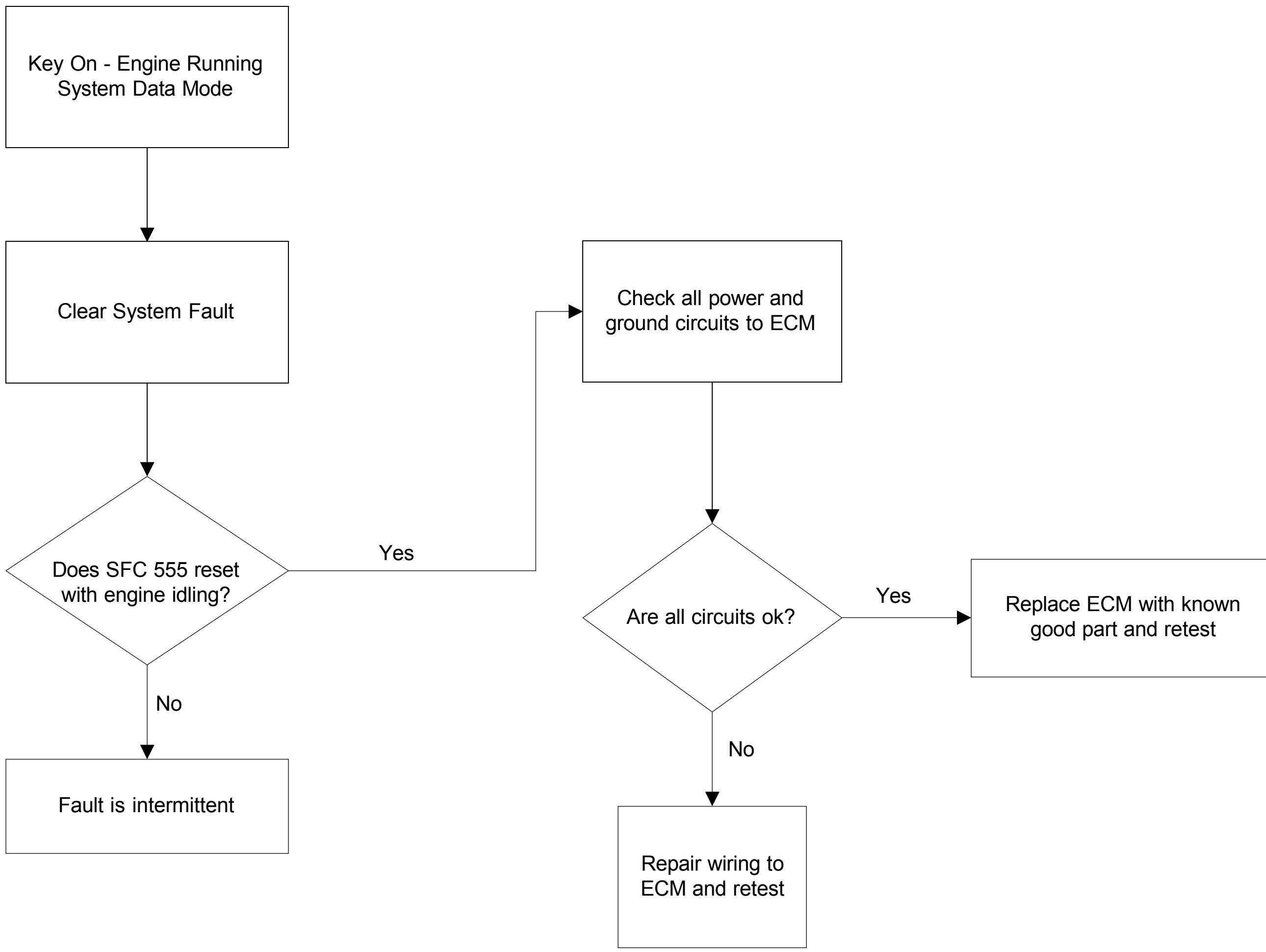


- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

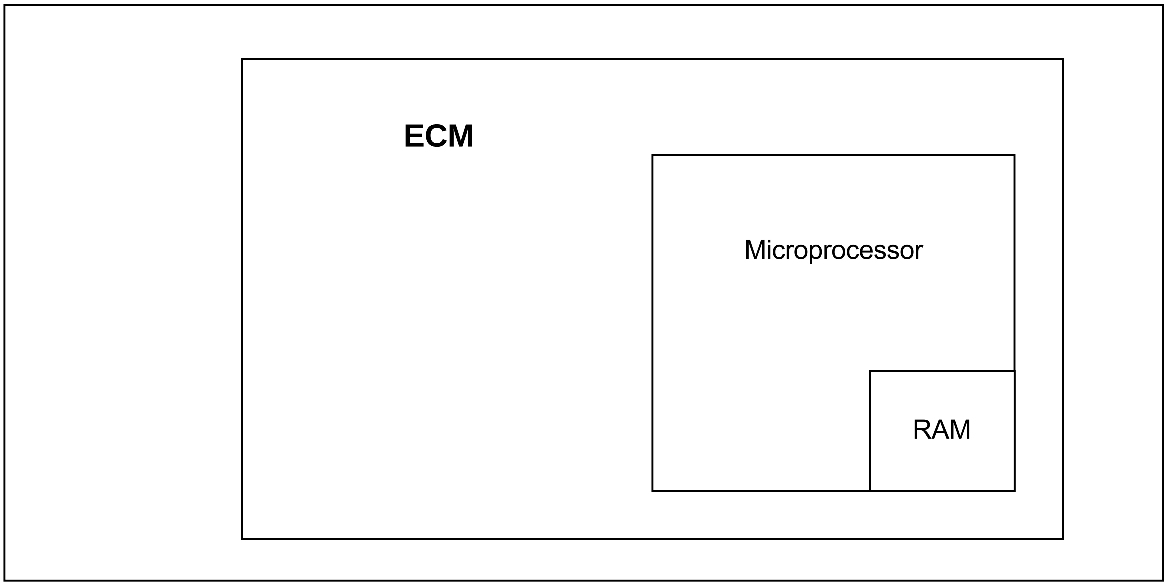
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

SFC 555- RTI 2 Loss



DTC 1614- Microprocessor Failure - RTI 3

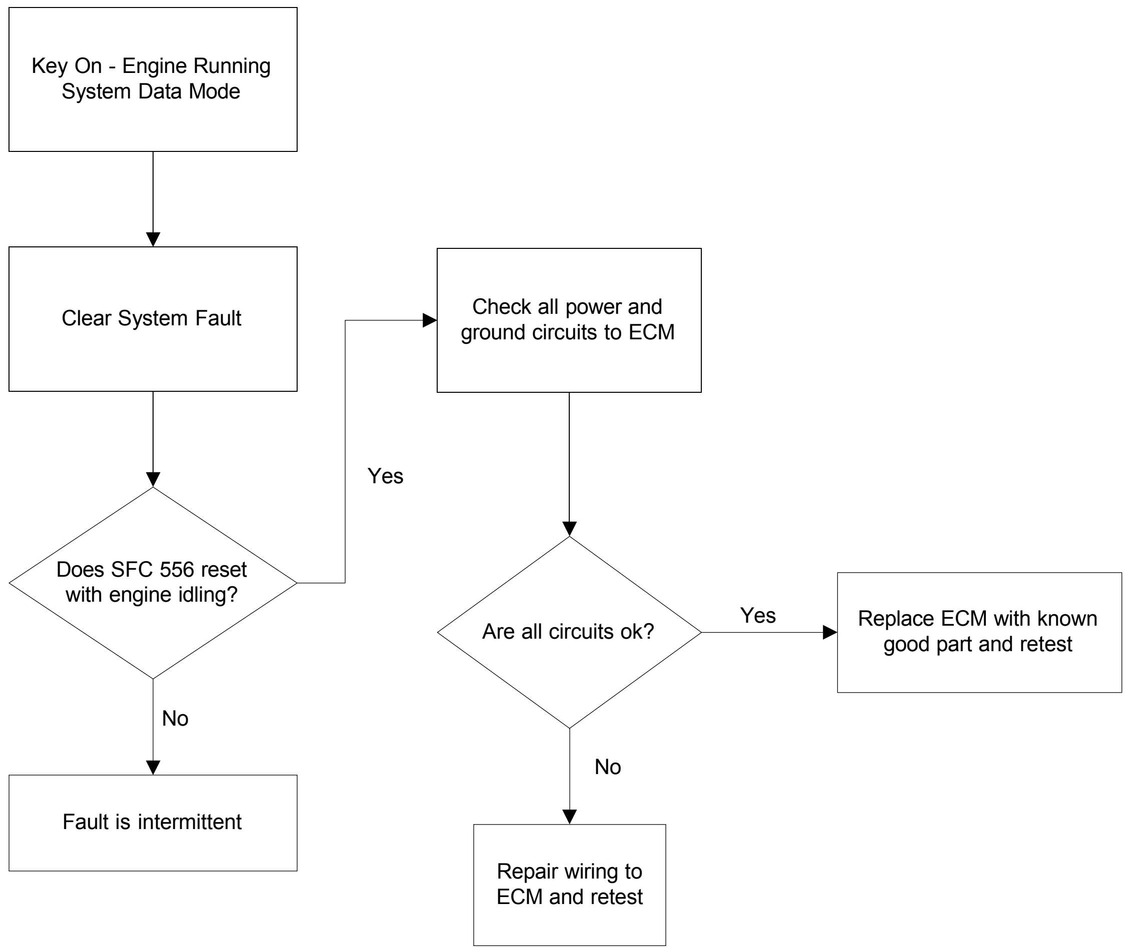


- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

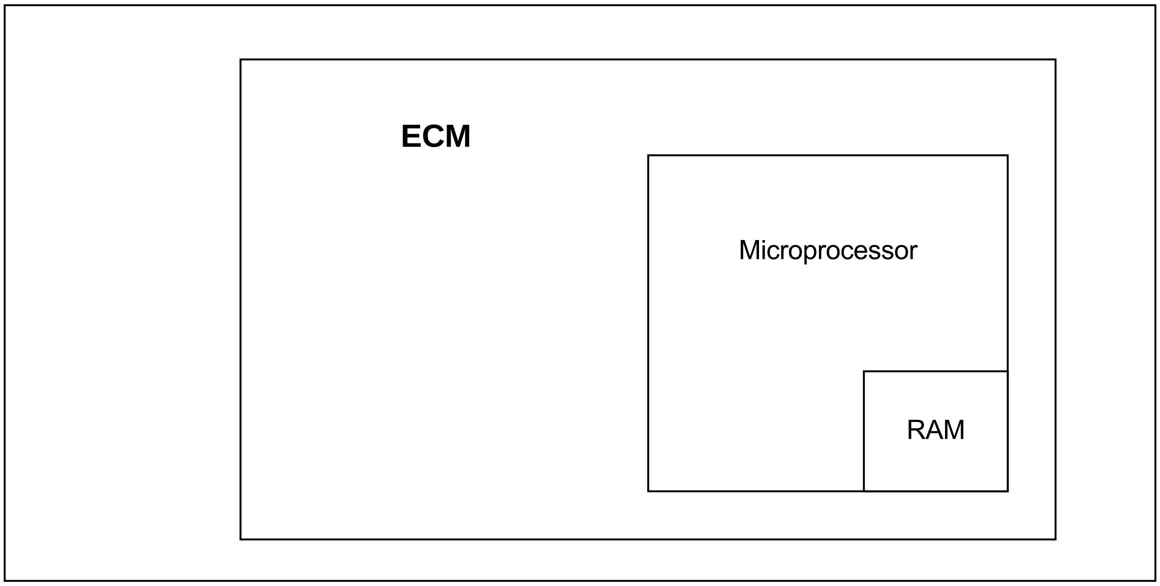
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

SFC 556- RTI 3 Loss



DTC 1615- Microprocessor Failure - A/D

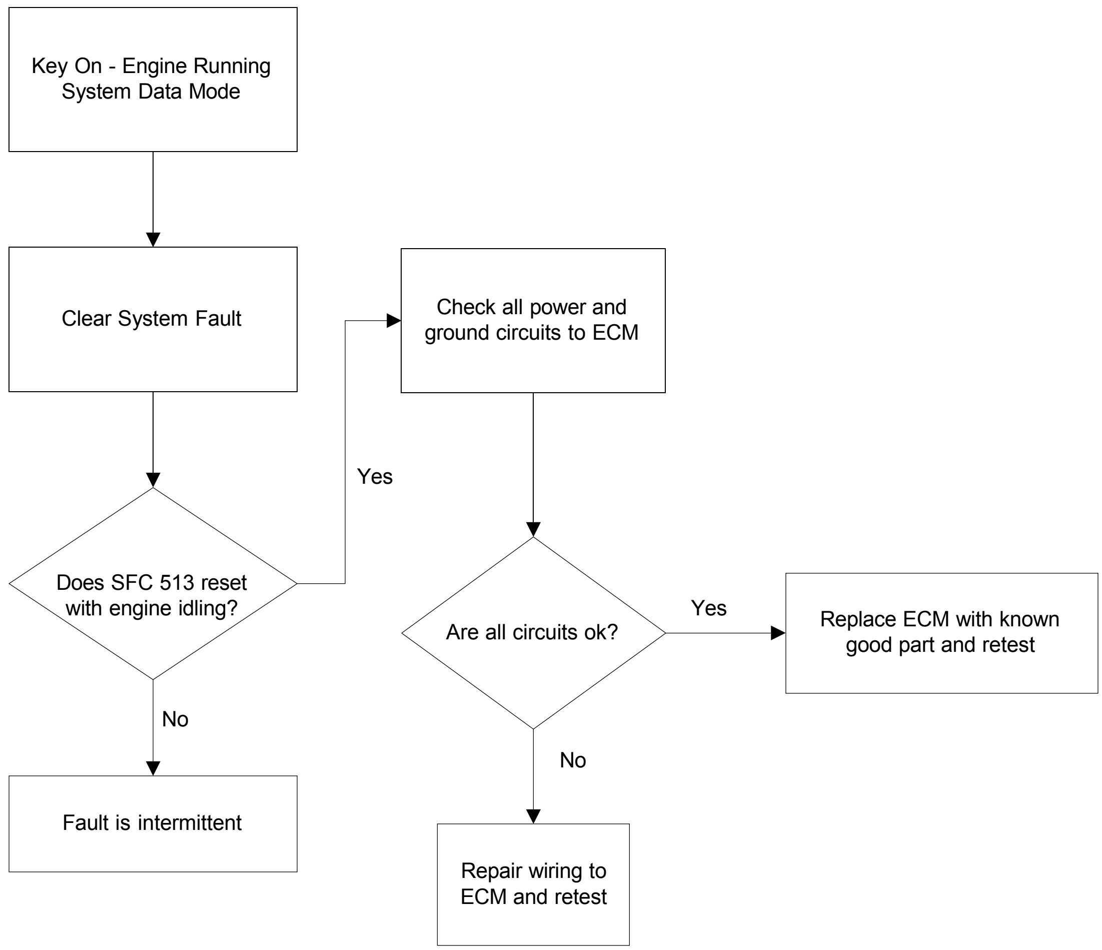


- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

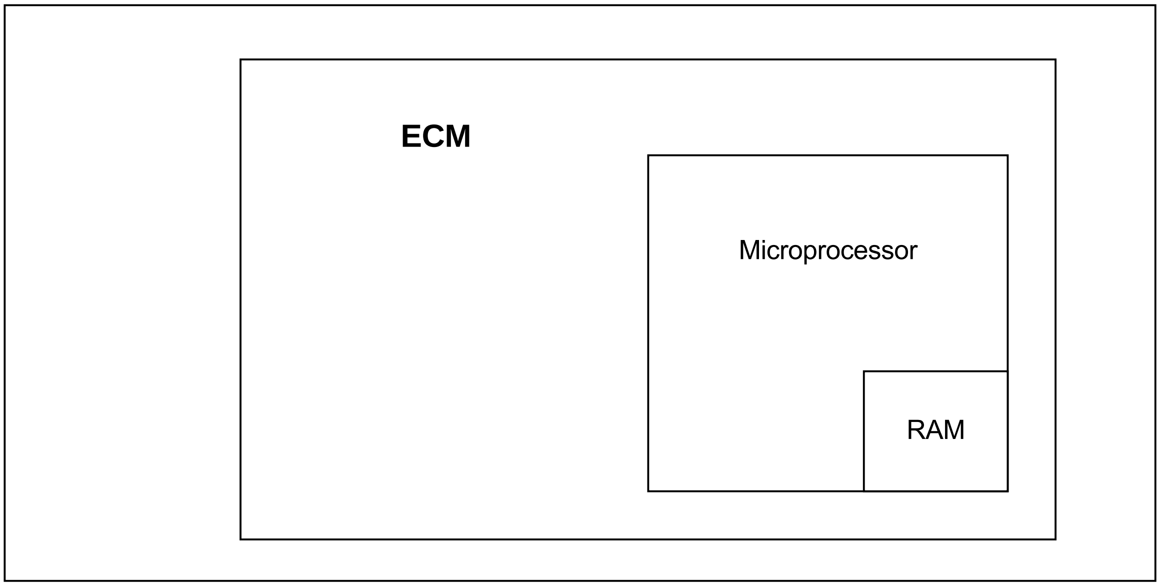
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

SFC 513- A/D Loss



DTC 1616- Microprocessor Failure - Interrupt

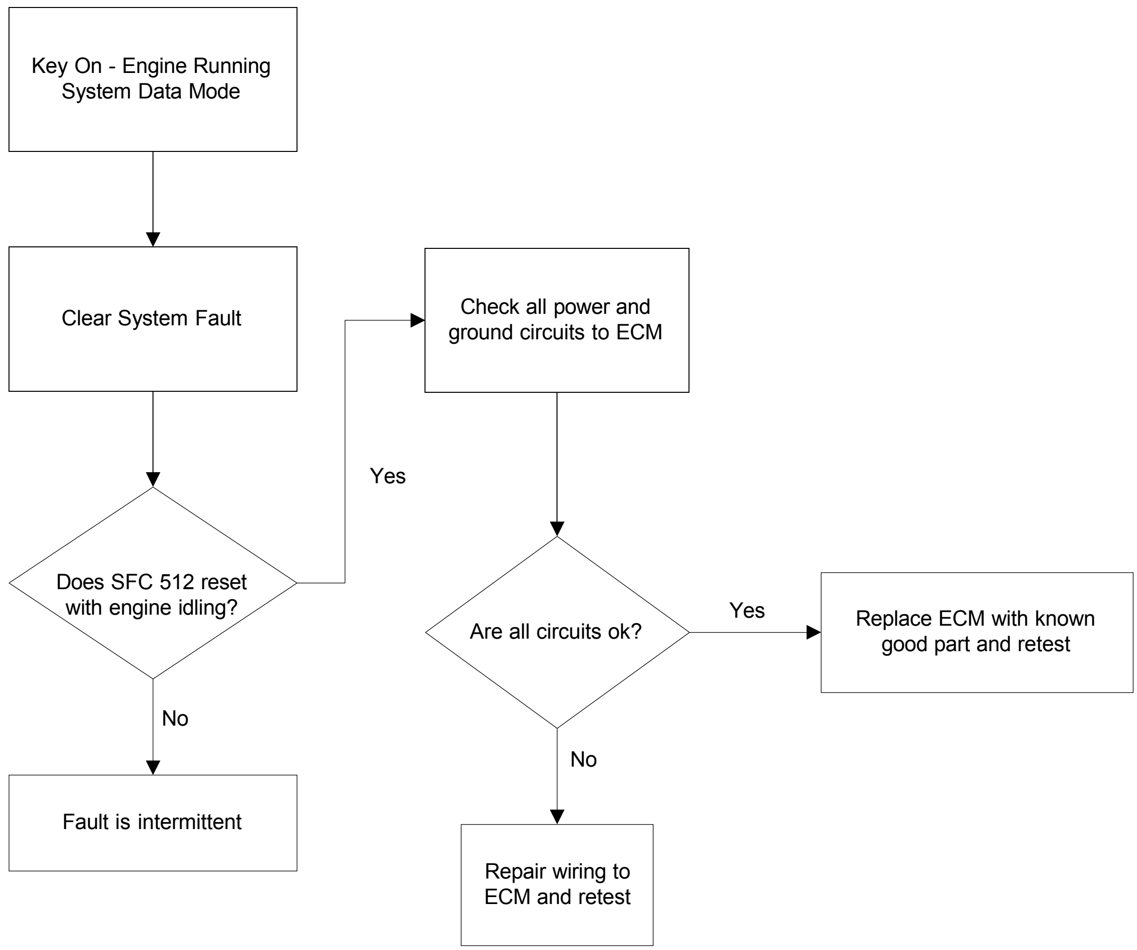


- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

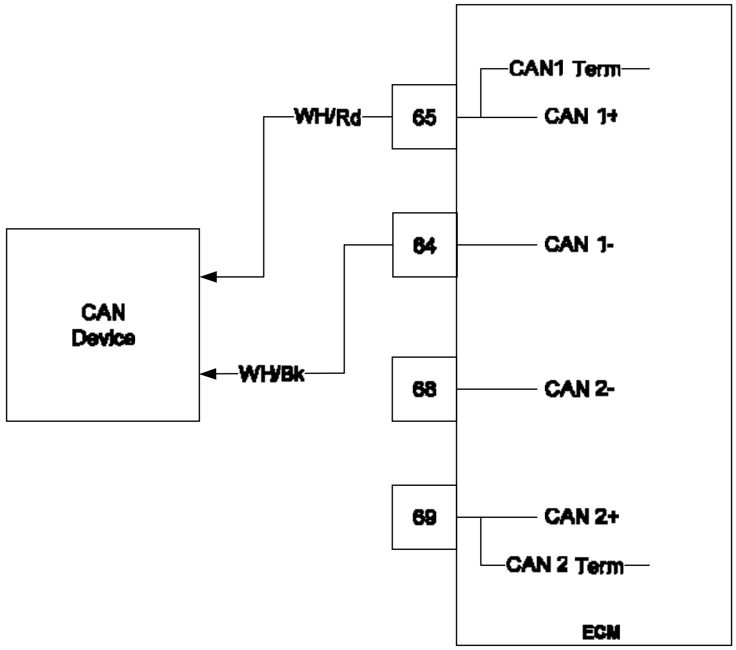
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

SFC 512- Invalid Interrupt



DTC 1628- CAN Address Conflict Failure

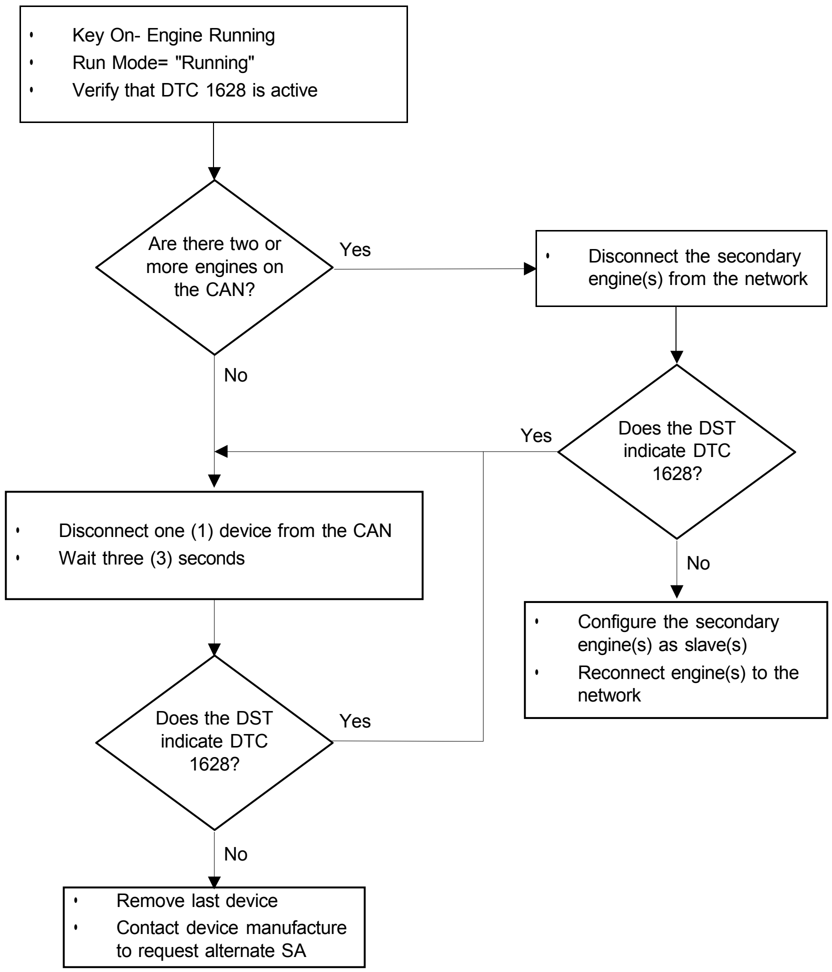


- CAN device(s)
- Check Condition- Key On, Engine on
- Fault Condition- two or more devices on the network that contain the same SA
- Corrective Action(s)- Sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

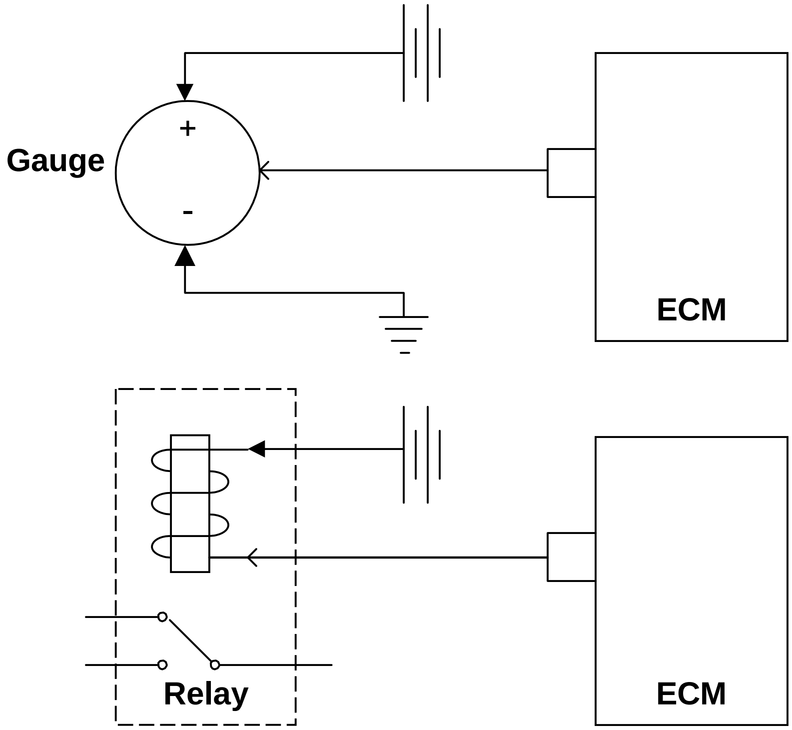
The controller area network serves as a communication portal between intelligent devices. These devices may be but are not limited to other engine ECMs (slave), diagnostic tools, “smart” gauges, “smart” sensors, powertrain control units, vehicle controllers, actuators, etc. The network permits several devices to communicate with each other receiving and broadcasting commands as programmed. This type of network allows devices to be added to an entire system through only two conductors and permits all other devices to broadcast and receive commands to and from the device when properly commanded. CAN1 is used for general network communication including gauge display, scan tool communication, and other general 3rd party traffic. CAN2 is reserved solely for engine control (engine synchronization, throttle control, vehicle controller commands, etc.) and is limited to EControls Inc. approved devices only.

This fault indicates that there are two (2) or more devices on the network that use the same source address.

DTC 1628- CAN Address Conflict Failure



DTC 1631- PWM1/Gauge1 Open/Ground Short



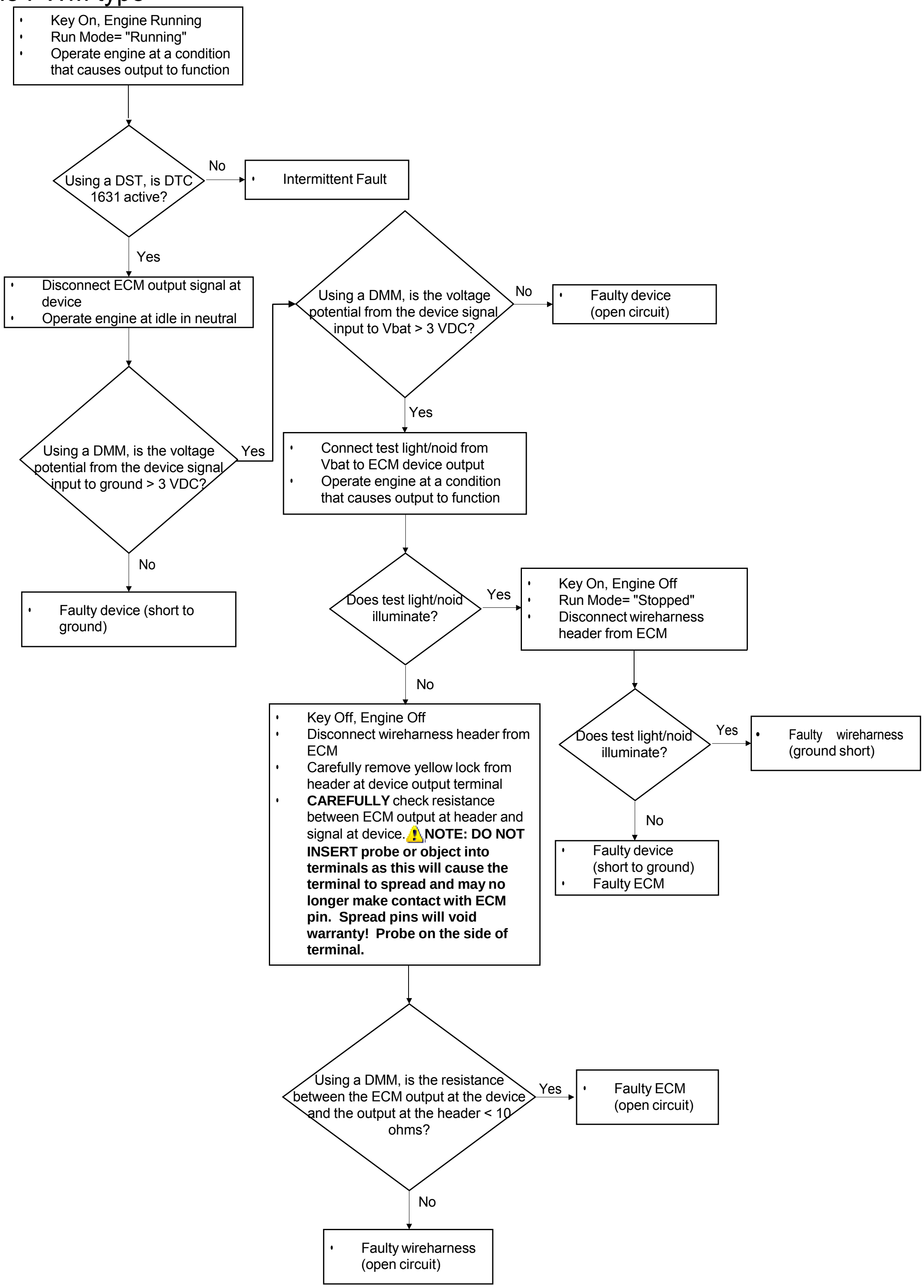
- Analog gauge, proportional actuator, on-off device
- Check Condition- Key-On, Engine On
- Fault Condition- AUX PWM1 output open circuit or shorted to ground
- Corrective Action(s)- Trigger buzzer/secondary warning device
- Non-emissions related fault

AUX_PWM1 is an output that, depending on the ECM hardware configuration, may be used to:

- Simulate the resistance of a sender to drive an analog gauge (Gauge driver config)
- PWM an analog gauge (PWM config)
- PWM the low-side of a on-off device (PWM config)
- PWM a proportional actuator (PWM config)

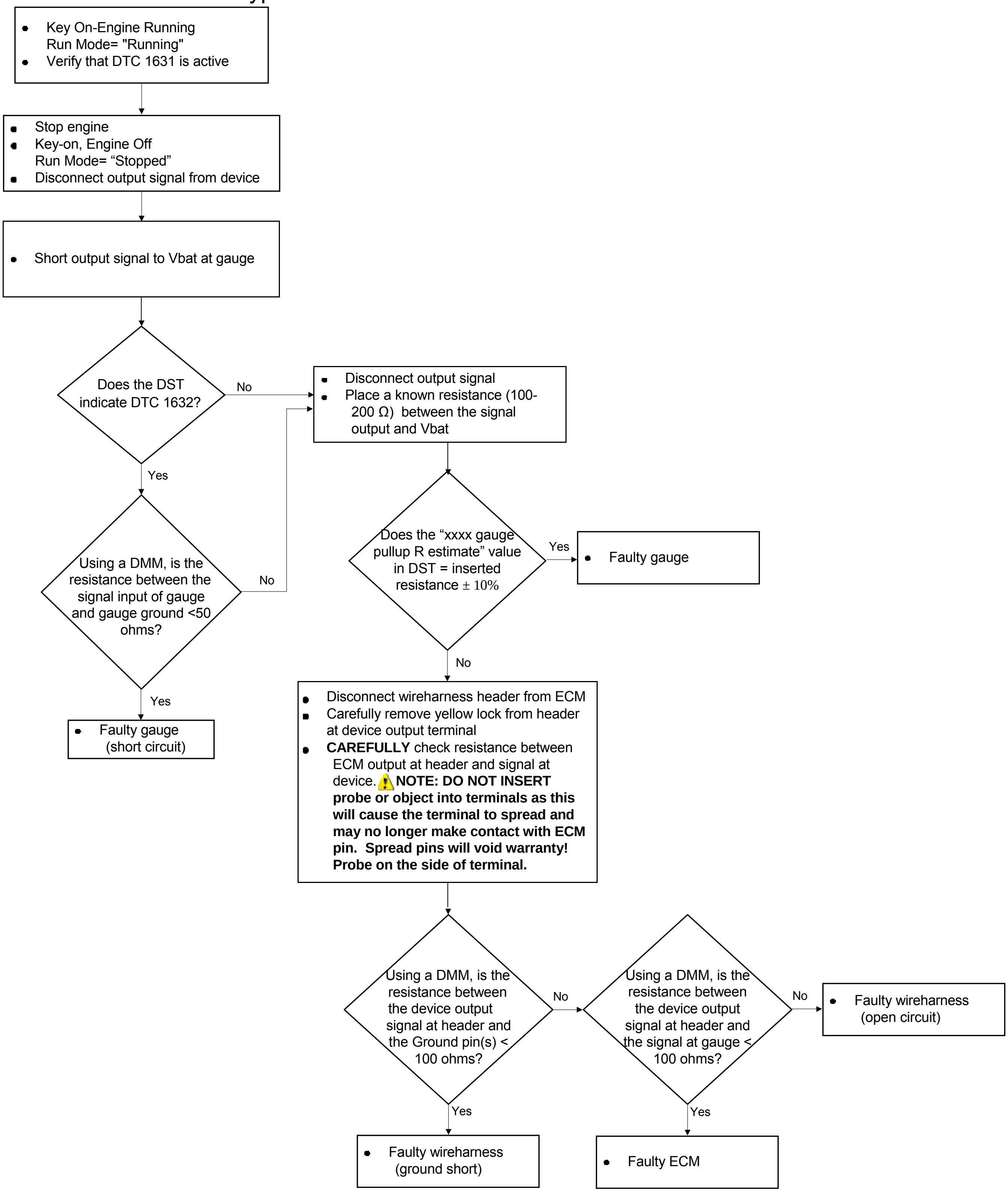
DTC 1631- PWM1/Gauge1 Open/Ground Short

Duty-cycle PWM type

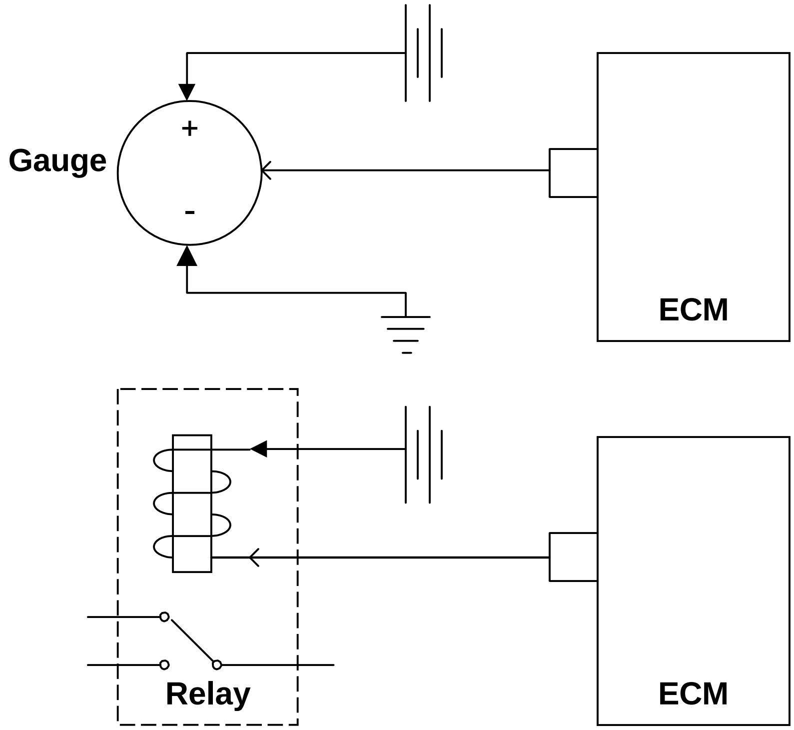


DTC 1631- PWM1/Gauge1 Open/Ground Short

Resistance Simulation type



DTC 1632- PWM1/Gauge1 Short-To-Power



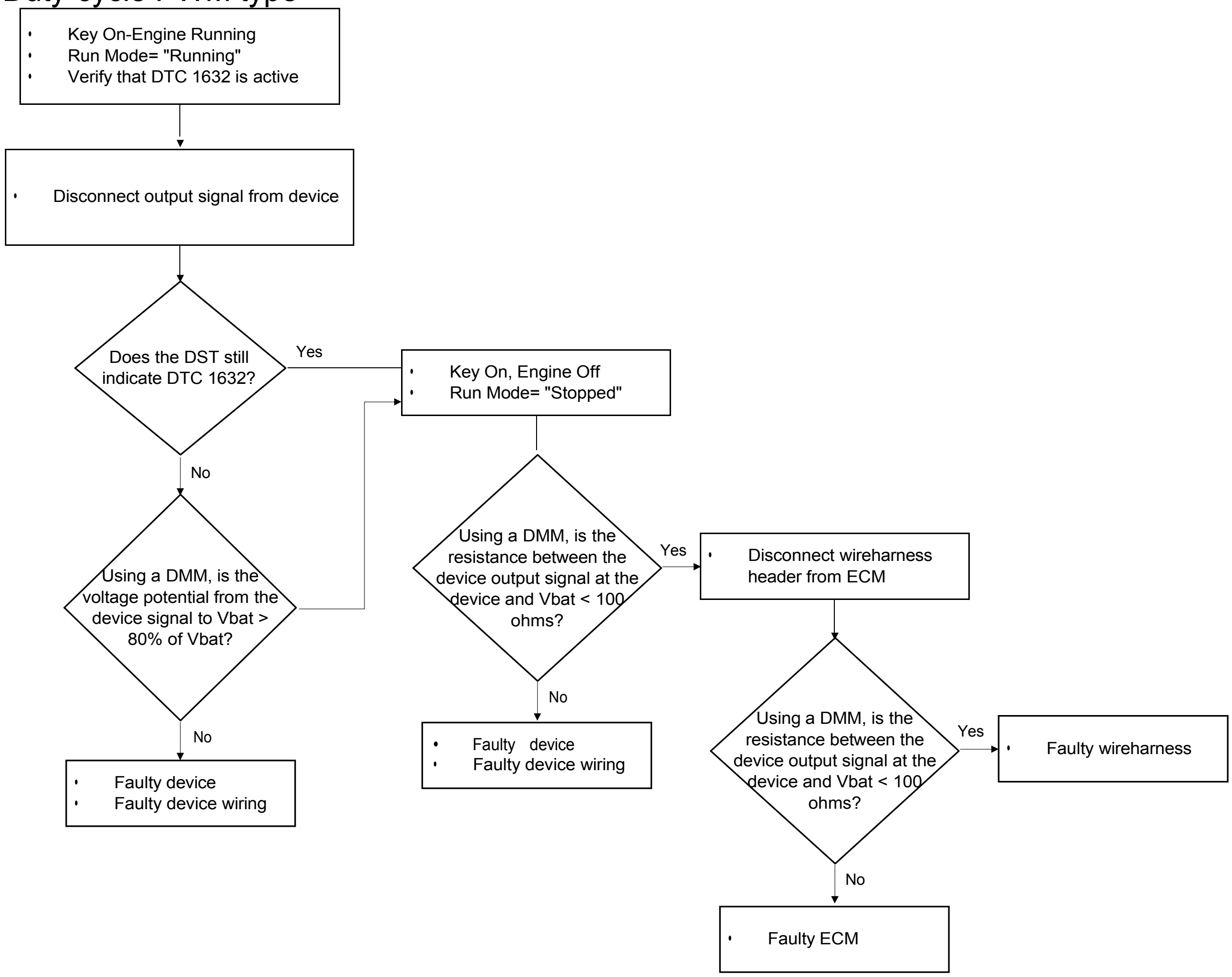
- Analog gauge, proportional actuator, on-off device
- Check Condition- Key-On, Engine On
- Fault Condition- AUX PWM1 output shorted to power
- Corrective Action(s)- Trigger buzzer/secondary warning device
- Non-emissions related fault

AUX_PWM1 is an output that, depending on the ECM hardware configuration, may be used to:

- Simulate the resistance of a sender to drive an analog gauge (Gauge driver config)
- PWM an analog gauge (PWM config)
- PWM the low-side of a on-off device (PWM config)
- PWM a proportional actuator (PWM config)

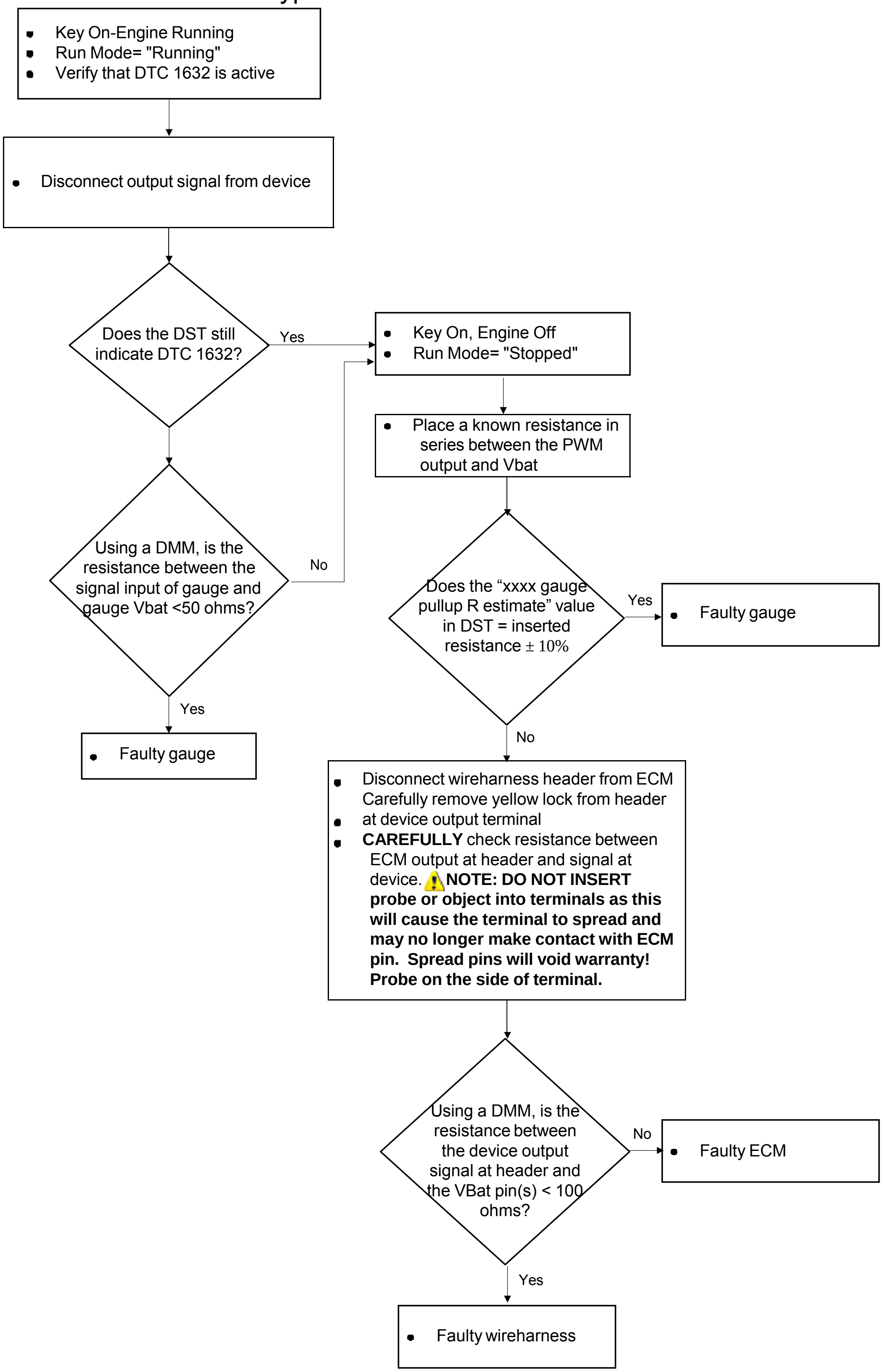
DTC 1632- PWM1/Gauge1 Short-To-Power

Duty-cycle PWM type

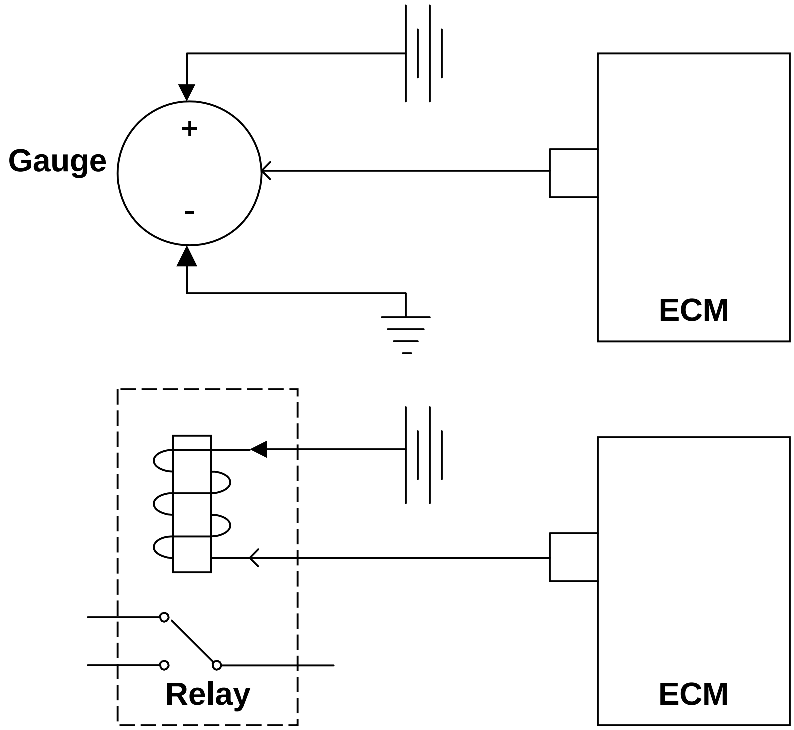


DTC 1632- PWM1/Gauge1 Short-To-Power

Resistance Simulation type



DTC 1633- PWM2/Gauge2 Open/Ground Short

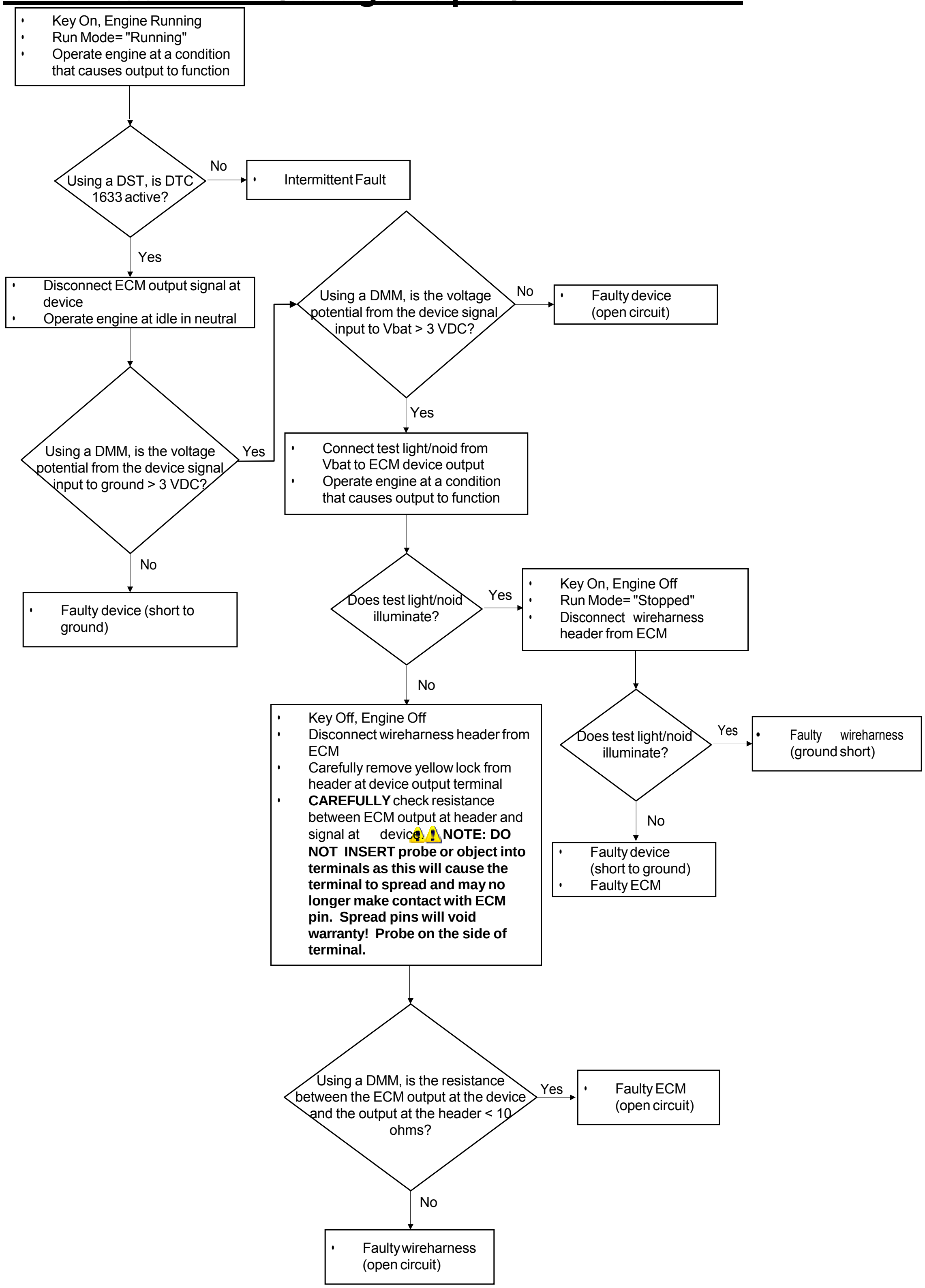


- Analog gauge, proportional actuator, on-off device
- Check Condition- Key-On, Engine On
- Fault Condition- AUX PWM2 output open circuit or shorted to ground
- Corrective Action(s)- Trigger buzzer/secondary warning device
- Non-emissions related fault

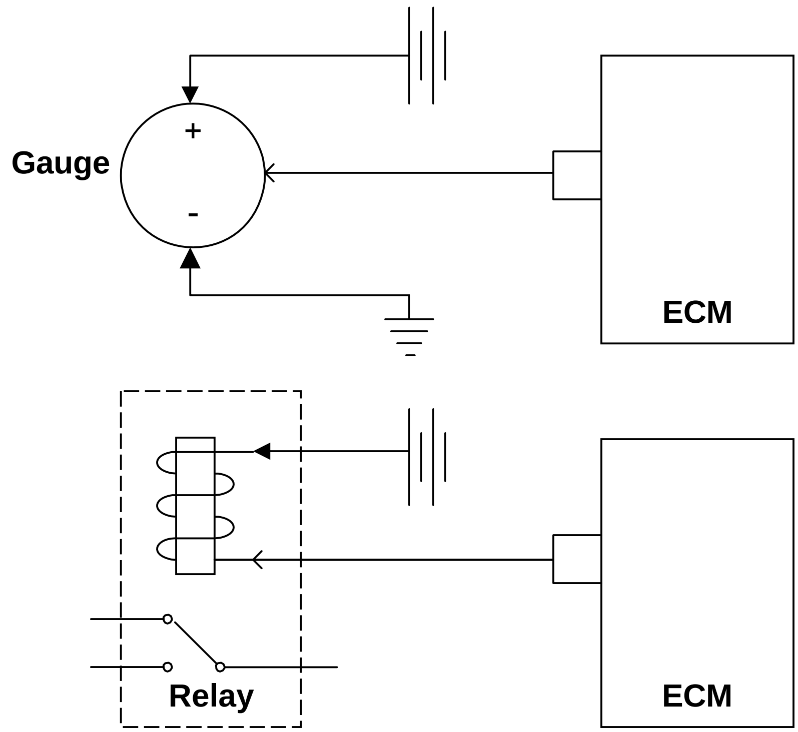
AUX_PWM2 is an output that, depending on the ECM hardware configuration, may be used to:

- Simulate the resistance of a sender to drive an analog gauge (Gauge driver config)
- PWM an analog gauge (PWM config)
- PWM the low-side of a on-off device (PWM config)
- PWM a proportional actuator (PWM config)

DTC 1633- PWM2/Gauge2 Open/Ground Short



DTC 1634- PWM2/Gauge2 Short-To-Power



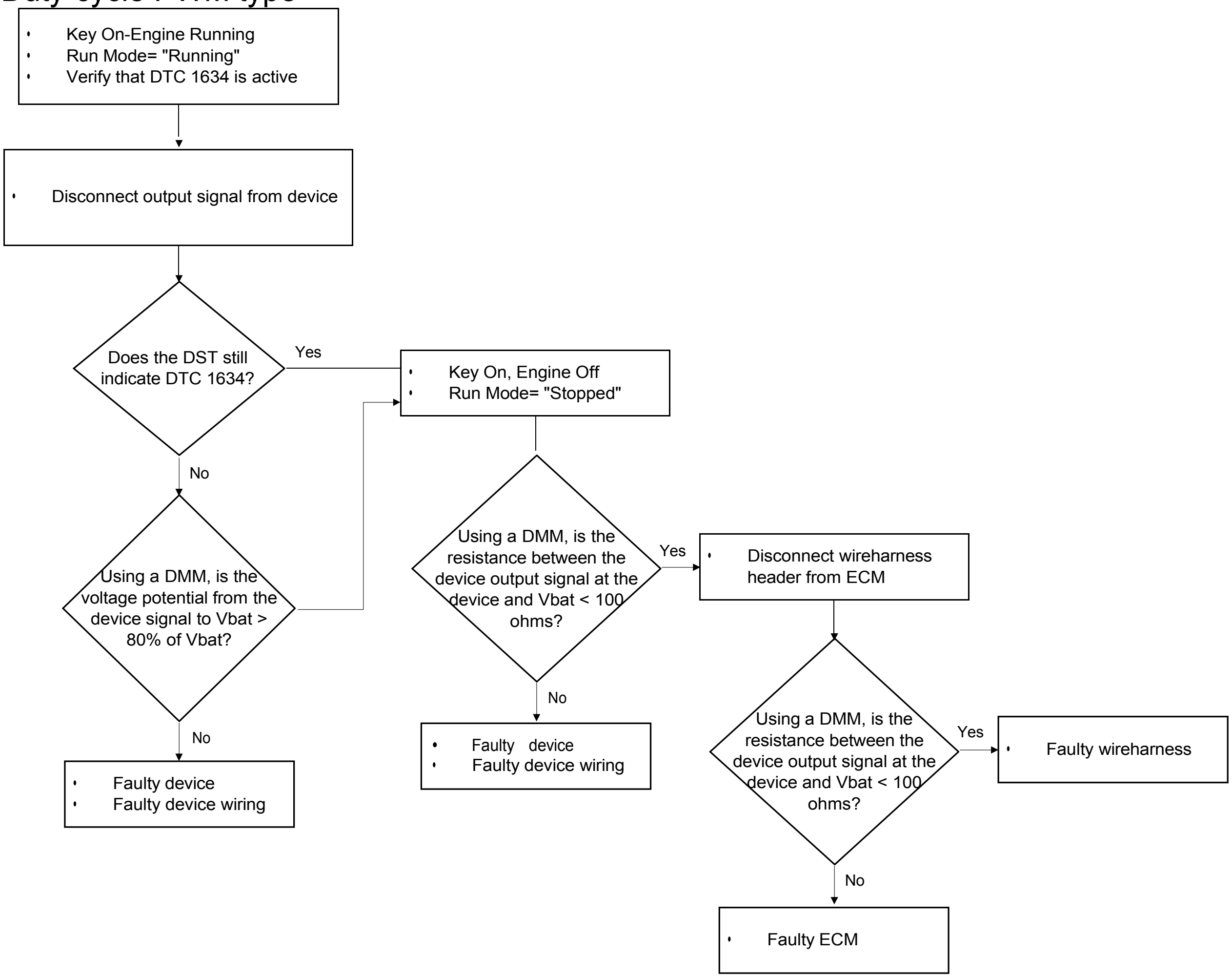
- Analog gauge, proportional actuator, on-off device
- Check Condition- Key-On, Engine On
- Fault Condition- AUX PWM2 output shorted to power
- Corrective Action(s)- Trigger buzzer/secondary warning device
- Non-emissions related fault

AUX_PWM2 is an output that, depending on the ECM hardware configuration, may be used to:

- Simulate the resistance of a sender to drive an analog gauge (Gauge driver config)
- PWM an analog gauge (PWM config)
- PWM the low-side of a on-off device (PWM config)
- PWM a proportional actuator (PWM config)

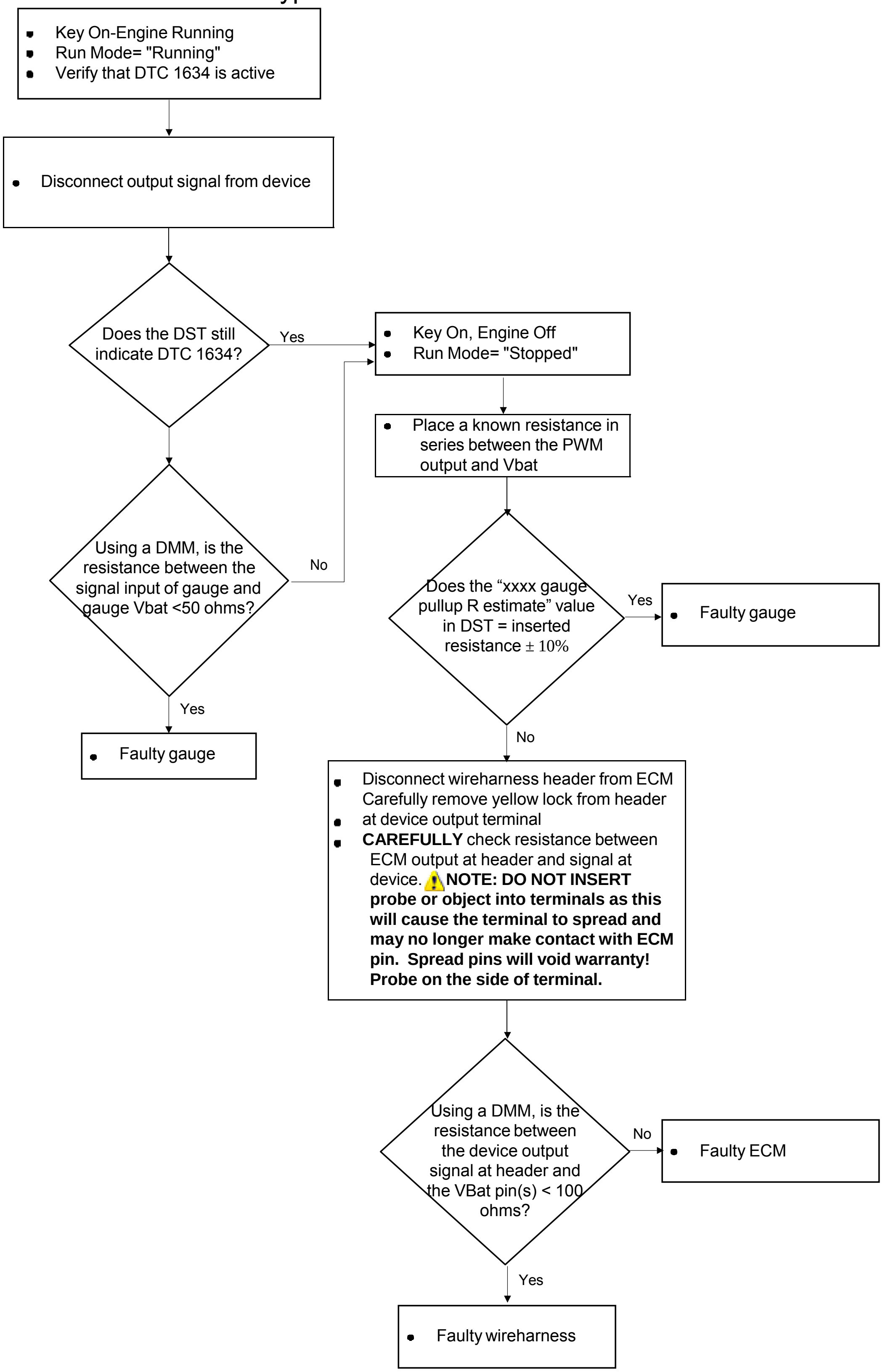
DTC 1634- PWM2/Gauge2 Short-To-Power

Duty-cycle PWM type

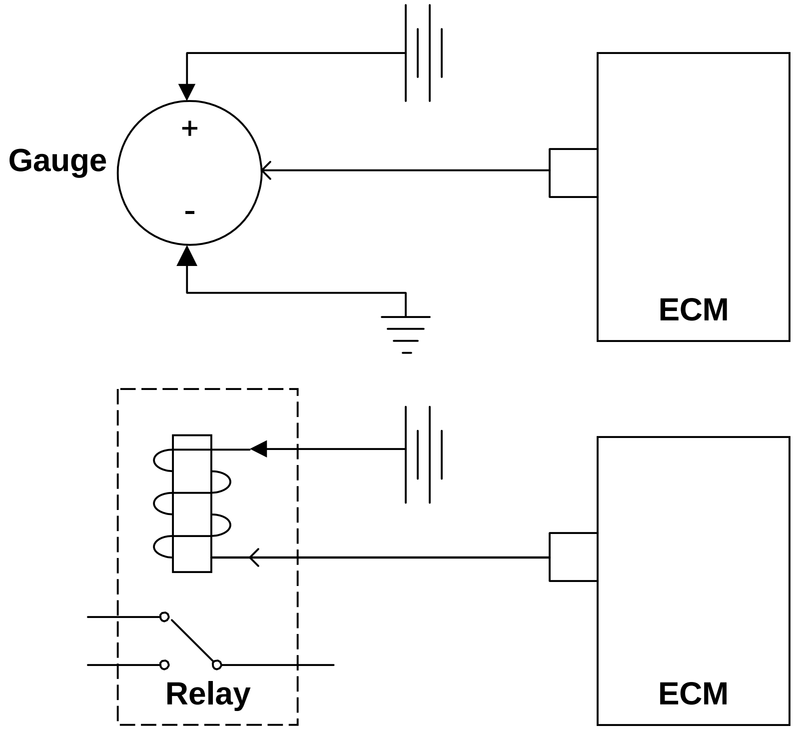


DTC 1634- PWM2/Gauge2 Short-To-Power

Resistance Simulation type



DTC 1635- PWM3/Gauge3 Open/Ground Short



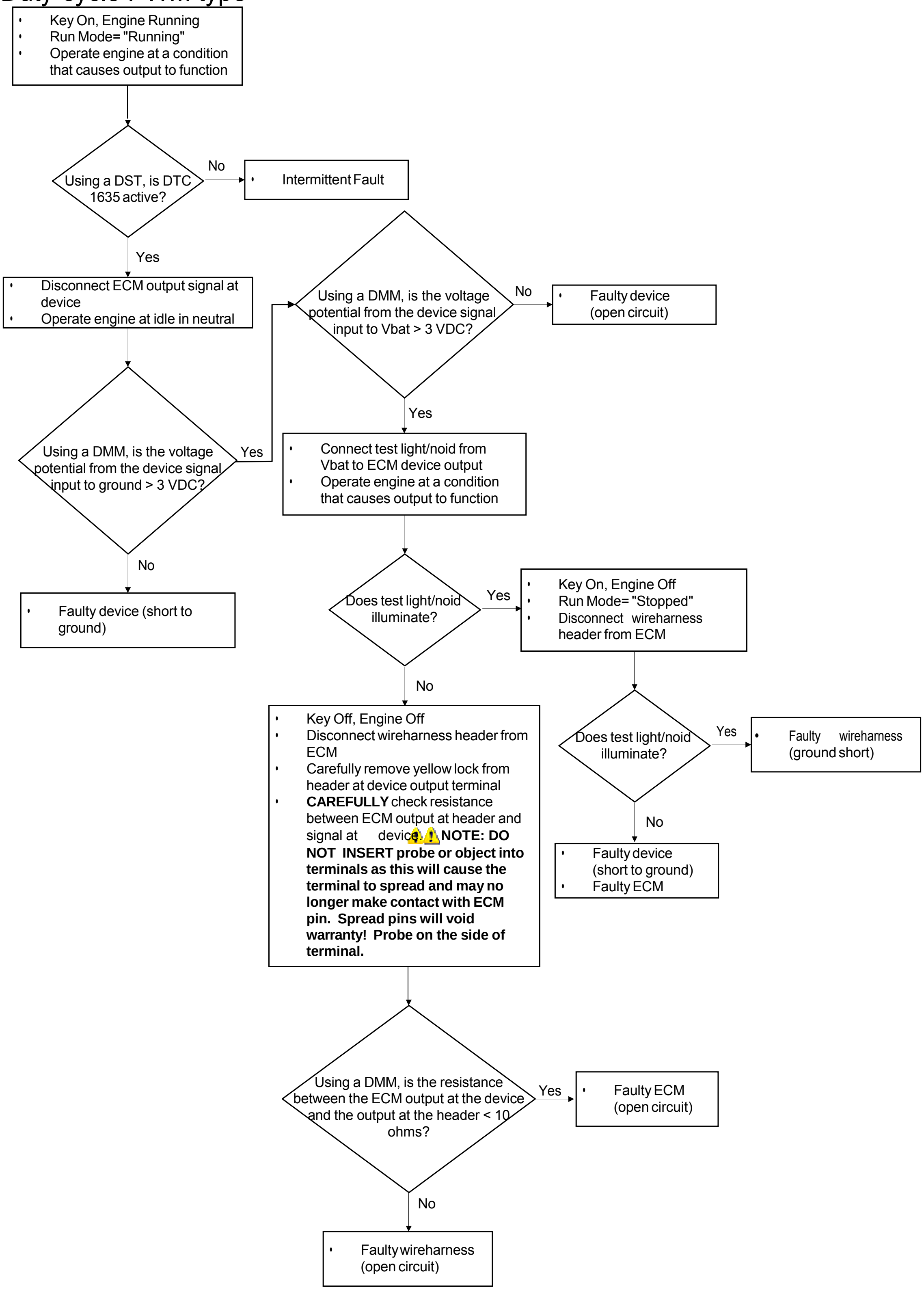
- Analog gauge, proportional actuator, on-off device
- Check Condition- Key-On, Engine On
- Fault Condition- AUX PWM3 output open circuit or shorted to ground
- Corrective Action(s)- Trigger buzzer/secondary warning device
- Non-emissions related fault

AUX_PWM3 is an output that, depending on the ECM hardware configuration, may be used to:

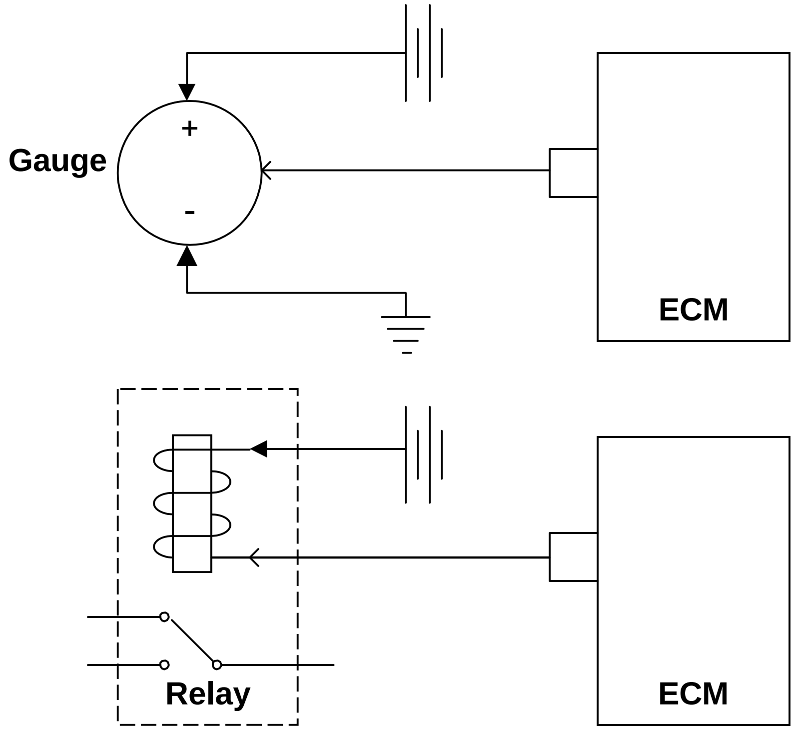
- Simulate the resistance of a sender to drive an analog gauge (Gauge driver config)
- PWM an analog gauge (PWM config)
- PWM the low-side of a on-off device (PWM config)
- PWM a proportional actuator (PWM config)

DTC 1635- PWM3/Gauge3 Open/Ground Short

Duty-cycle PWM type



DTC 1636- PWM3/Gauge3 Short-To-Power



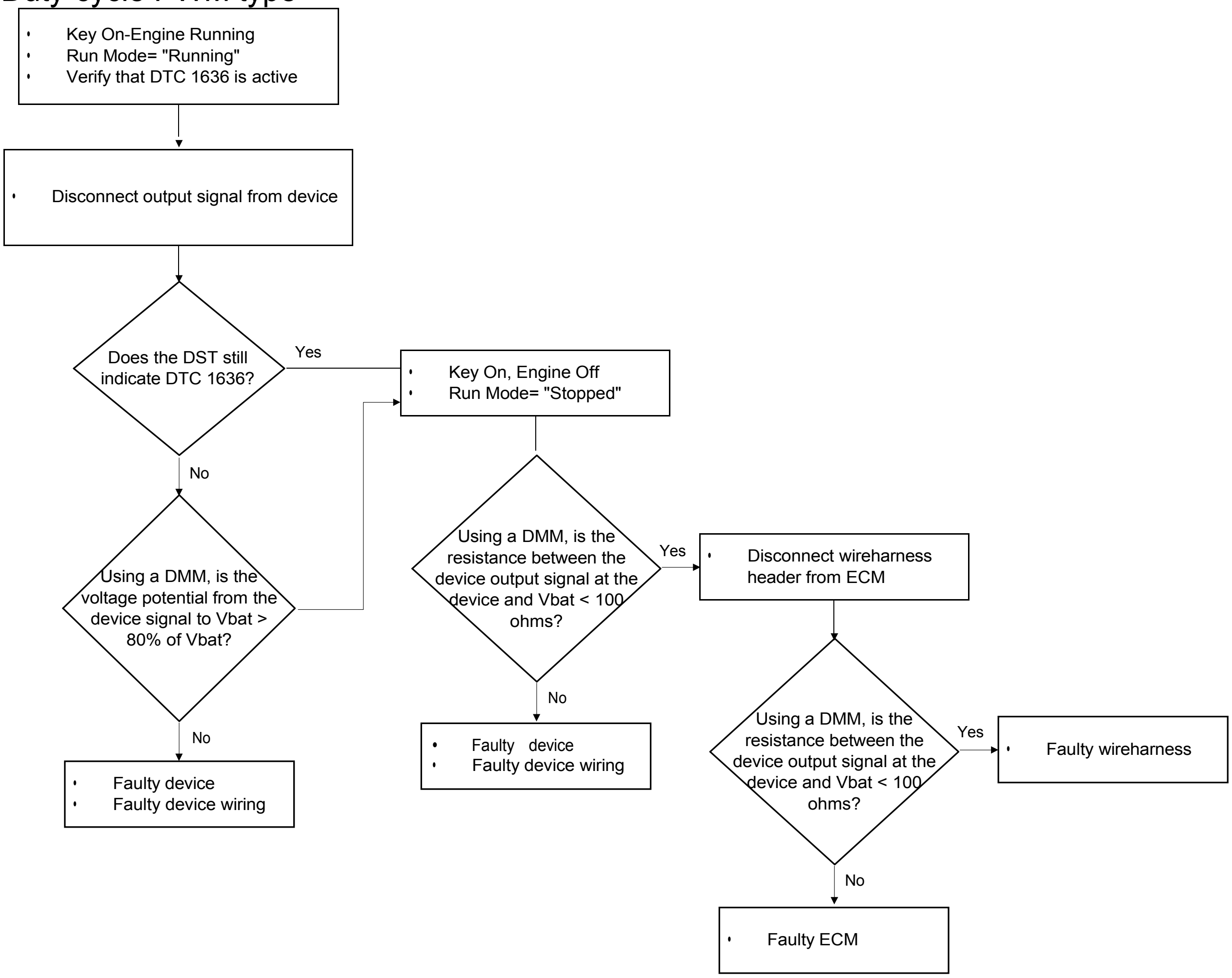
- Analog gauge, proportional actuator, on-off device
- Check Condition- Key-On, Engine On
- Fault Condition- AUX PWM3 output shorted to power
- Corrective Action(s)- Trigger buzzer/secondary warning device
- Non-emissions related fault

AUX_PWM3 is an output that, depending on the ECM hardware configuration, may be used to:

- Simulate the resistance of a sender to drive an analog gauge (Gauge driver config)
- PWM an analog gauge (PWM config)
- PWM the low-side of a on-off device (PWM config)
- PWM a proportional actuator (PWM config)

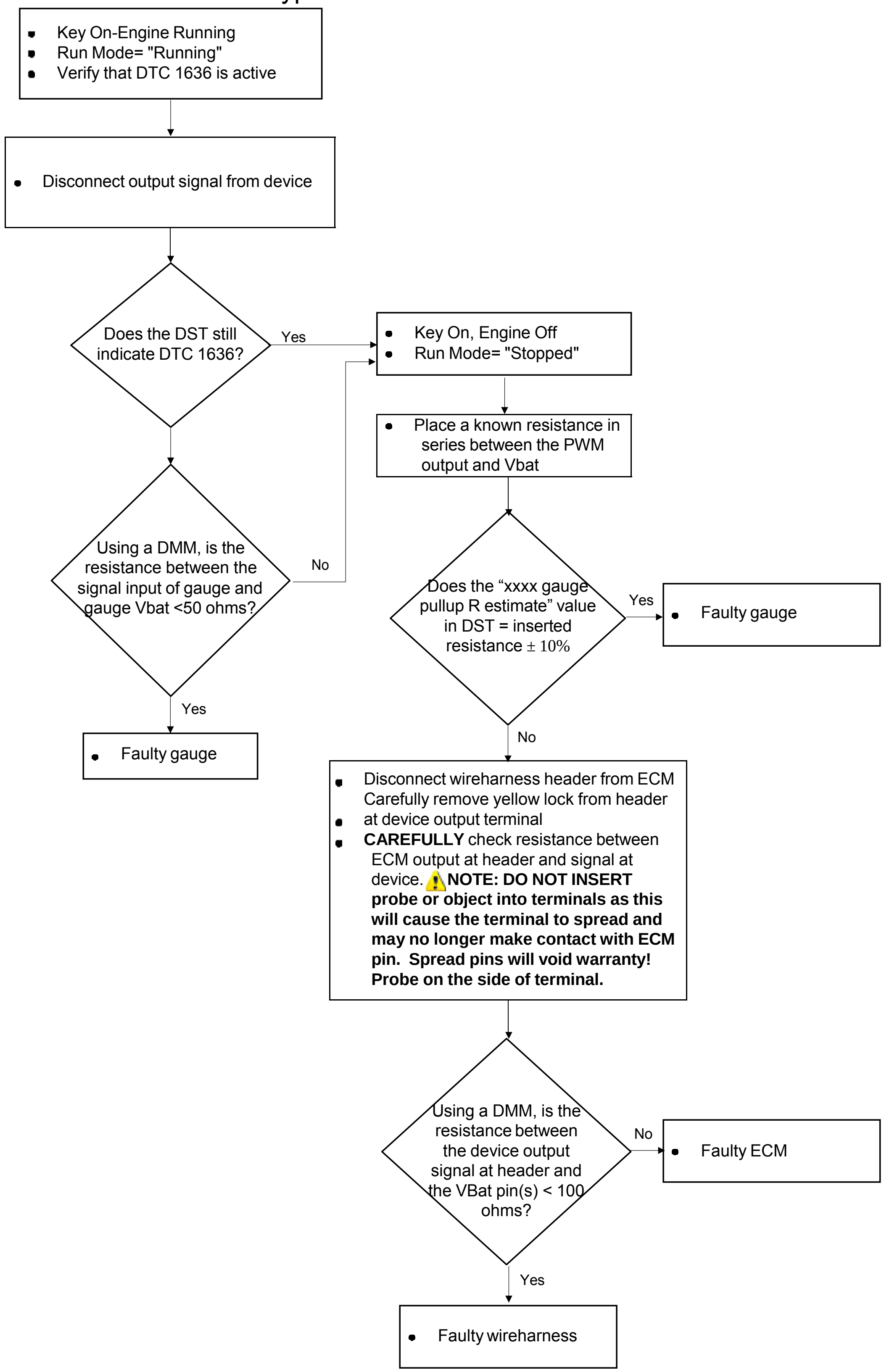
DTC 1636- PWM3/Gauge3 Short-To-Power

Duty-cycle PWM type

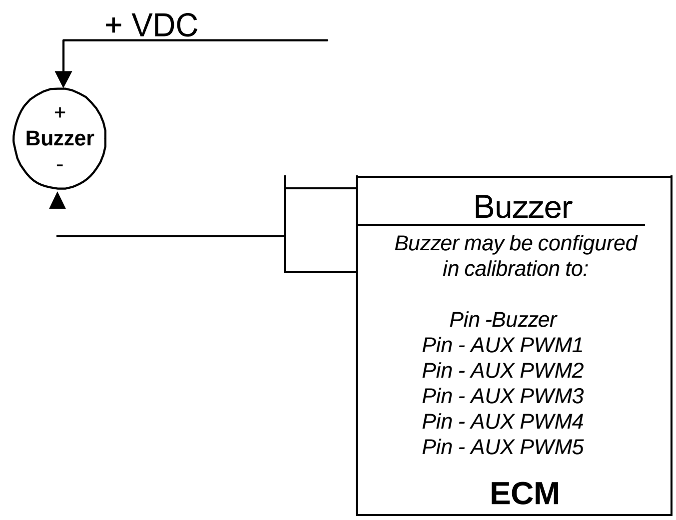


DTC 1636- PWM3/Gauge3 Short-To-Power

Resistance Simulation type



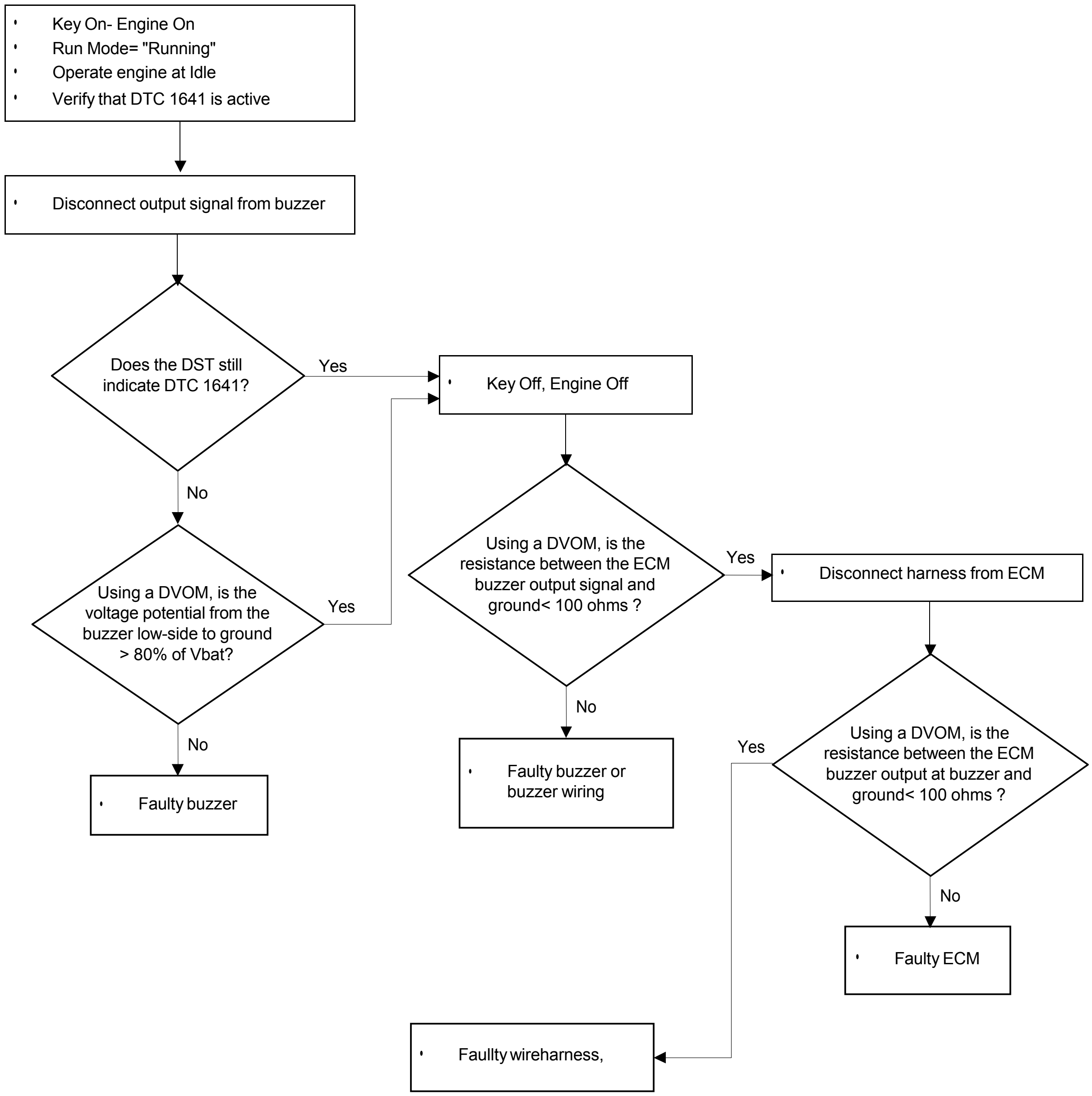
SPN 920, FMI 4 - Buzzer Control Ground Short



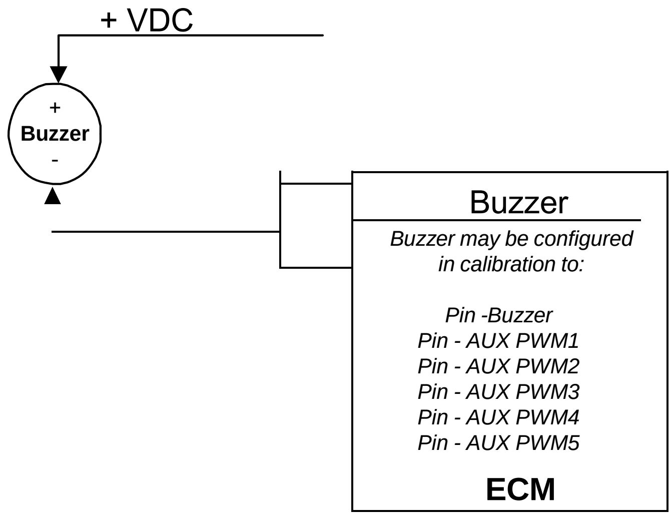
- Buzzer/Secondary warning device
- Check Condition- Key On, Engine On
- Fault Condition- ECM buzzer output shorted to ground
- Corrective Action(s)- Illuminate MIL
- Non-emissions related fault

This ECM output is used to provide a low-side switch to a secondary warning device such as an audible buzzer or secondary warning lamp.

SPN 920, FMI 4 - Buzzer Control Ground Short



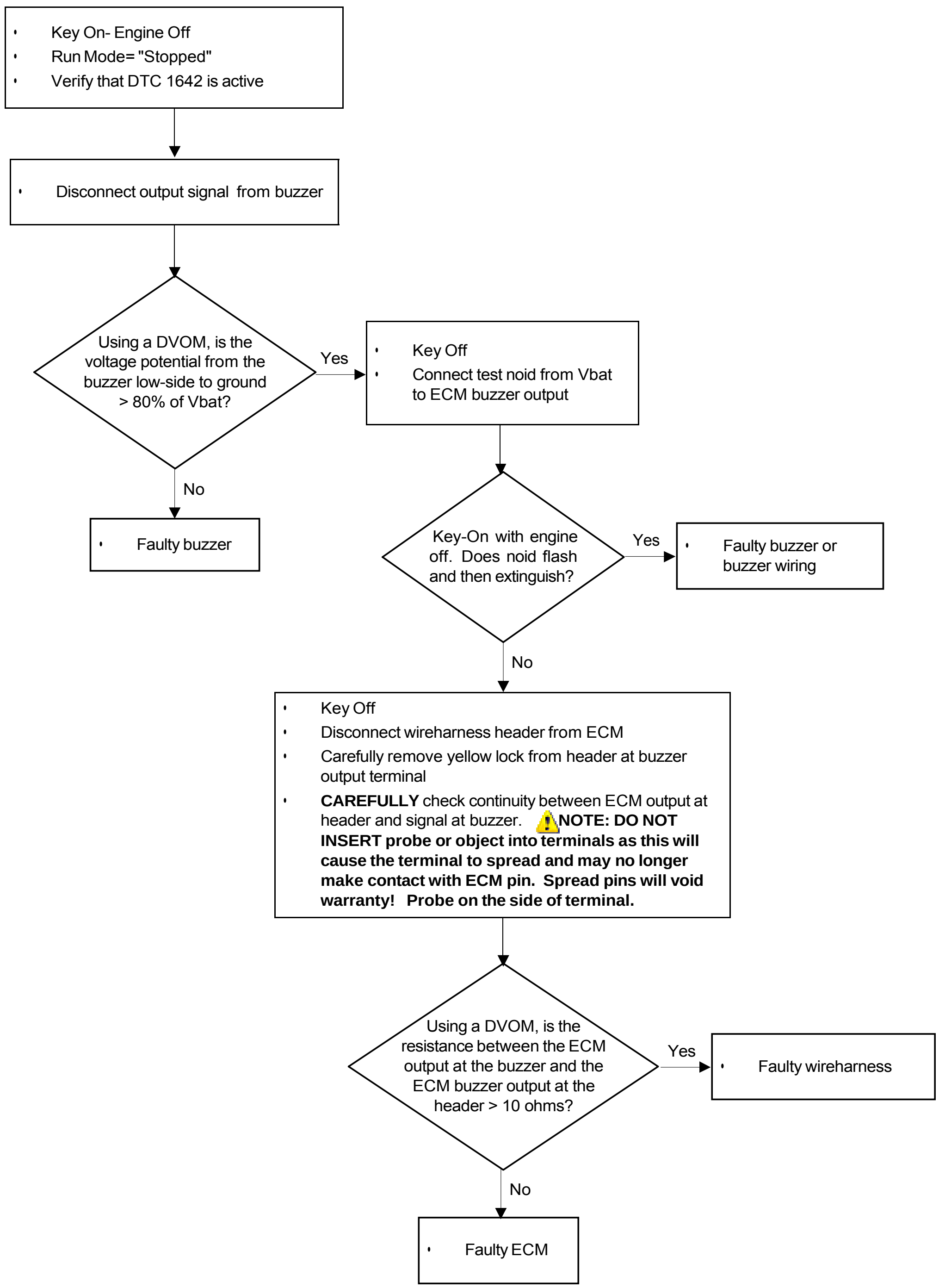
SPN 920, FMI 5 - Buzzer Open



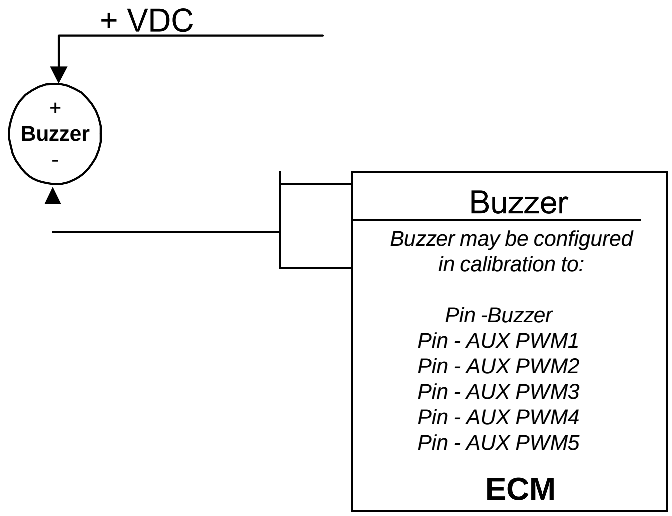
- Buzzer/Secondary warning device
- Check Condition- Key On, Engine Off
- Fault Condition- ECM buzzer output open circuit
- Corrective Action(s)- Illuminate MIL
- Non-emissions related fault

This ECM output is used to provide a low-side switch to a secondary warning device such as an audible buzzer or secondary warning lamp.

SPN 920, FMI 5 - Buzzer Open



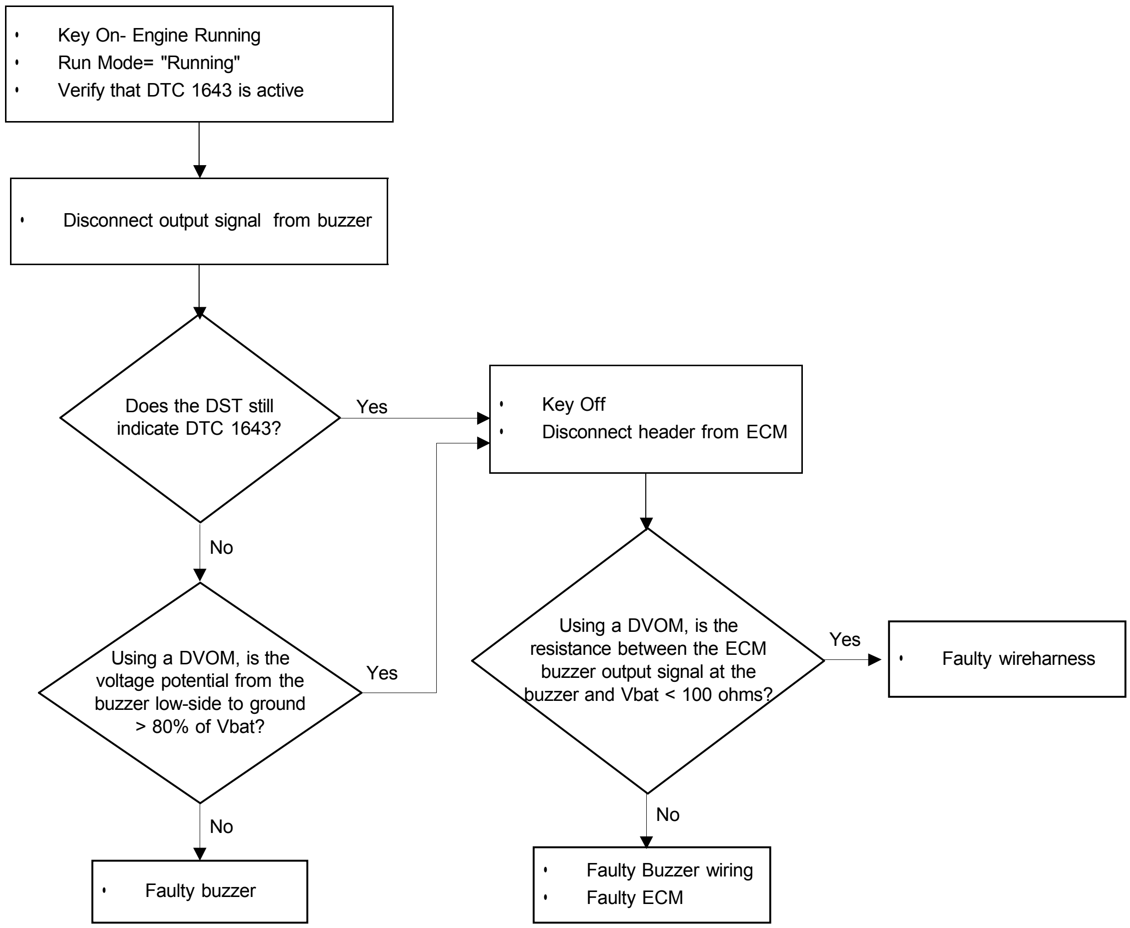
SPN 920, FMI 3 - Buzzer Control Short-To-Power



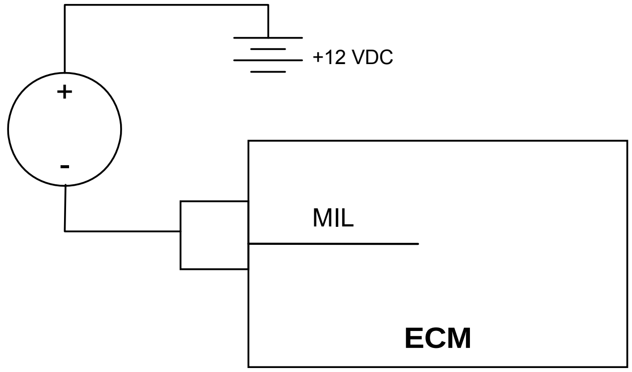
- Buzzer/Secondary warning device
- Check Condition- Key On, Engine On
- Fault Condition- ECM buzzer output shorted to power
- Corrective Action(s)- Illuminate MIL
- Non-emissions related fault

This ECM output is used to provide a low-side switch to a secondary warning device such as an audible buzzer or secondary warning lamp.

SPN 920, FMI 3 - Buzzer Control Short-To-Power



SPN 1213, FMI 4 - MIL Control Ground Short

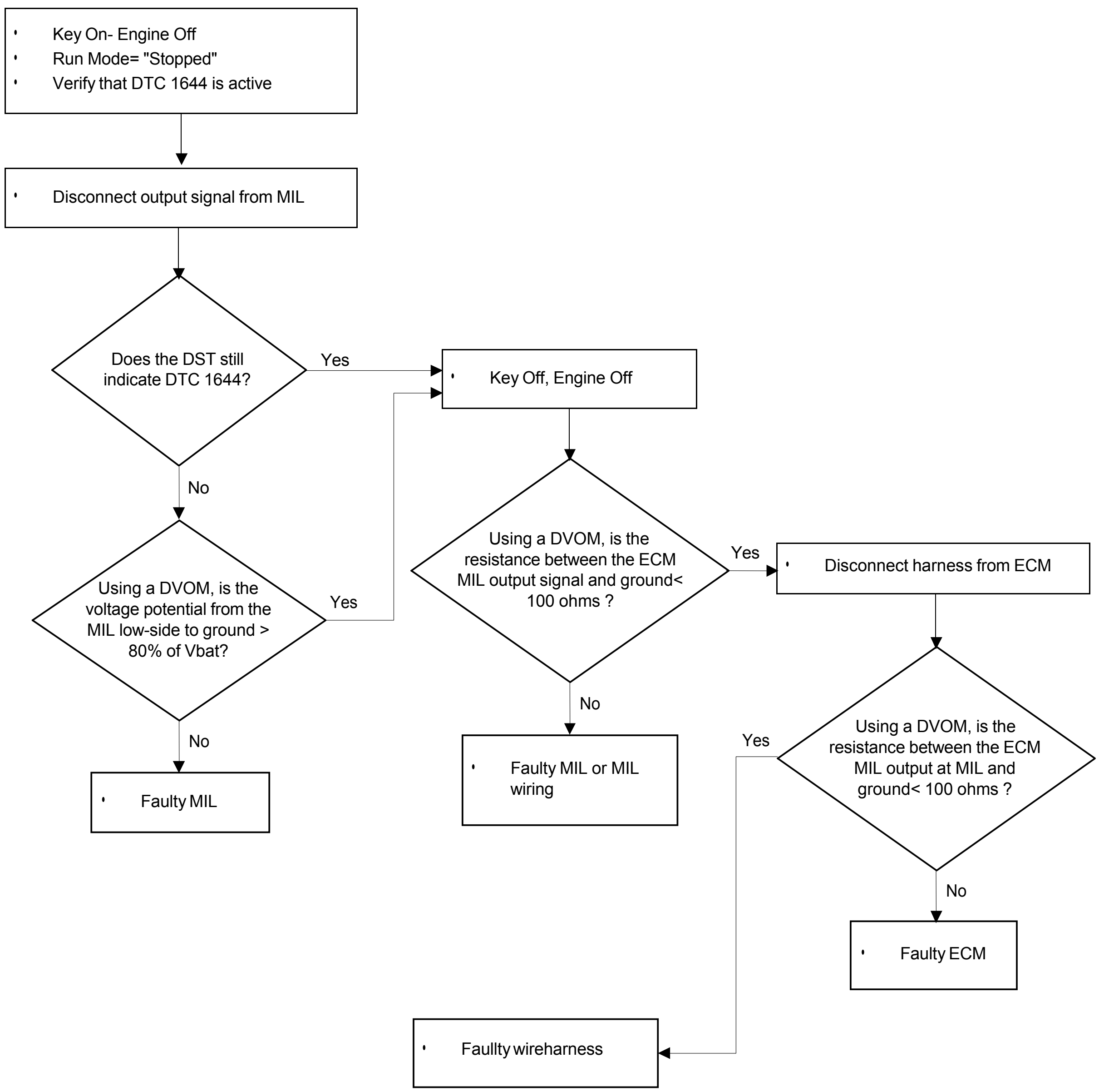


- MIL
- Check Condition- Key On, Engine Off or Running
- Fault Condition- ECM MIL output shorted to ground
- Corrective Action(s)- sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

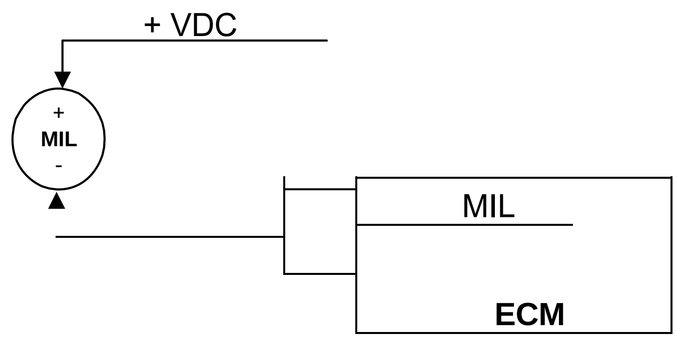
This ECM output is used to provide a low-side switch to a MIL that is used to indicate that an emission related fault has been set.

This fault will set if the ECM detects that there is a ground short of the MIL output.

SPN 1213, FMI 4 - MIL Control Ground Short



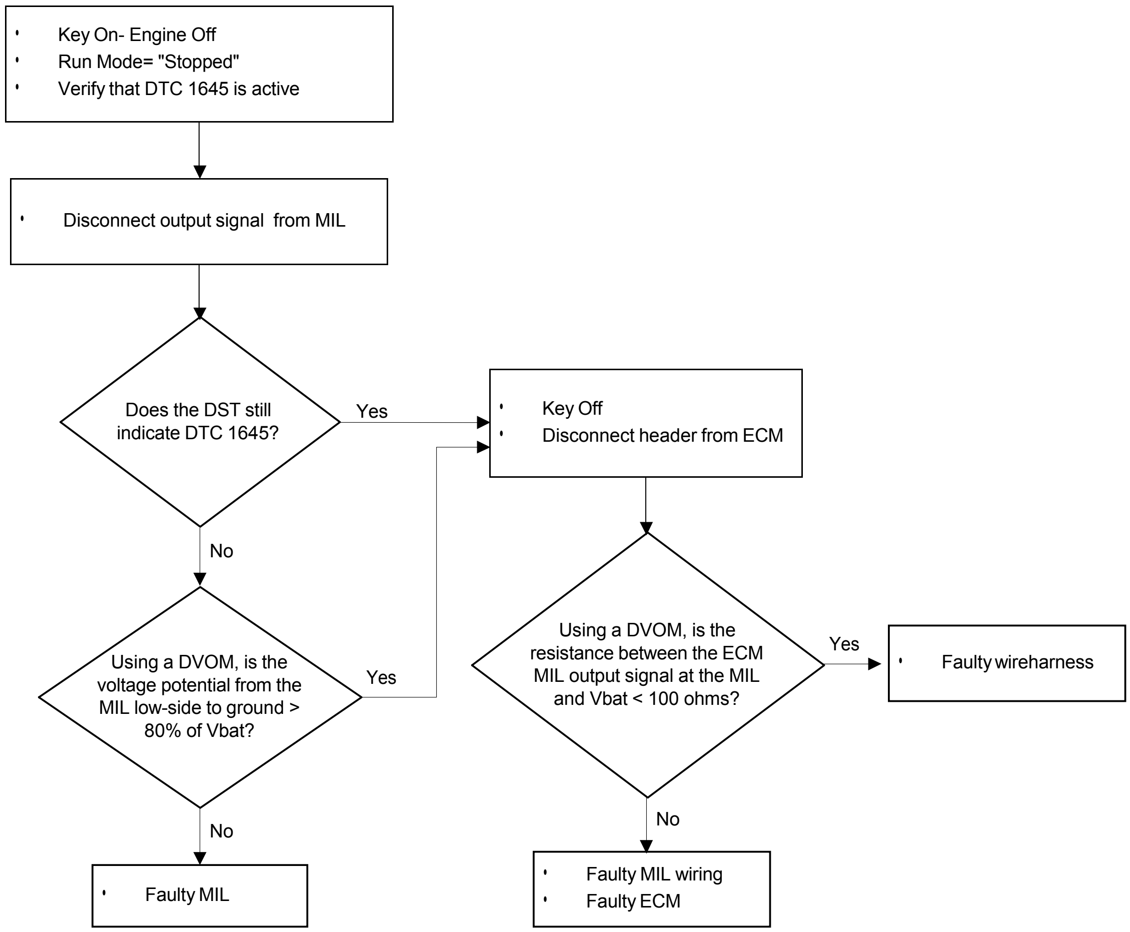
SPN 1213, FMI 3 - MIL Control Short to Power



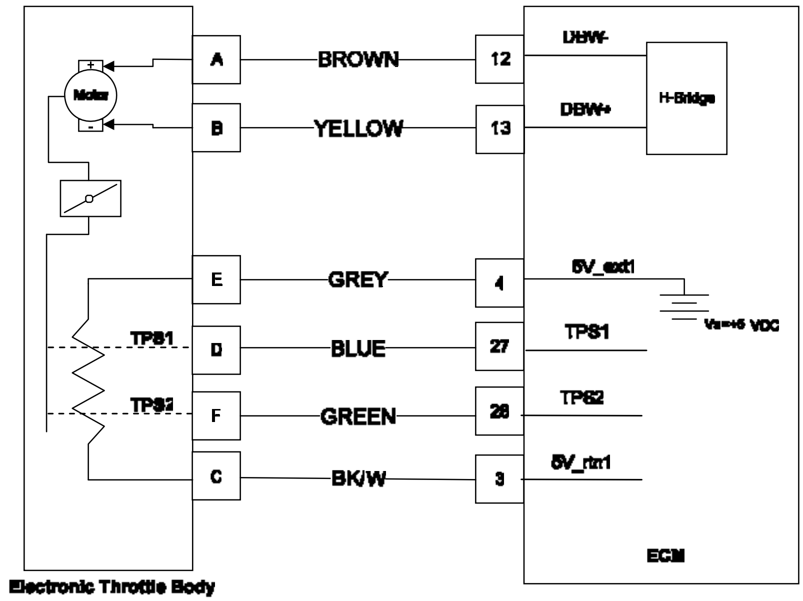
- MIL
- Check Condition- Key On, Engine Off
- Fault Condition- ECM MIL output shorted to power
- Corrective Action(s)- Trigger buzzer/secondary warning device
- Non-emissions related fault

This ECM output is used to provide a low-side switch to a MIL indicating an emission related fault has been set.

SPN 1213, FMI 3 - MIL Control Short to Power



<u>**SPN 51, FMI 7 - : Unable to Reach Lower TPS**</u>

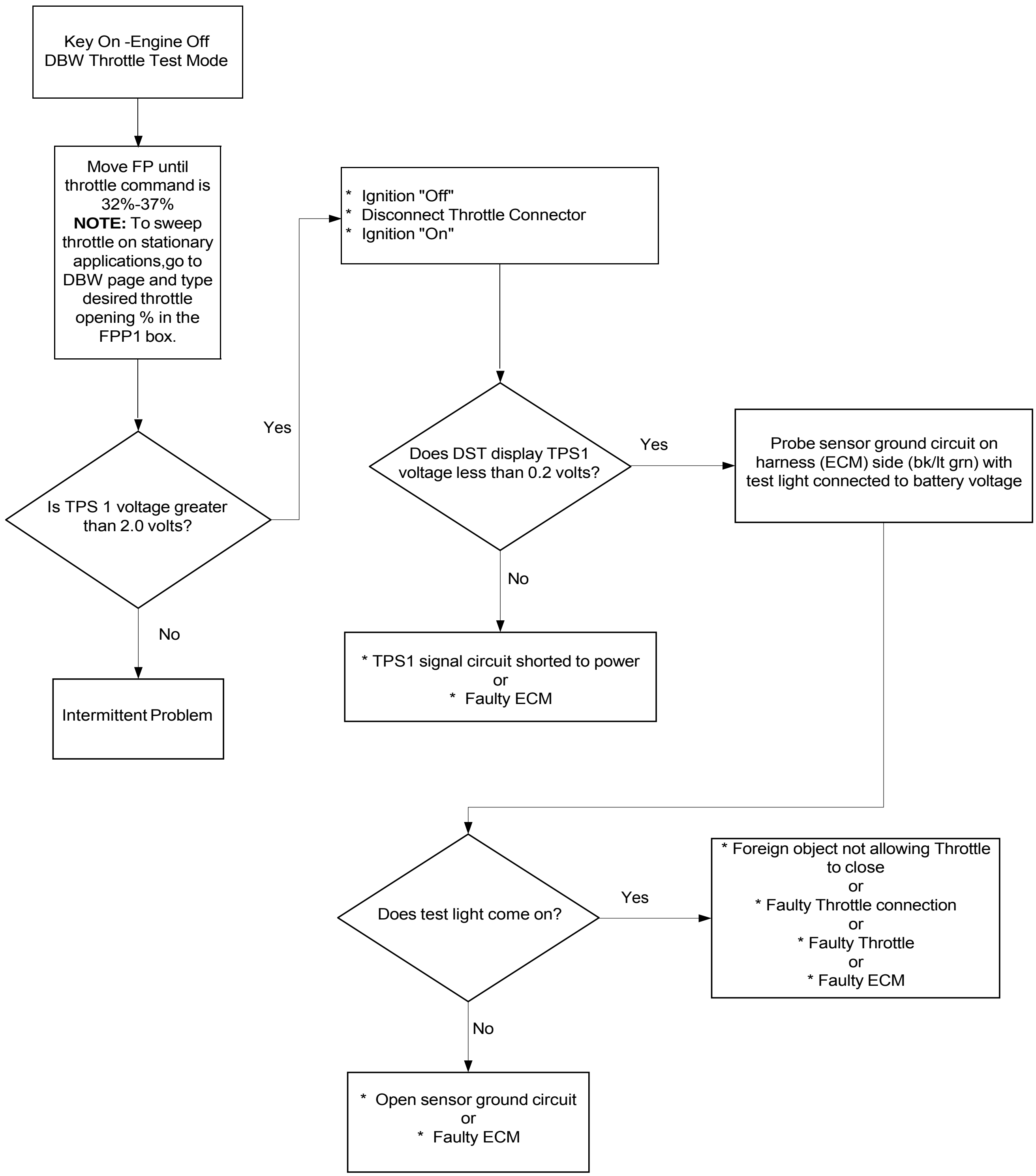


- Throttle Position Sensor
- Check Condition-Cranking or Running
- Fault Condition-Throttle command is 20% less than throttle position for 200ms or longer
- MIL-On during active fault
- Adaptive-Enabled
- Closed Loop-Enabled
- Engine Shut Down

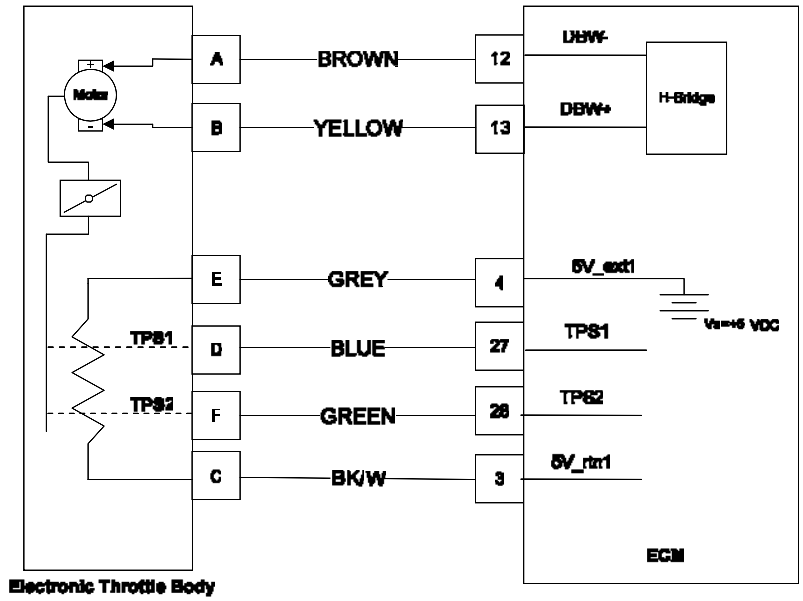
There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded.

This fault will set if the throttle command is 20% less than the actual throttle position. During this active fault the MIL light will be on and the engine will shut down.

SFC 638-Throttle Unable To Close



DTC 2112: Unable to Reach Higher TPS

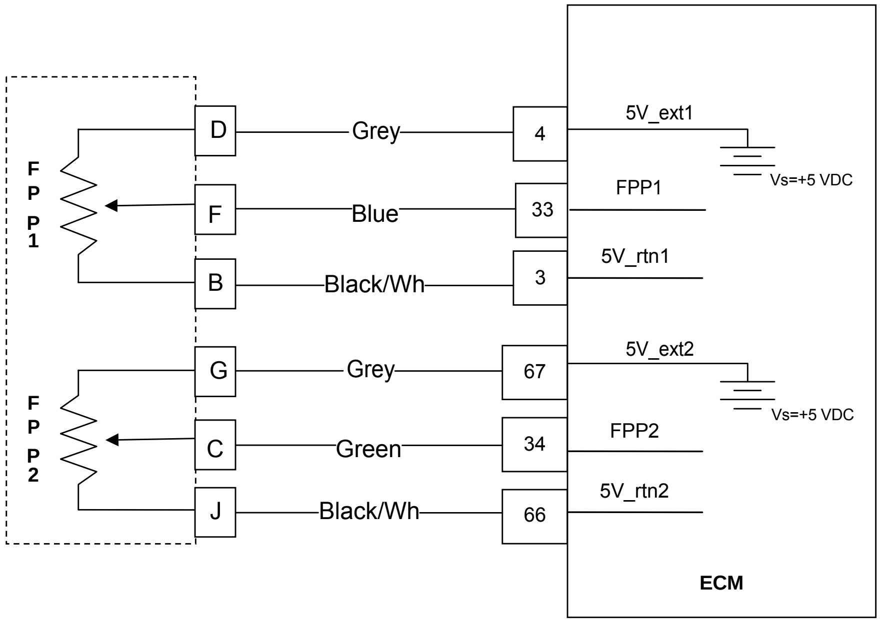


- Throttle Position Sensor
- Check Condition-Cranking or Running
- Fault Condition-Throttle command is 20% more than actual throttle position
- MIL-On during active fault
- Adaptive-Enabled
- Closed Loop-Enabled
- Engine Shut Down

There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded.

This fault will set if the throttle command is 20% or more than the actual throttle position. During this active fault the MIL light will be on and the engine will shut down.

SPN 91, FMI 18 - FPP1 Lower than FPP2

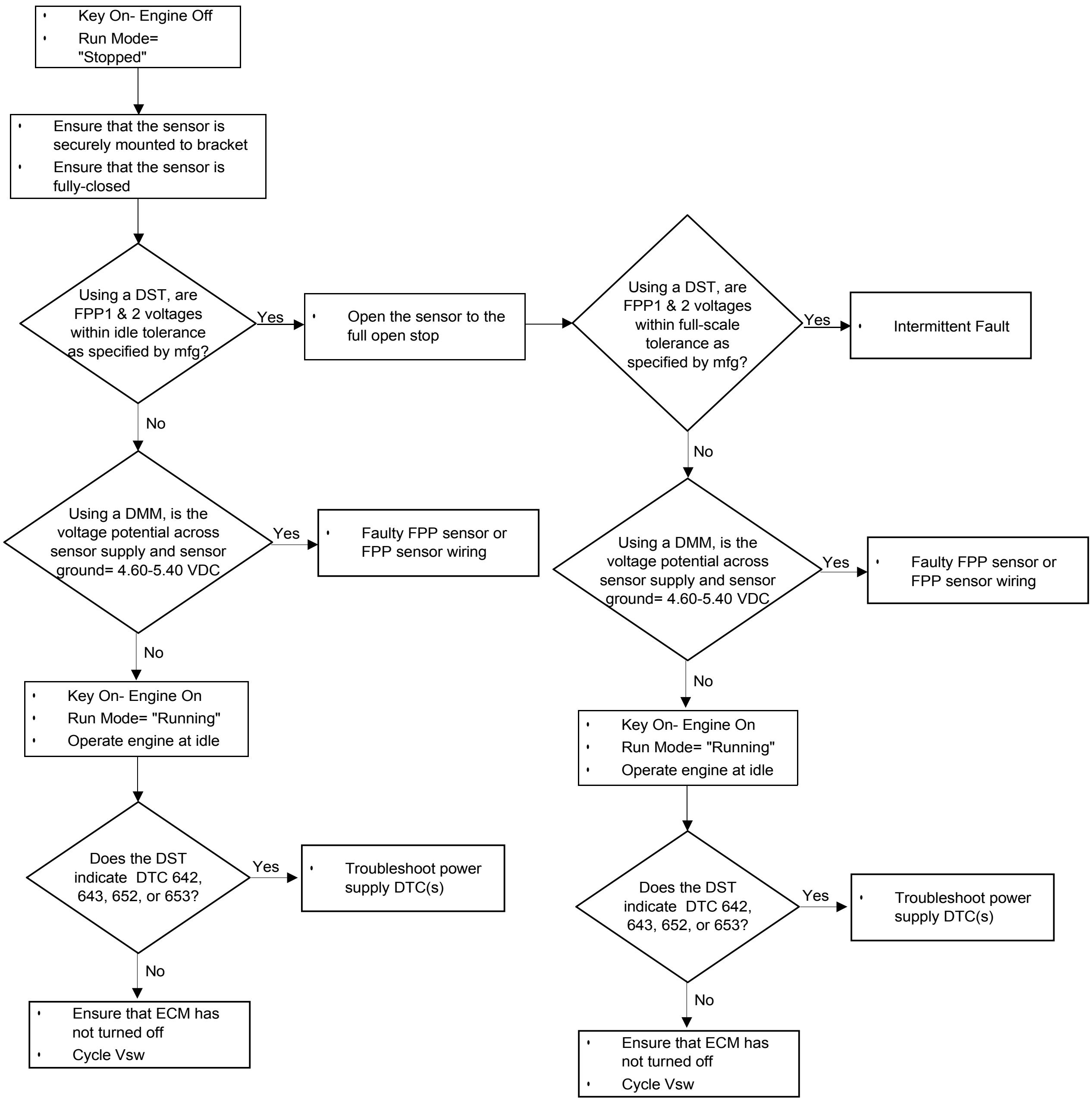


- Electronic foot pedal/throttle control sensor
- Check Condition- Key On, Engine Off
- Fault Condition- FPP1% lower than FPP2%
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp, and power derate, low rev limit, or forced idle
- Non-emissions related fault

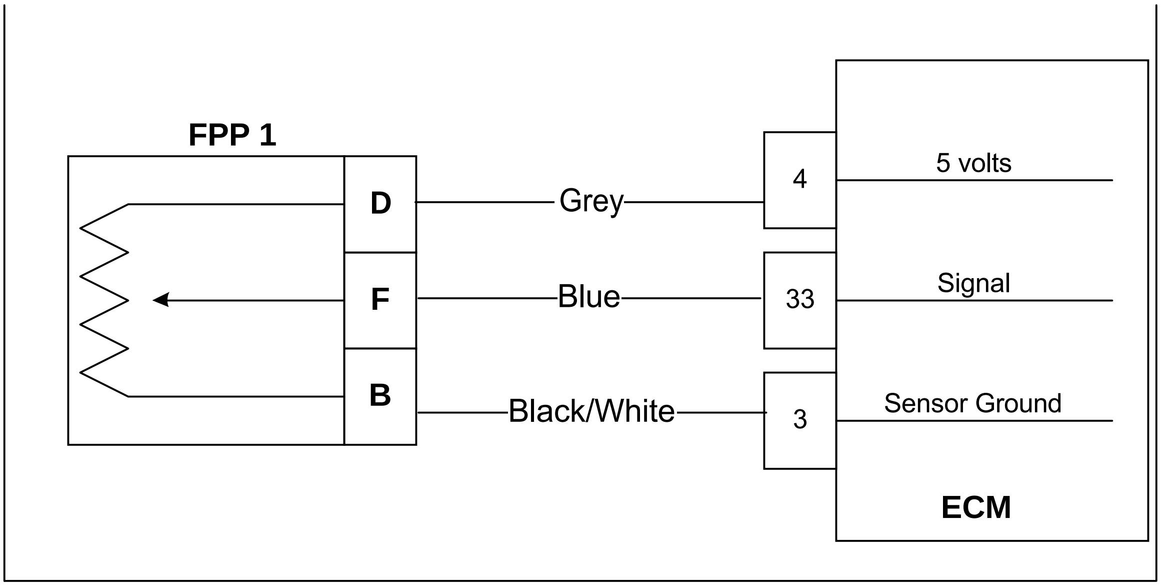
The FPP sensor is an electronic device that is coupled to a mechanically driven input as commanded by the vehicle/engine operator. A FPP sensor may be, but is not limited to a foot pedal assembly, a cable-lever-sensor assembly, or a rotary potentiometer. General sensor configurations consist of single potentiometer with IVS, two potentiometers, or two potentiometers with IVS. The FPP sensor outputs are proportional to the commanded input. The ECM uses the FPP sensor inputs to control the throttle and adjust the engine's load in order to achieve the requested power. Since the FPP sensor inputs directly affect the engine's power output, redundant sensors are generally used to ensure safe, reliable operation.

This fault indicates that the measured % deflection of sensor 1 is less than sensor 2 by an amount defined in calibration.

SPN 91, FMI 18 - FPP1 Lower than FPP2



SPN 91, FMI 3 - FPP1 Voltage High

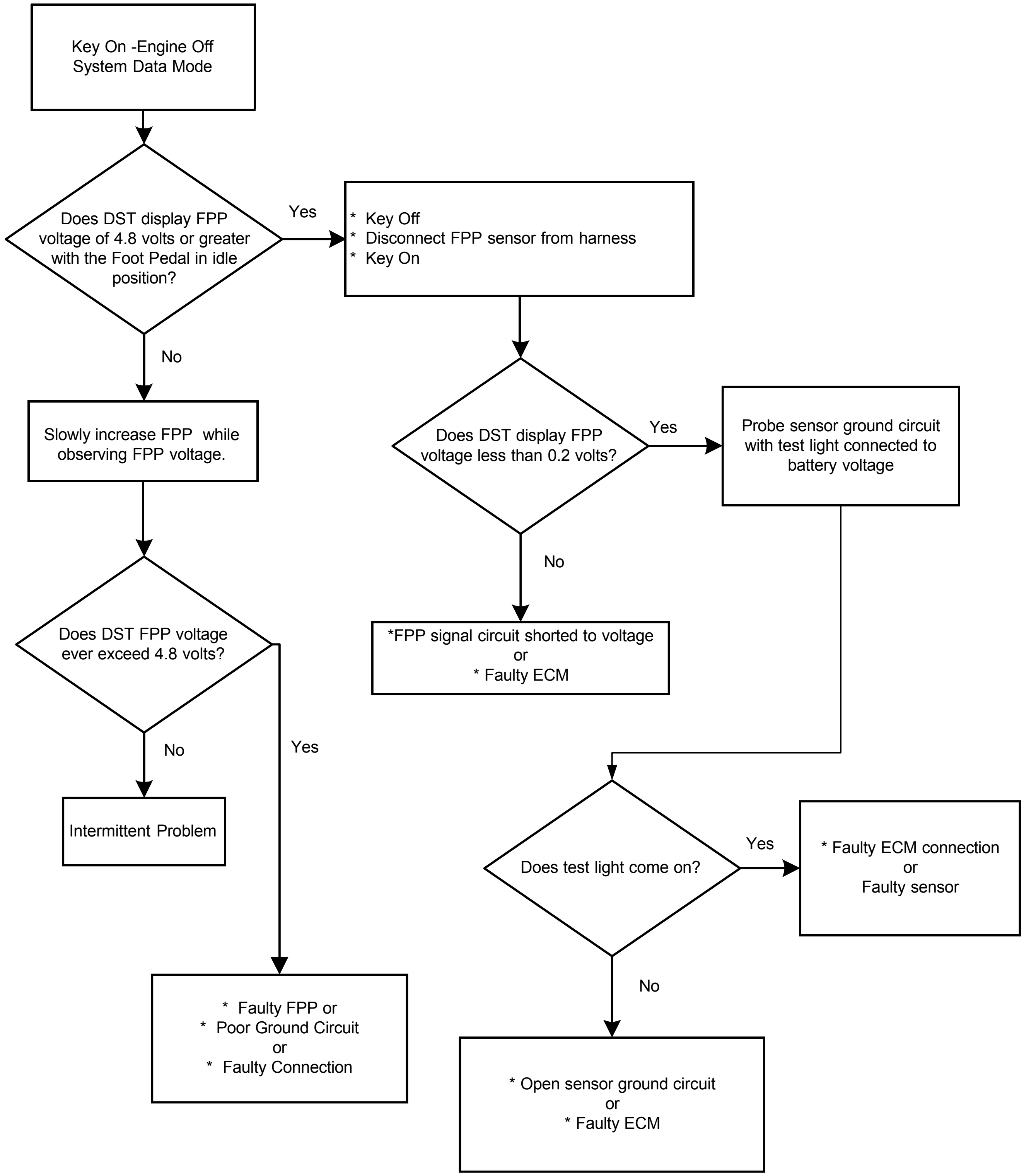


- Foot Pedal Position
- Check Condition-Key On
- Fault Condition-FPP1 sensor voltage exceeds 4.8
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycle
- Adaptive-Enabled
- Closed Loop-Enabled
- Power Derate (level 1) and Low Rev Limit enforced

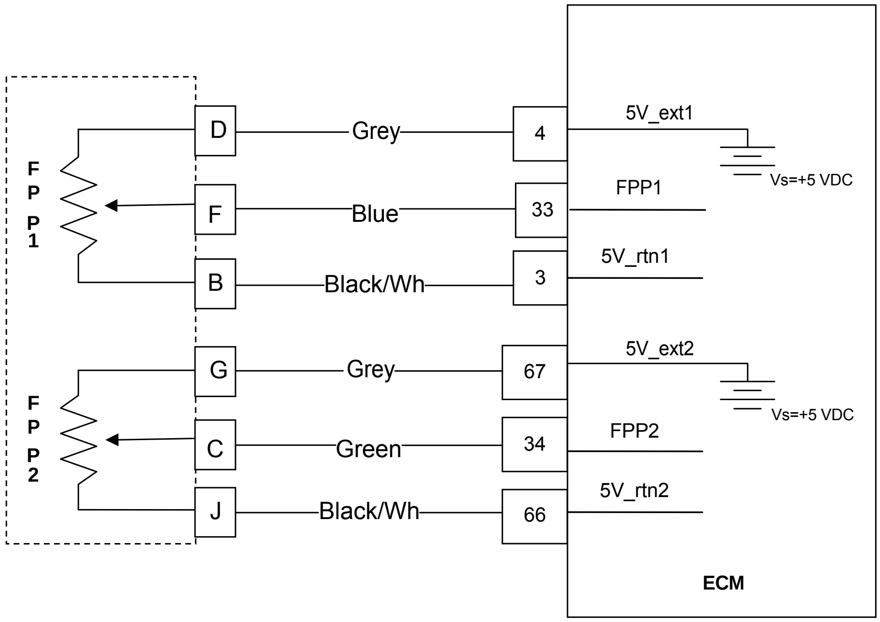
The Foot Pedal Position sensor uses a variable resistor to determine signal voltage based on pedal position. Less depression of pedal results in lower voltage, and greater depression results in higher voltage.

This fault will set if voltage is over 4.8 volts at any operating condition while the key is on. If the voltage exceeds 4.8, then FPP is considered to be out of specifications. At this point the ECM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level 1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1600 RPM. The Low Rev Limit is enforced for the remainder of the key-on cycle. Rev limit is still enforced if the active fault is no longer present; the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Low Rev Limit is still enforced.

SFC 611-FPP High Voltage



SPN 520199, FMI11 - FPP2 Invalid Voltage and FPP1 Disagrees with IVS



- Electronic foot pedal/throttle control sensor
- Check Condition- Key On, Engine Off
- Fault Condition- FPP2 VDC out-of-range, FPP1% does not match IVS state
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp, and forced idle
- Non-emissions related fault

The FPP sensor is an electronic device that is coupled to a mechanically driven input as commanded by the vehicle/engine operator. A FPP sensor may be, but is not limited to a foot pedal assembly, a cable-lever-sensor assembly, or a rotary potentiometer. General sensor configurations consist of single potentiometer with IVS, two potentiometers, or two potentiometers with IVS. The FPP sensor outputs are proportional to the commanded input. The ECM uses the FPP sensor inputs to control the throttle and adjust the engine's load in order to achieve the requested power. Since the FPP sensor inputs directly affect the engine's power output, redundant sensors are generally used to ensure safe, reliable operation.

This fault is only applicable with dual potentiometer/single IVS sensors and indicates that FPP2 voltage is out-of-range and FPP1% does not correlate with the IVS state resulting in a loss of redundancy.

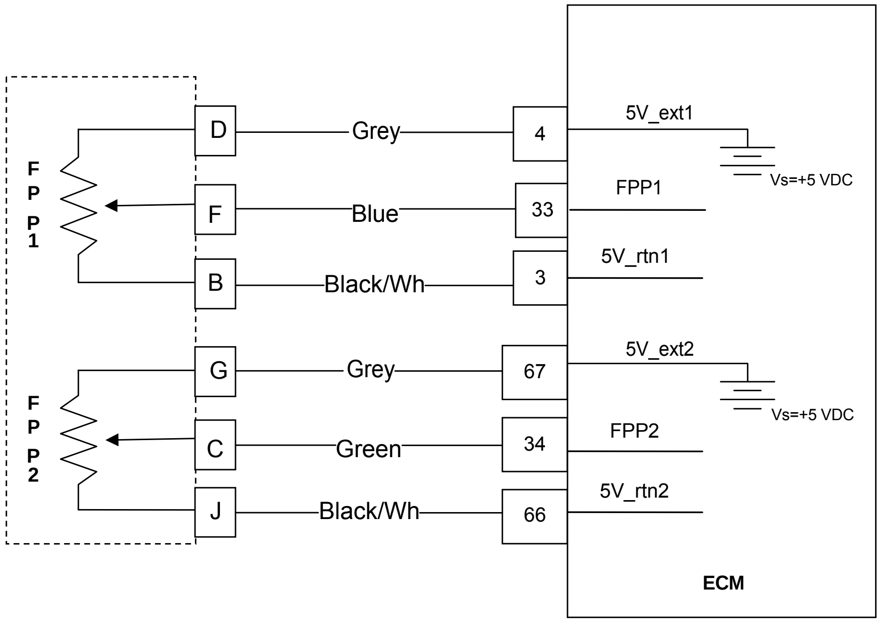
SPN 520199, FMI11 - FPP2 Invalid Voltage and FPP1 Disagrees with IVS

Diagnostic Aids

Troubleshoot *FPP2 voltage out-of-range* following DTC 2127 and 2128 procedures.

Troubleshoot *FPP1 disagrees with IVS* following DTC 2115 and 2139 procedures.

SPN 91, FMI 16 - FPP1 Higher than FPP2

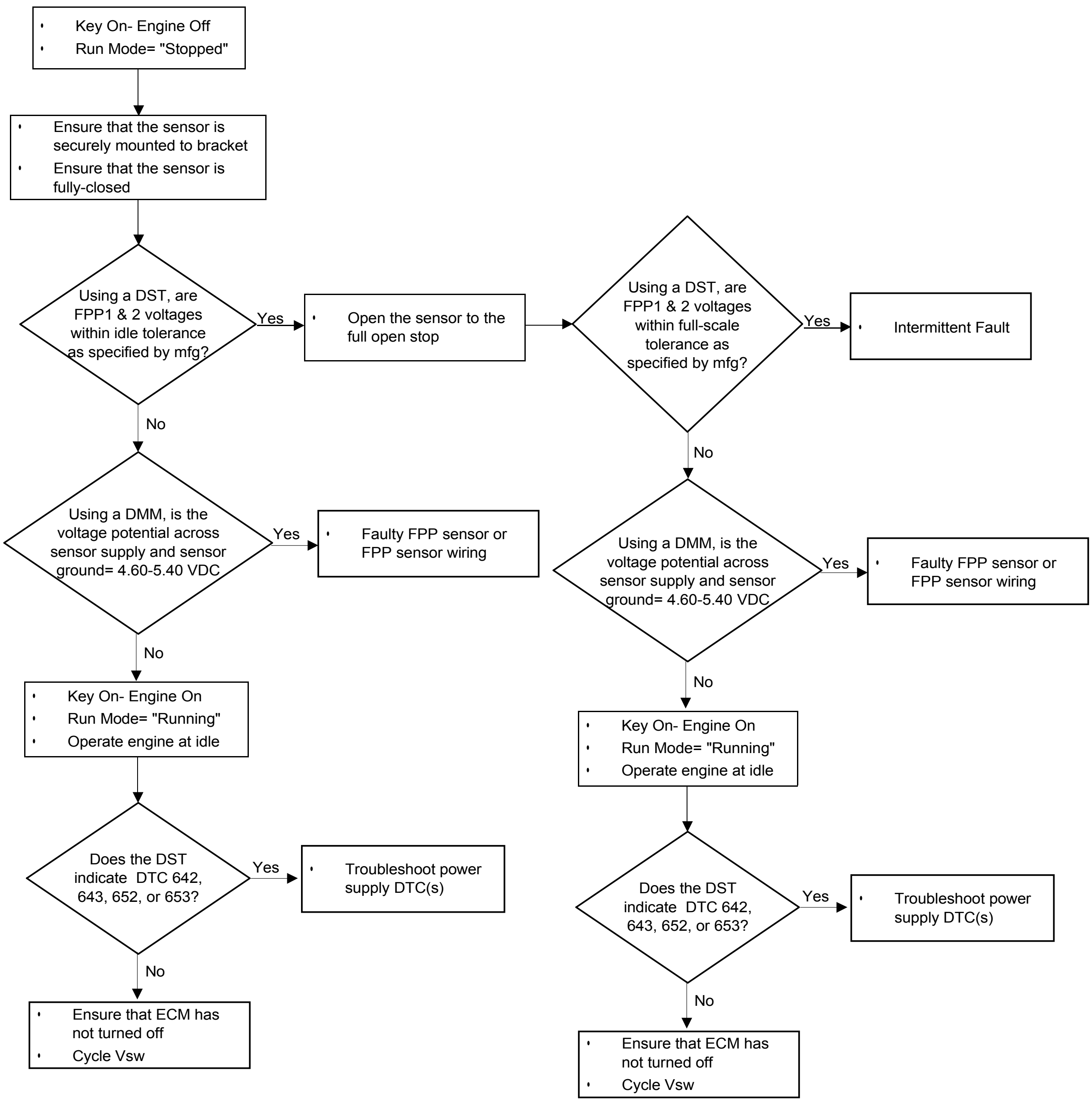


- Electronic foot pedal/throttle control sensor
- Check Condition- Key On, Engine Off
- Fault Condition- FPP1% higher than FPP2%
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp, and power derate, low rev limit, or forced idle
- Non-emissions related fault

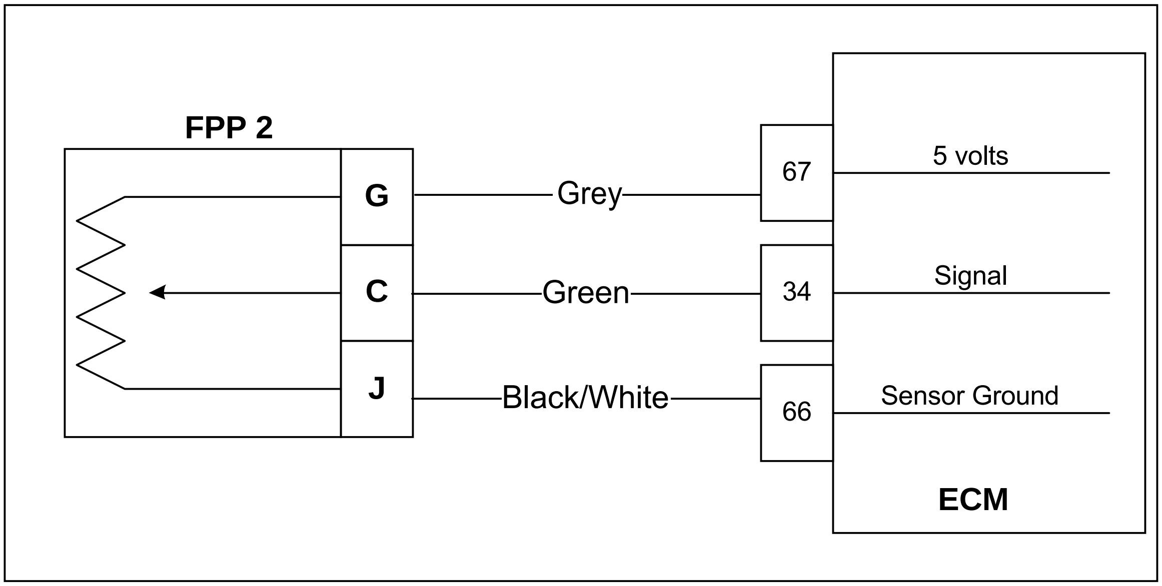
The FPP sensor is an electronic device that is coupled to a mechanically driven input as commanded by the vehicle/engine operator. A FPP sensor may be, but is not limited to a foot pedal assembly, a cable-lever-sensor assembly, or a rotary potentiometer. General sensor configurations consist of single potentiometer with IVS, two potentiometers, or two potentiometers with IVS. The FPP sensor outputs are proportional to the commanded input. The ECM uses the FPP sensor inputs to control the throttle and adjust the engine's load in order to achieve the requested power. Since the FPP sensor inputs directly affect the engine's power output, redundant sensors are generally used to ensure safe, reliable operation.

This fault indicates that the measured % deflection of sensor 1 is greater than sensor 2 by an amount defined in calibration.

SPN 91, FMI 16 - FPP1 Higher than FPP2



SPN 29, FMI 4 - FPP2 voltage low

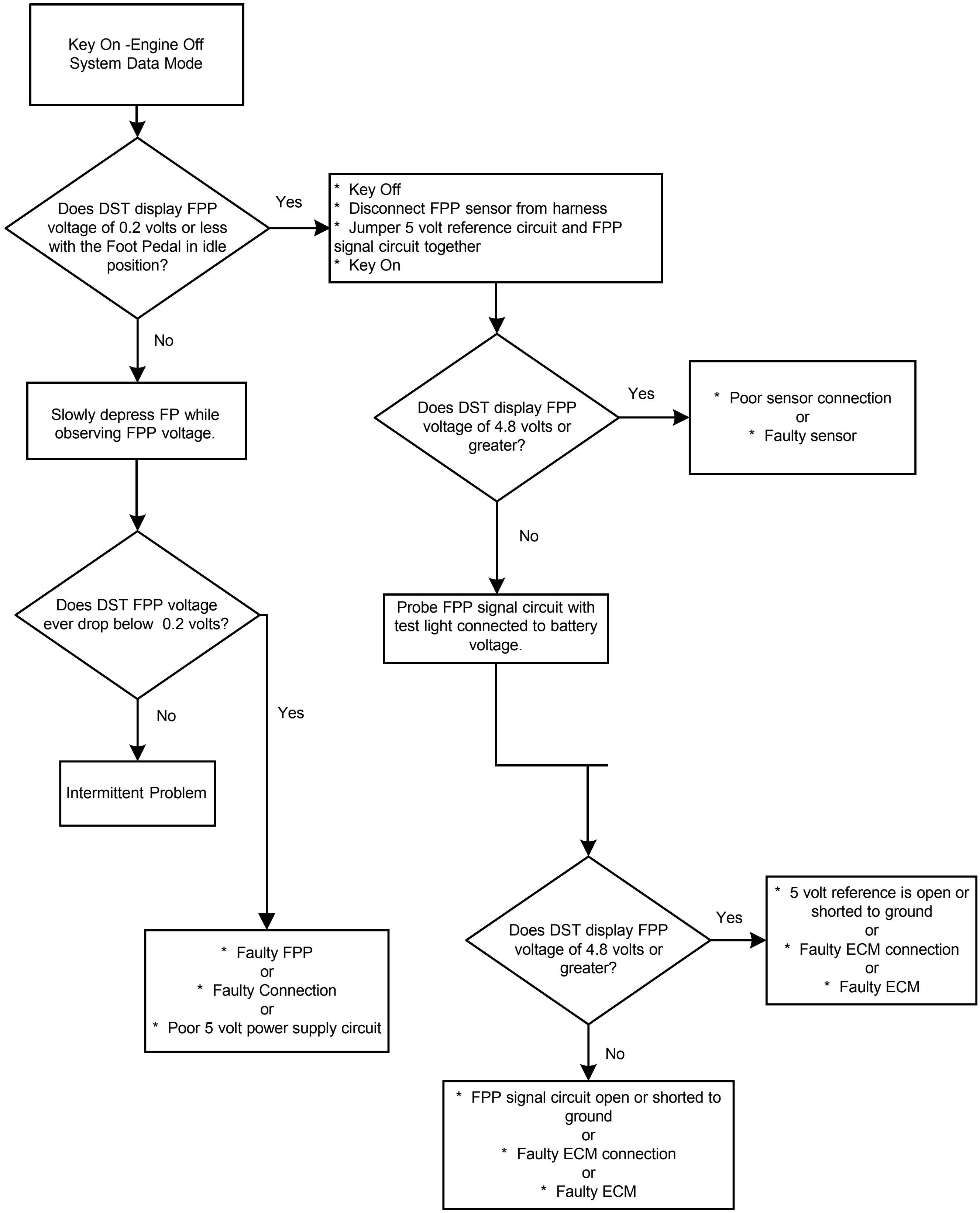


- Foot Pedal Position
- Check Condition-Key On
- Fault Condition-FPP sensor voltage less than 0.2
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycle
- Adaptive-Enabled
- Closed Loop-Enabled
- Power Derate (level 1) and Low Rev Limit enforced

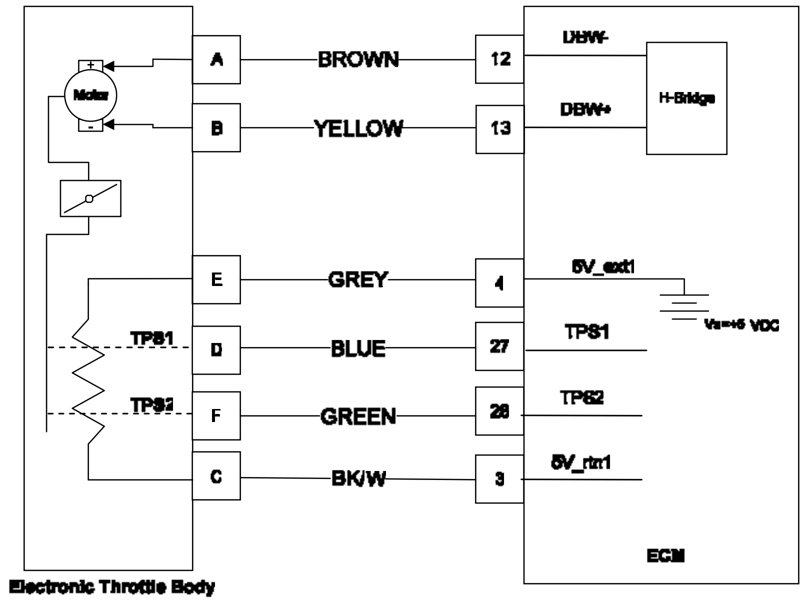
The Foot Pedal Position sensor uses a variable resistor to determine signal voltage based on pedal position. Less depression of pedal results in lower voltage, and greater depression results in higher voltage.

This fault will set if voltage is less than 0.2 volts at any operating condition while the key is on. If the voltage is less than 0.2, then FPP is considered to be out of specifications. At this point the ECM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level-1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1600 RPM. The low rev limit is enforced for the remainder of the key-on cycle. If the active fault is no longer present, the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Low Rev Limit is still enforced.

SFC 612-FPP Low Voltage



SPN 51, FMI 31 - TPS1/2 Simultaneous Voltages Out-of-Range



- Electronic throttle body
- Check Condition- Key On, Engine On
- Fault Condition- TPS1 and TPS2 voltages are both simultaneously out-of-range
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp, and shutdown engine
- Non-emissions related fault

The throttle is an air valve used to control the amount of air available to the engine for combustion and thereby the engine's power output. An electronic throttle simply means that a motor is controlled electronically through an electronic control system to actuate the throttle valve. Electronic throttle control is advantageous because it tends to offer improved starting, improved idle governing, improved maximum speed governing, excellent load acceptance and steady-state speed governing, permits engine synchronization, and offers flexibility to protect the engine during certain fault conditions.

This fault is generated when both feedback sensors in the ETB (TPS1 and TPS2) simultaneously produce out-of-range faults. This fault indicates that there is no feedback of the throttle valve and as a result throttle control cannot take place. This fault is, and should always be, configured to shut the engine down.

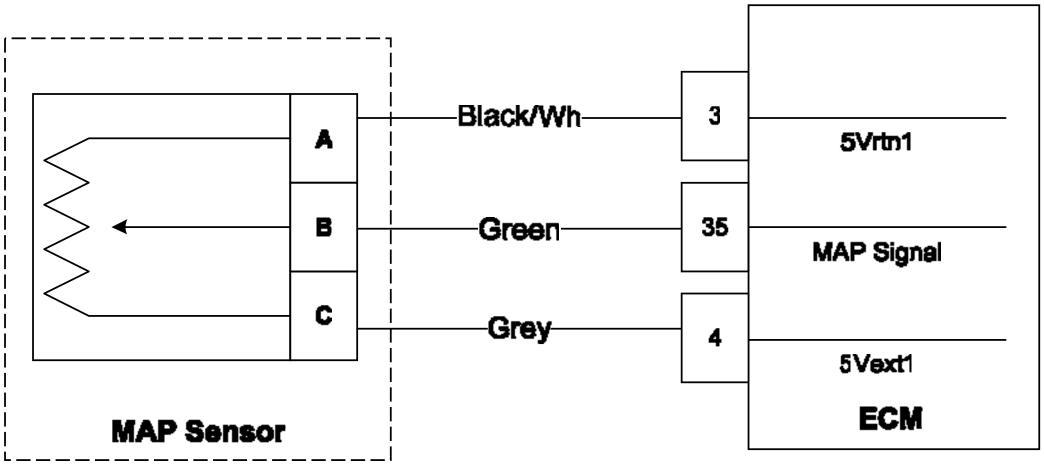
SPN 51, FMI 31 - TPS1/2 Simultaneous Voltages Out-of-Range

Diagnostic Aids

Troubleshoot according to *TPS1 voltage out-of-range* following DTC 122 and 123 procedures.

Troubleshoot according to *TPS2 voltage out-of-range* following DTC 222 and 223 procedures.

SPN 108, FMI 0 -BP High Pressure

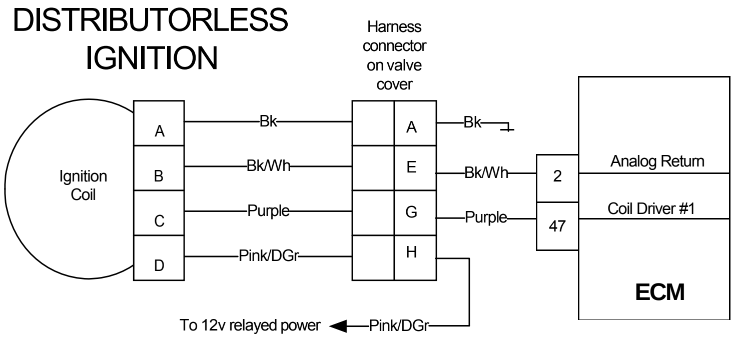


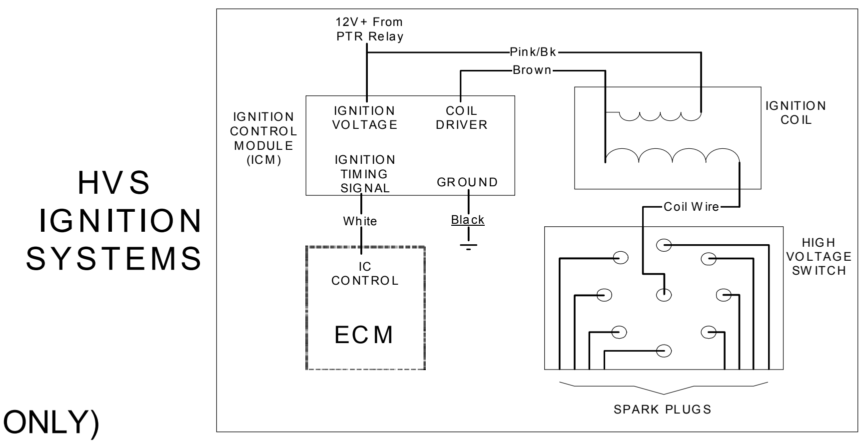
- Barometric Pressure
- Check Condition-Key On, Engine Off or after BP estimate during low-speed/high load operation
- Fault Condition-Barometric Pressure is greater than y psia
- Corrective Action(s): Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle
- Emissions related fault

Barometric Pressure is estimated from the MAP sensor at key-on and in some calibrations during low speed/high load operation as defined in the engine's calibration. The barometric pressure value is used for fuel and airflow calculations.

This fault sets if the barometric pressure is higher than y psia as defined in the diagnostic calibration.

SPN 1268, FMI 5 - Spark Coil #1 Primary Open/Short-to-Ground





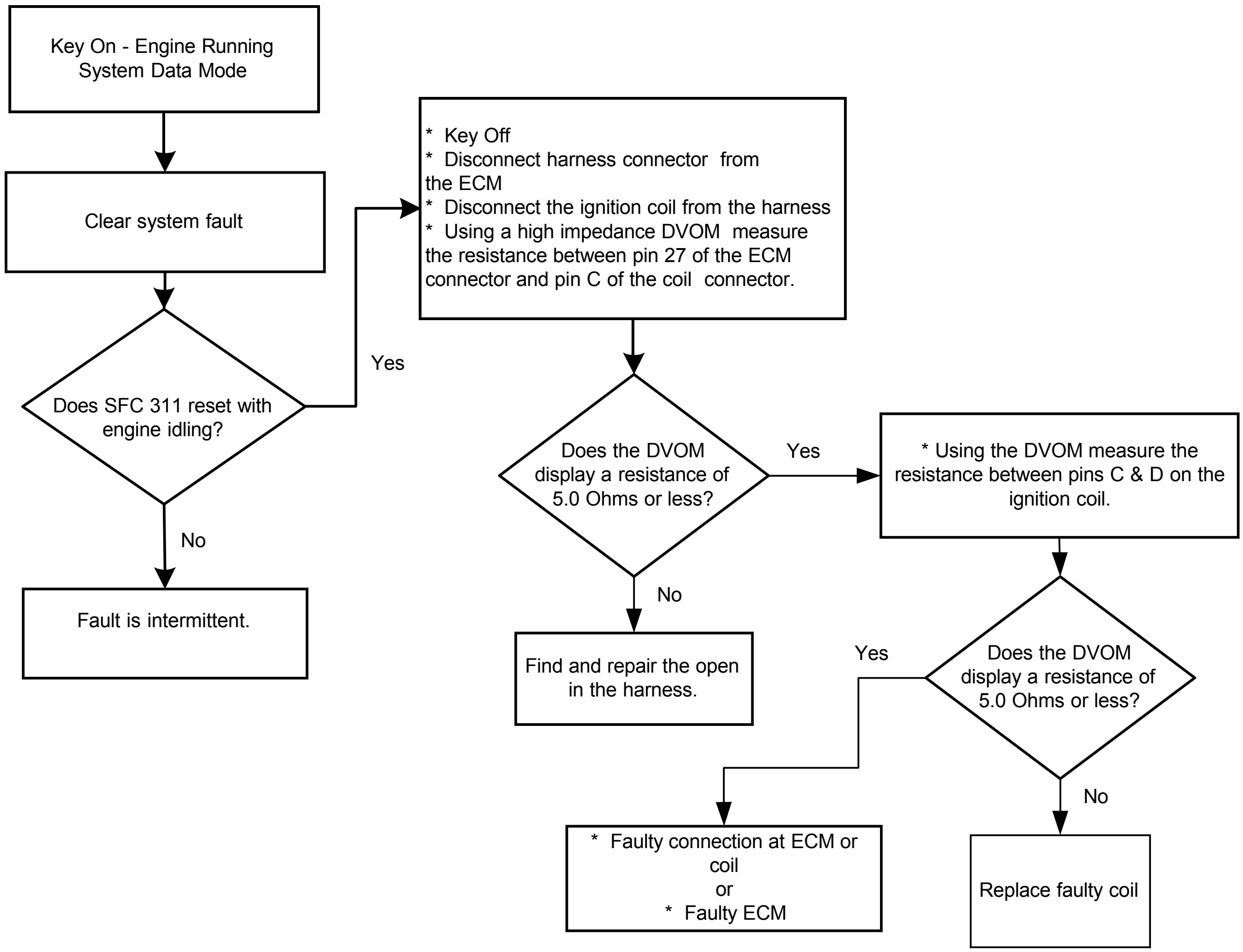
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is an open circuit or shorted-to-ground
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #1 fires either the 1st cylinder in the firing order or the 1st cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

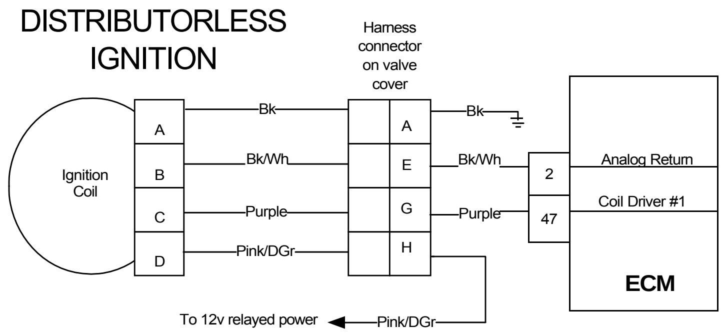
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is greater than y ms. or the total dwell is greater than w ms. and battery voltage is greater than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-ground or open circuit in the harness or internal to the primary coil.

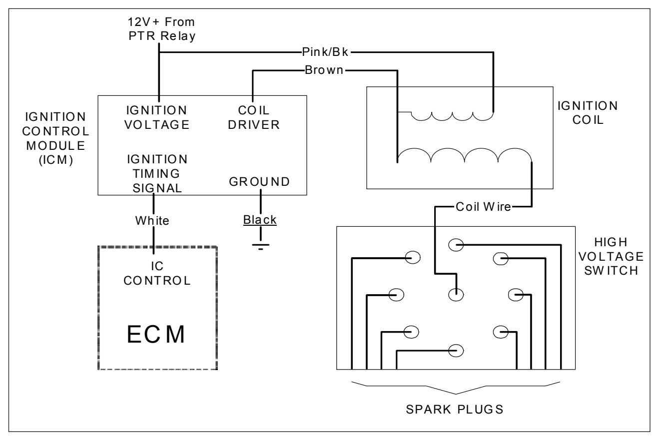
SFC 311-Coil Driver #1 Open



SPN 1268, FMI 6 - Spark Coil #1 Primary Short-to-Power



HVS
IGNITION
SYSTEMS



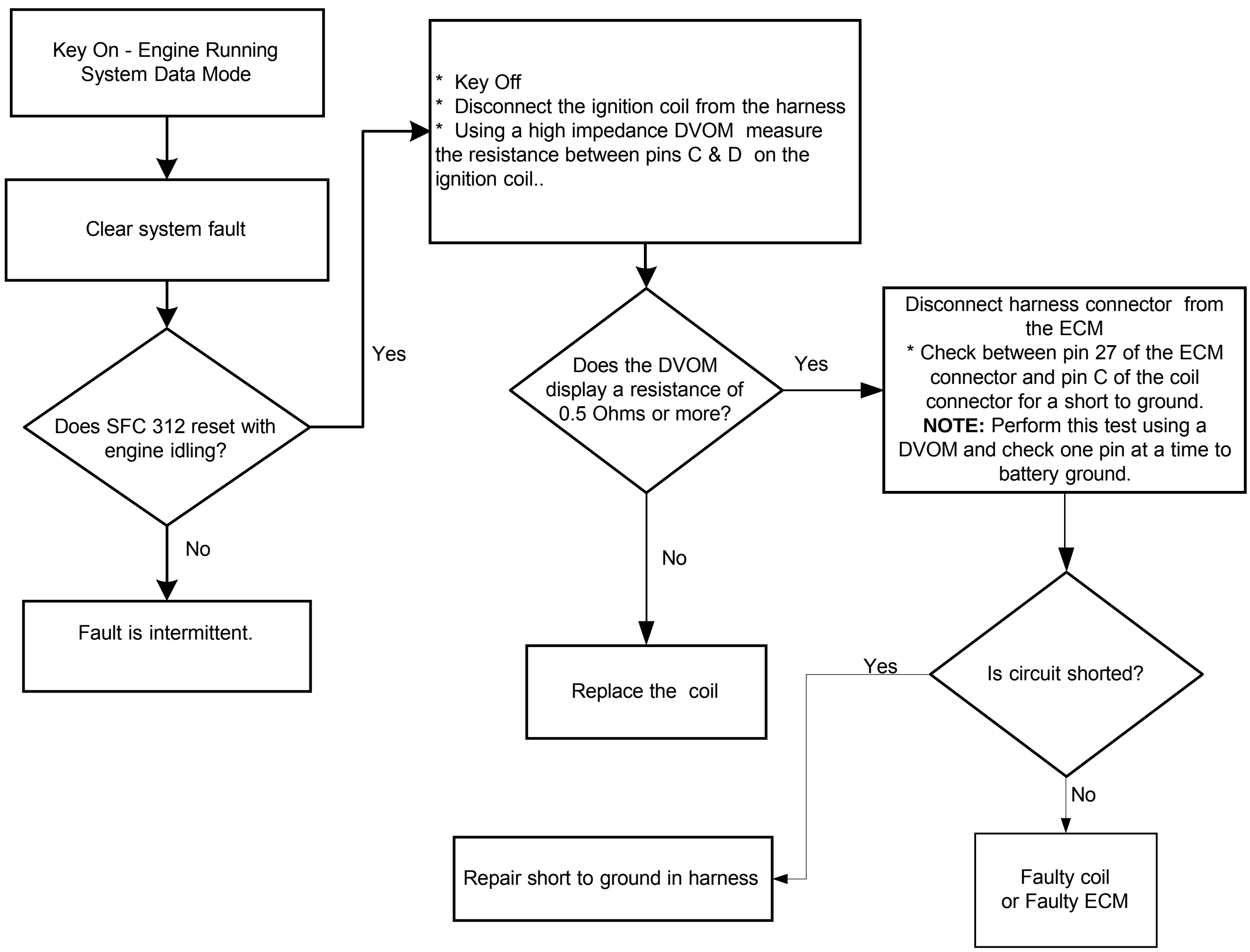
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is shorted-to-power
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #1 fires either the 1st cylinder in the firing order or the 1st cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

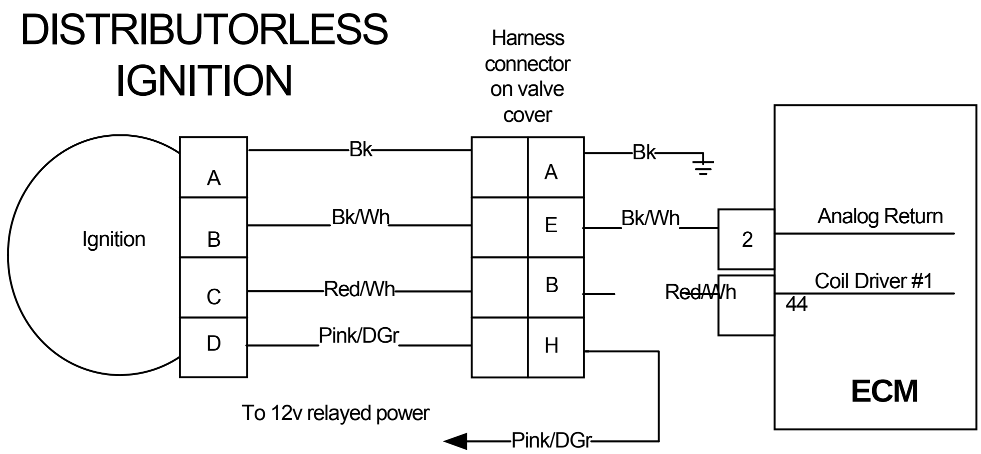
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is less than y ms. or the total dwell is less than w ms. and battery voltage is less than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-power in the harness or internal to the primary coil.

SFC 312-Coil Driver #1 Shorted



SPN 1269, FMI 5 - Spark Coil #2 Primary Open/Short-to-Ground



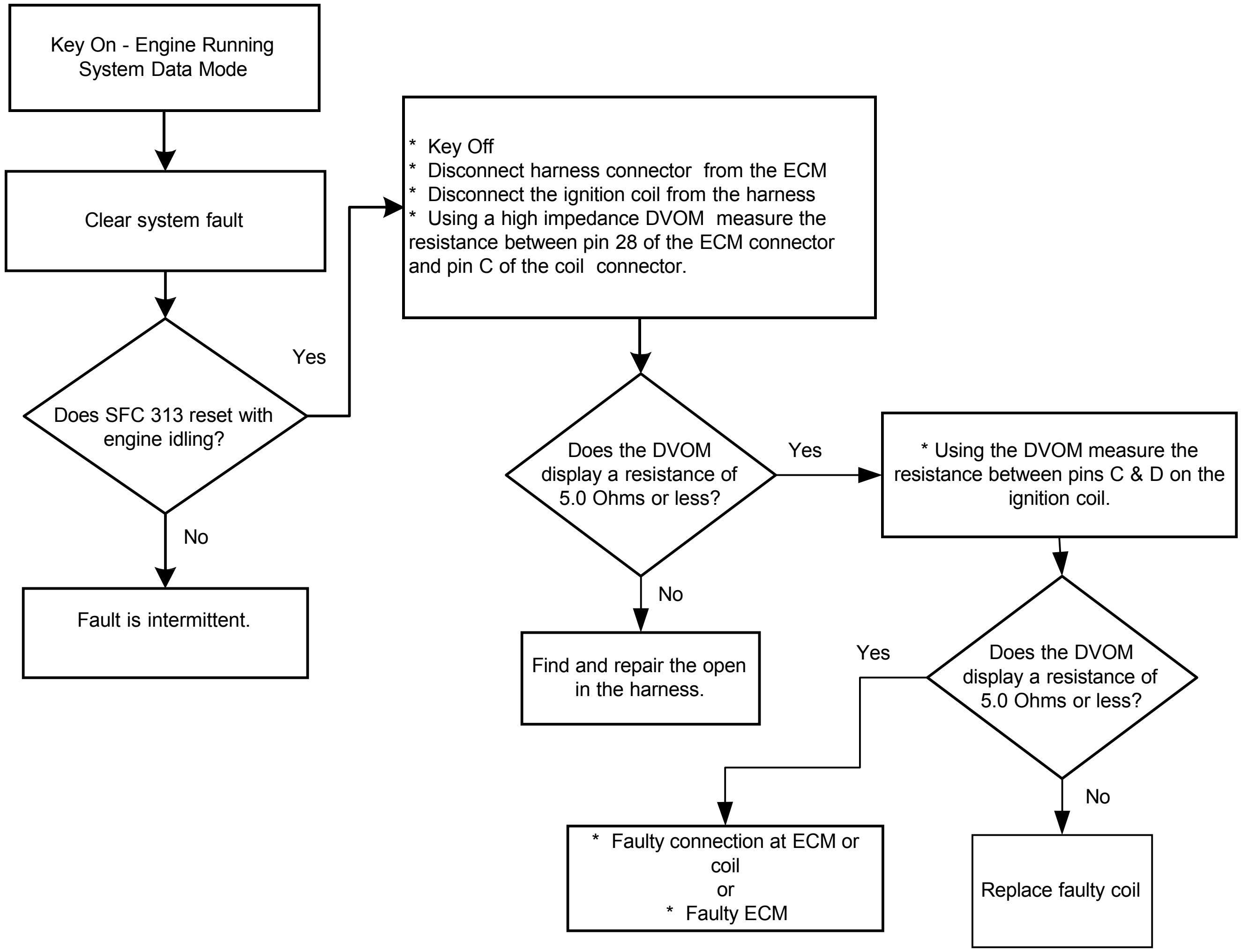
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is an open circuit or shorted-to-ground
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #2 fires either the 2nd cylinder in the firing order or the 2nd cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

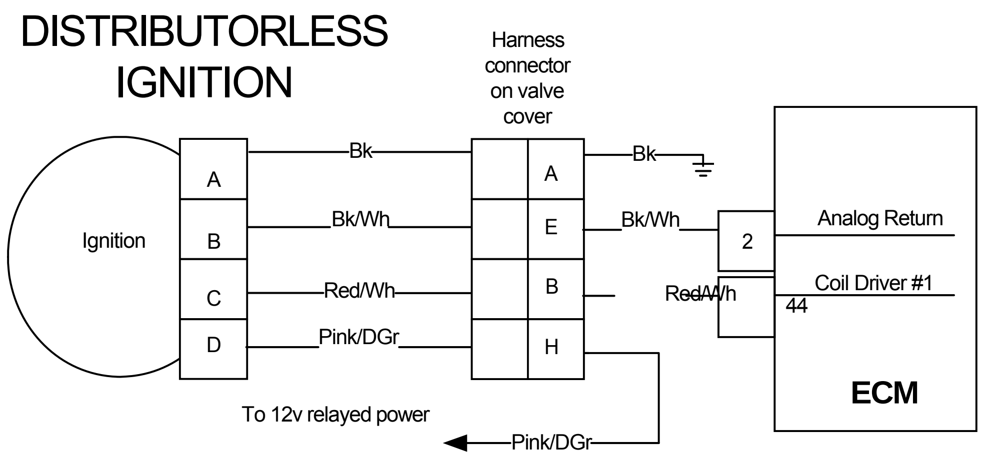
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is greater than y ms. or the total dwell is greater than w ms. and battery voltage is greater than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-ground or open circuit in the harness or internal to the primary coil.

SFC 313-Coil Driver #2 Open



SPN 1269, FMI 6- Spark Coil #2 Primary Short-to-Power



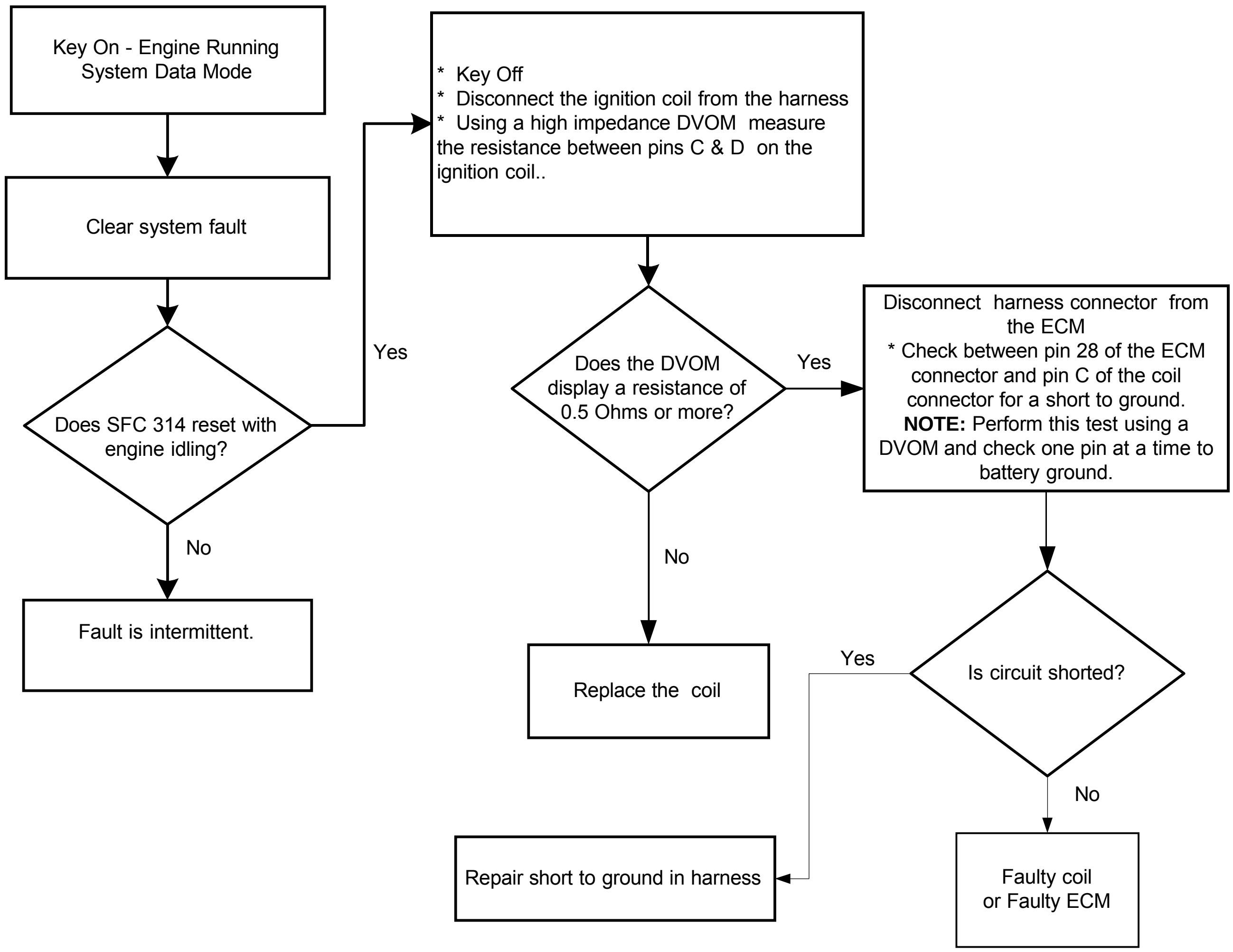
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is shorted-to-power
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #2 fires either the 2nd cylinder in the firing order or the 2nd cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

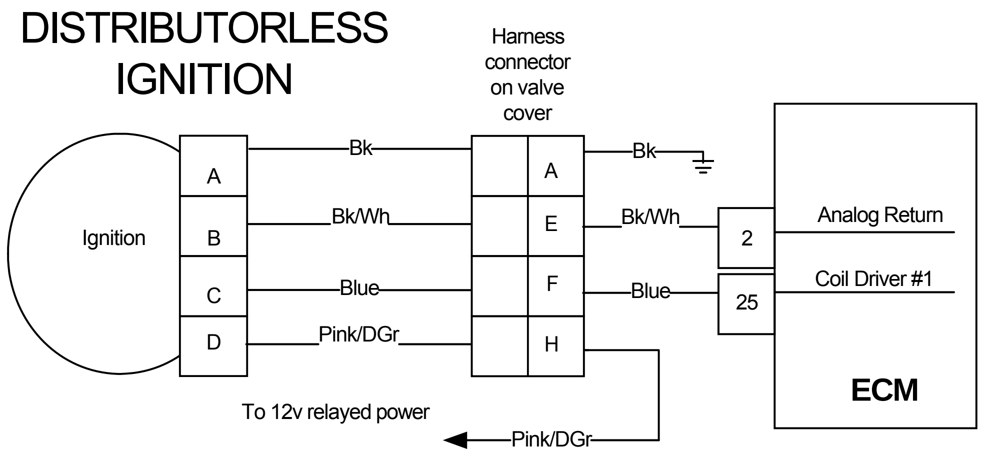
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is less than y ms. or the total dwell is less than w ms. and battery voltage is less than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-power in the harness or internal to the primary coil.

SFC 314-Coil Driver #2 Shorted



SPN 1270, FMI 5 - Spark Coil #3 Primary Open/Short-to-Ground



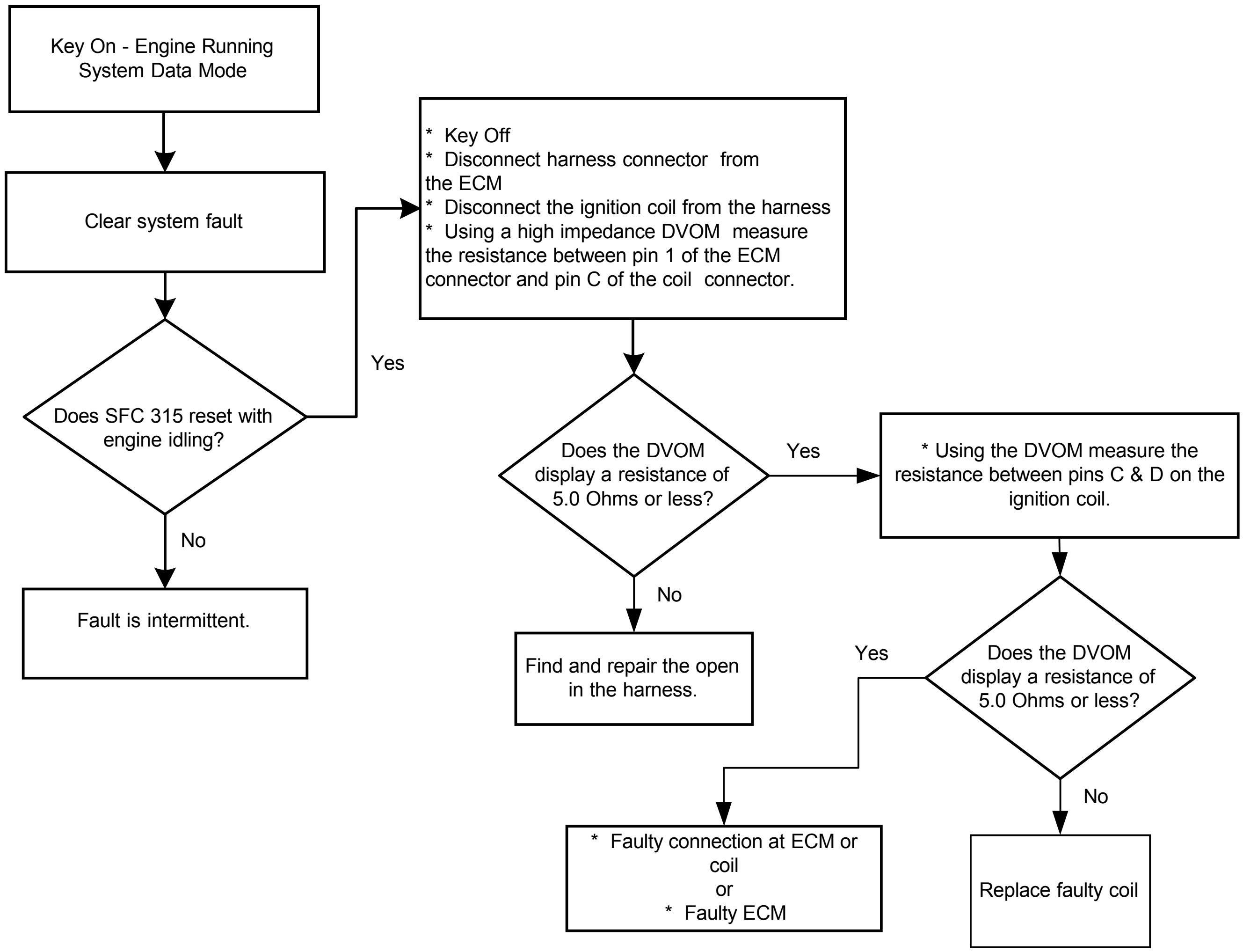
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is an open circuit or shorted-to-ground
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #3 fires either the 3rd cylinder in the firing order or the 3rd cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

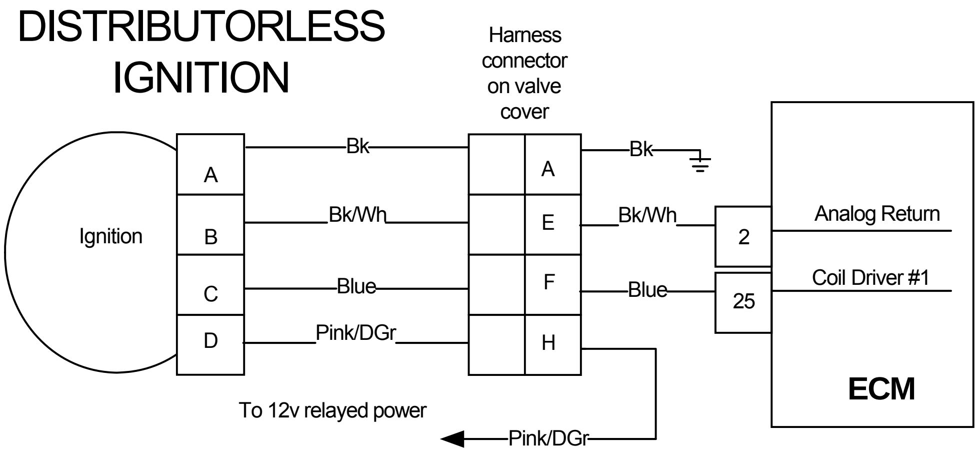
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is greater than y ms. or the total dwell is greater than w ms. and battery voltage is greater than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-ground or open circuit in the harness or internal to the primary coil.

SFC 315-Coil Driver #3 Open



SPN 1270, FMI 6 - Spark Coil #3 Primary Short-to-Power



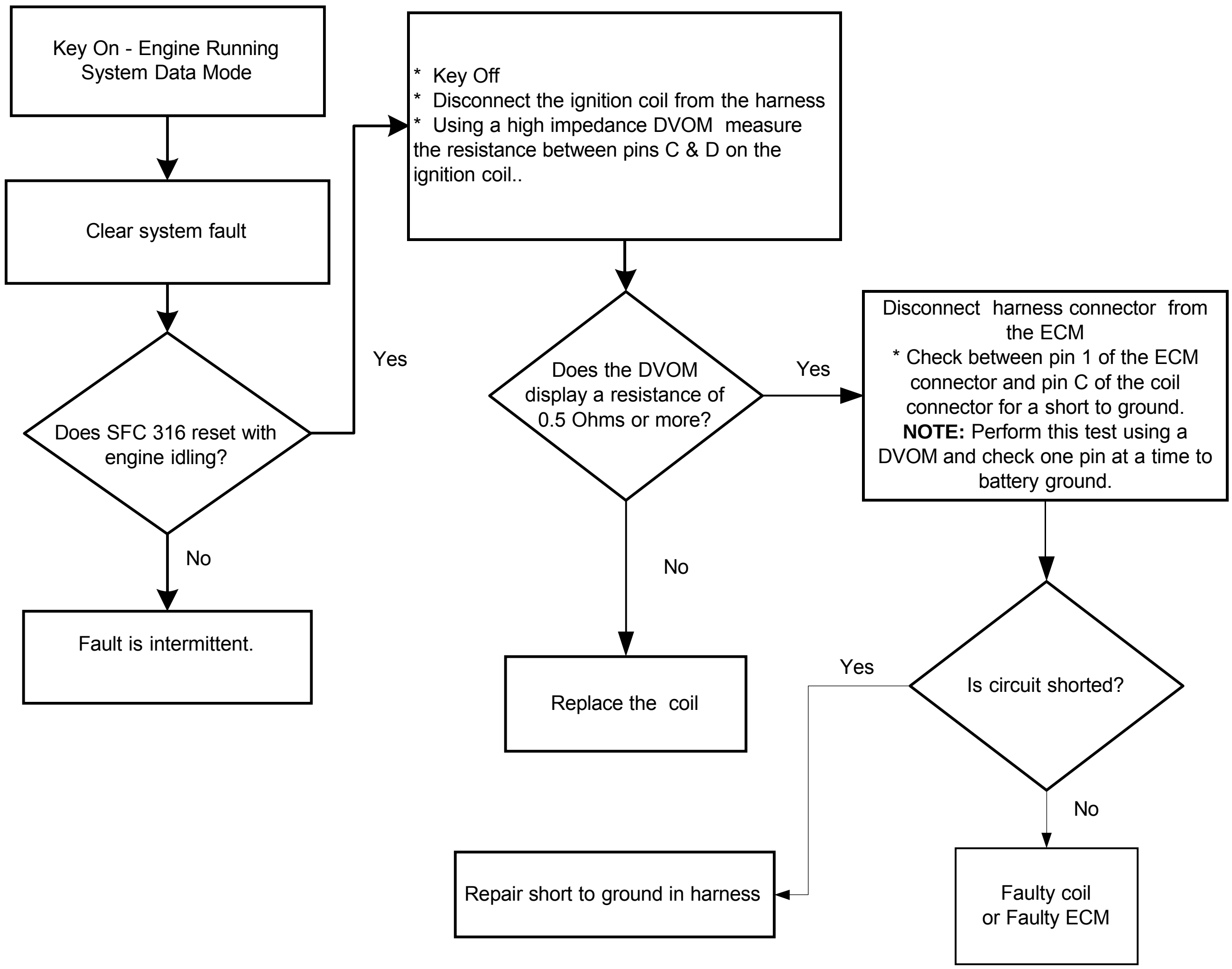
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is shorted-to-power
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #3 fires either the 3rd cylinder in the firing order or the 3rd cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

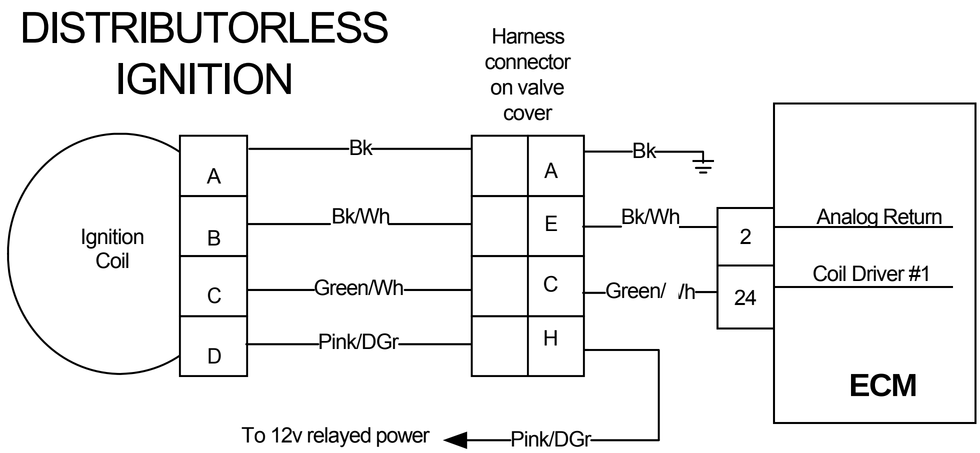
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is less than y ms. or the total dwell is less than w ms. and battery voltage is less than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-power in the harness or internal to the primary coil.

SFC 316-Coil Driver #3 Shorted



SPN 1271, FMI 5 - Spark Coil #4 Primary Open/Short-to-Ground



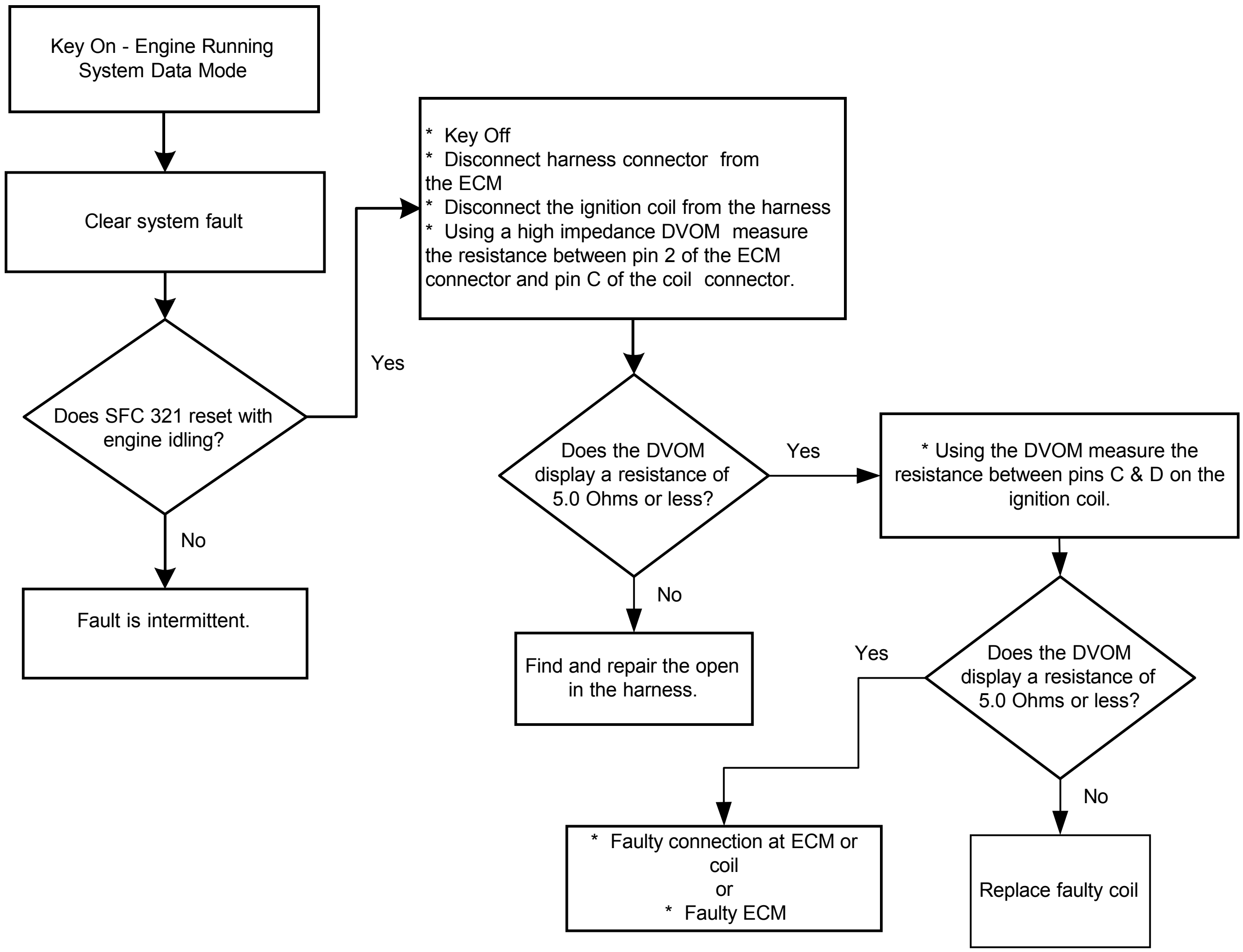
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is an open circuit or shorted-to-ground
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #4 fires either the 4th cylinder in the firing order or the 4th cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

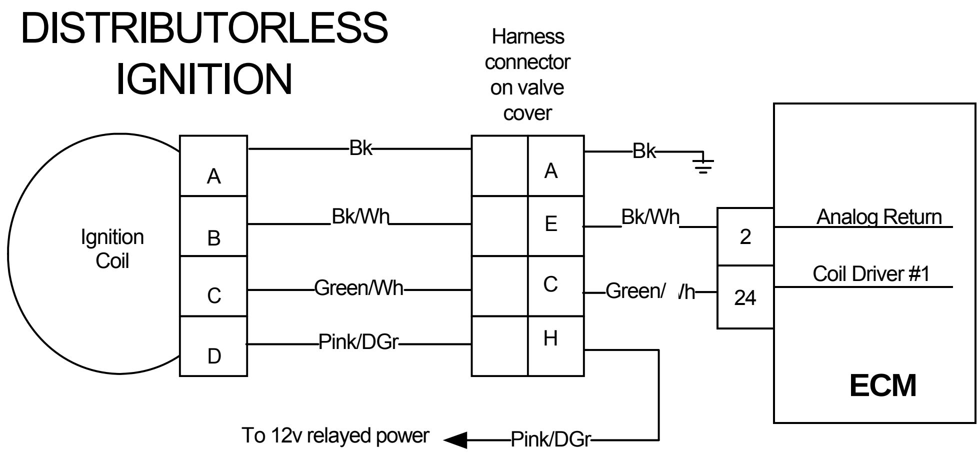
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is greater than y ms. or the total dwell is greater than w ms. and battery voltage is greater than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-ground or open circuit in the harness or internal to the primary coil.

SFC 321-Coil Driver #4 Open



SPN 1271, FMI 6 - Spark Coil #4 Primary Short-to-Power



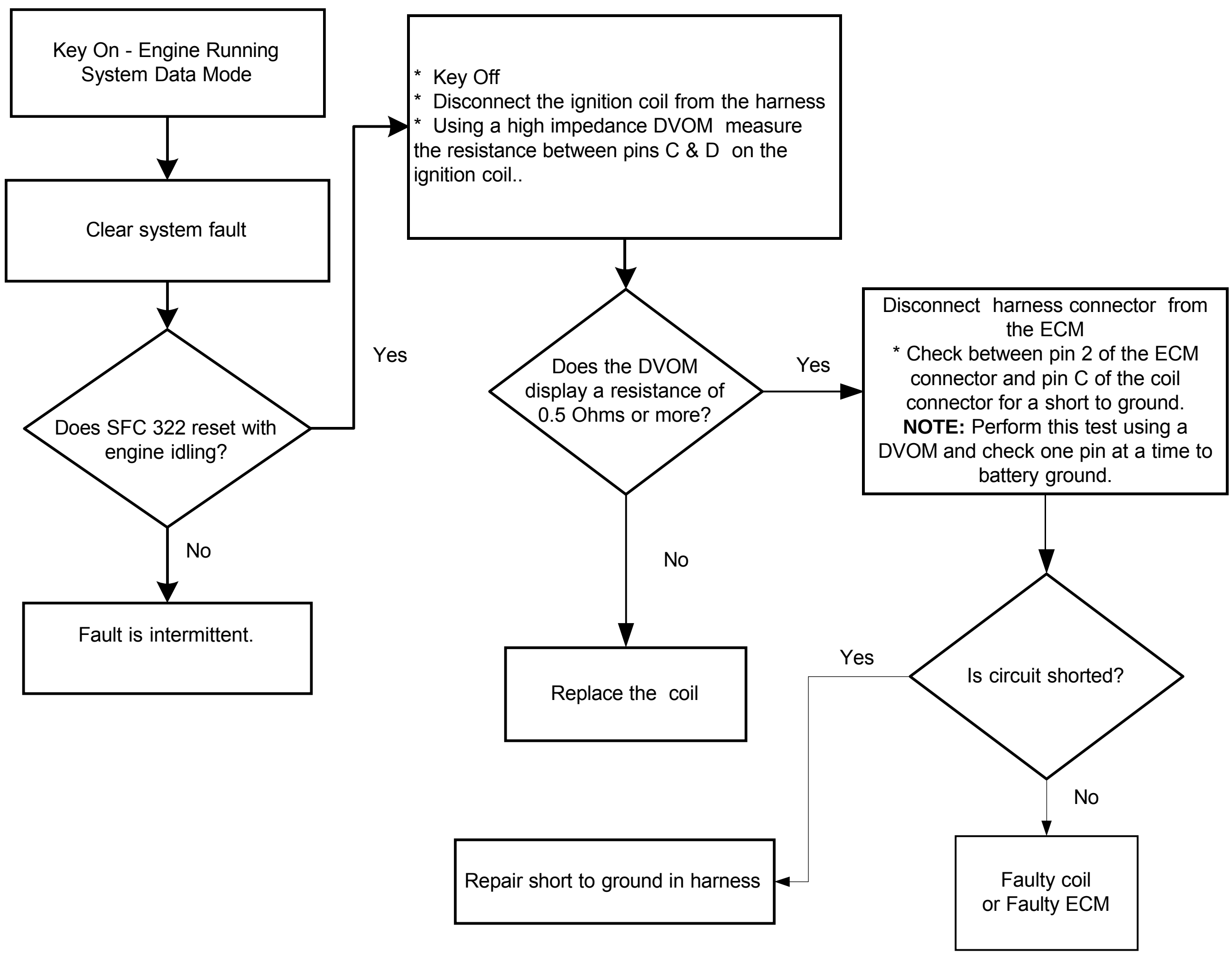
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is shorted-to-power
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #4 fires either the 4th cylinder in the firing order or the 4th cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

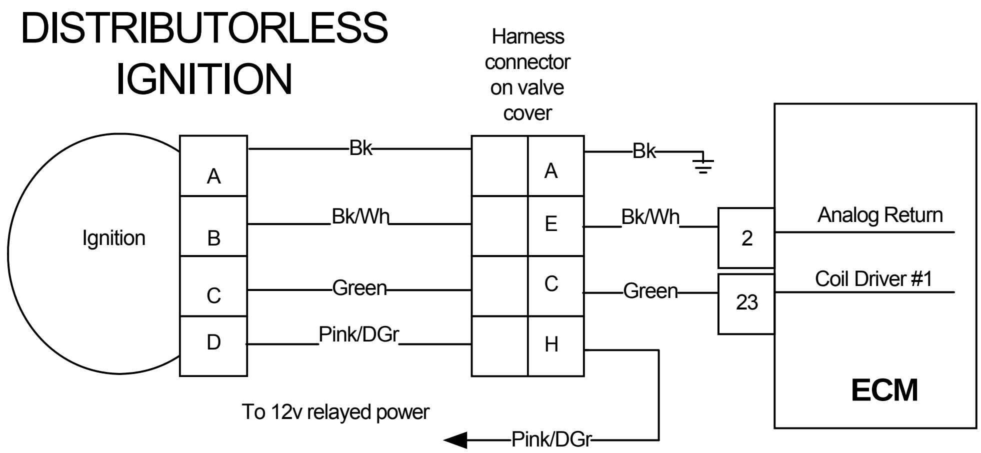
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is less than y ms. or the total dwell is less than w ms. and battery voltage is less than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-power in the harness or internal to the primary coil.

SFC 322-Coil Driver #4 Shorted



SPN 1272, FMI 5 - Spark Coil #5 Primary Open/Short-to-Ground



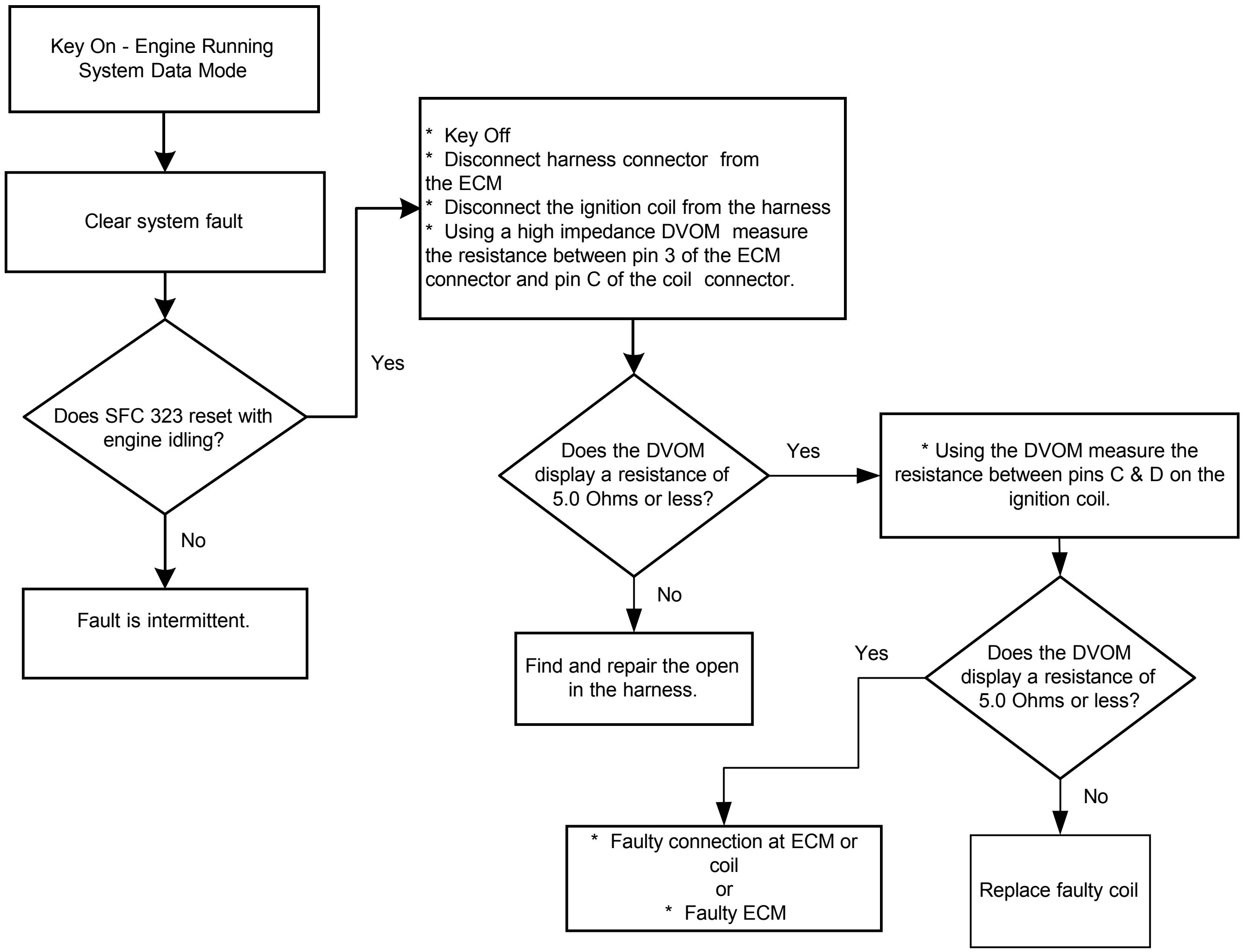
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is an open circuit or shorted-to-ground
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #5 fires either the 5th cylinder in the firing order or the 5th cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

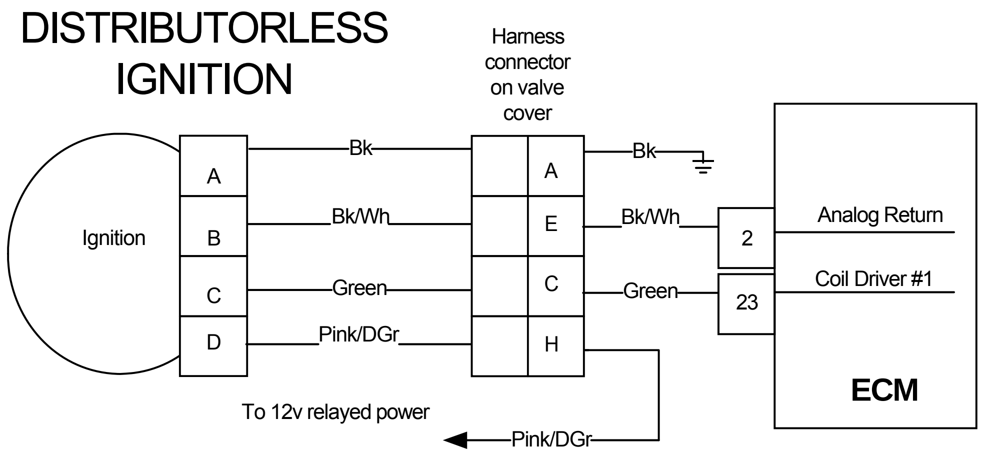
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is greater than y ms. or the total dwell is greater than w ms. and battery voltage is greater than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-ground or open circuit in the harness or internal to the primary coil.

SFC 323-Coil Driver #5 Open



SPN 1272, FMI 6 - Spark Coil #5 Primary Short-to-Power



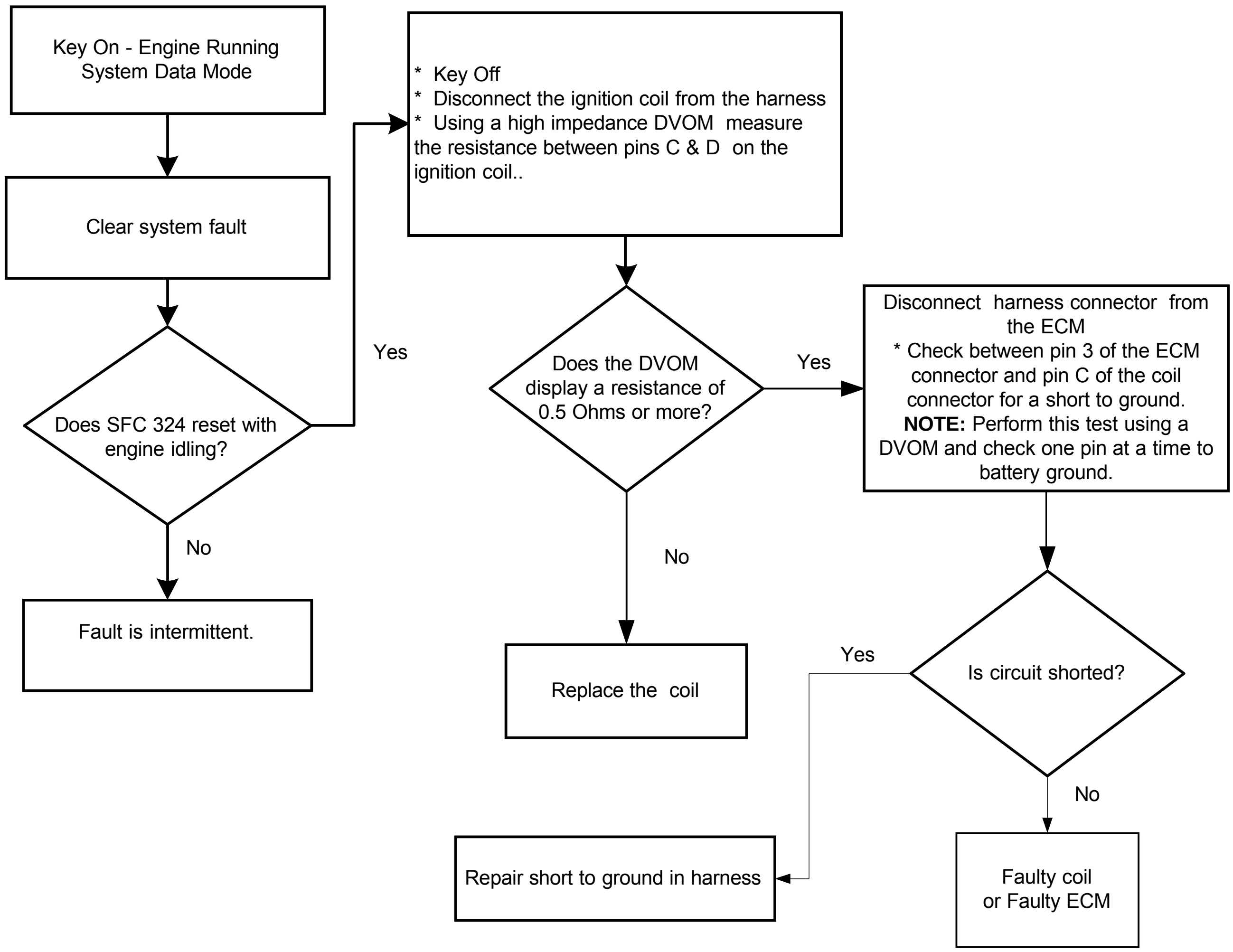
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is shorted-to-power
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #5 fires either the 5th cylinder in the firing order or the 5th cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

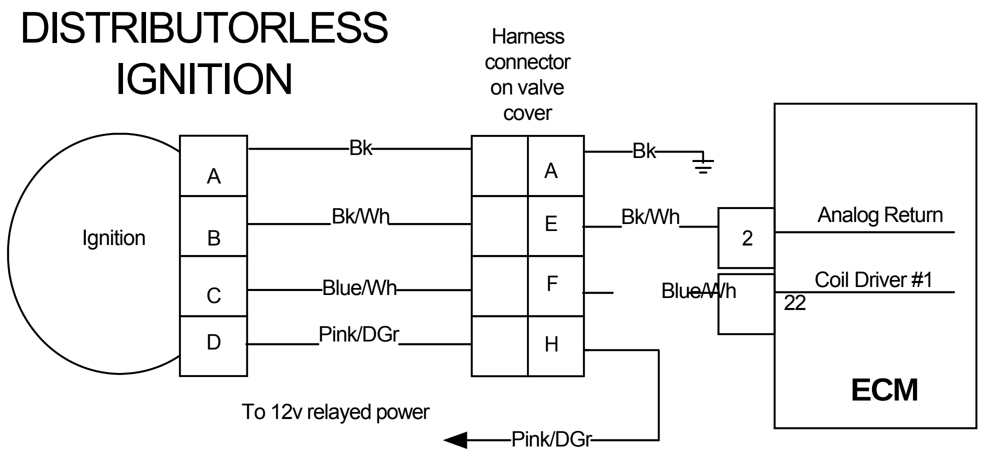
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is less than y ms. or the total dwell is less than w ms. and battery voltage is less than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-power in the harness or internal to the primary coil.

SFC 324-Coil Driver #5 Shorted



SPN 1273, FMI 5 - Spark Coil #6 Primary Open/Short-to-Ground



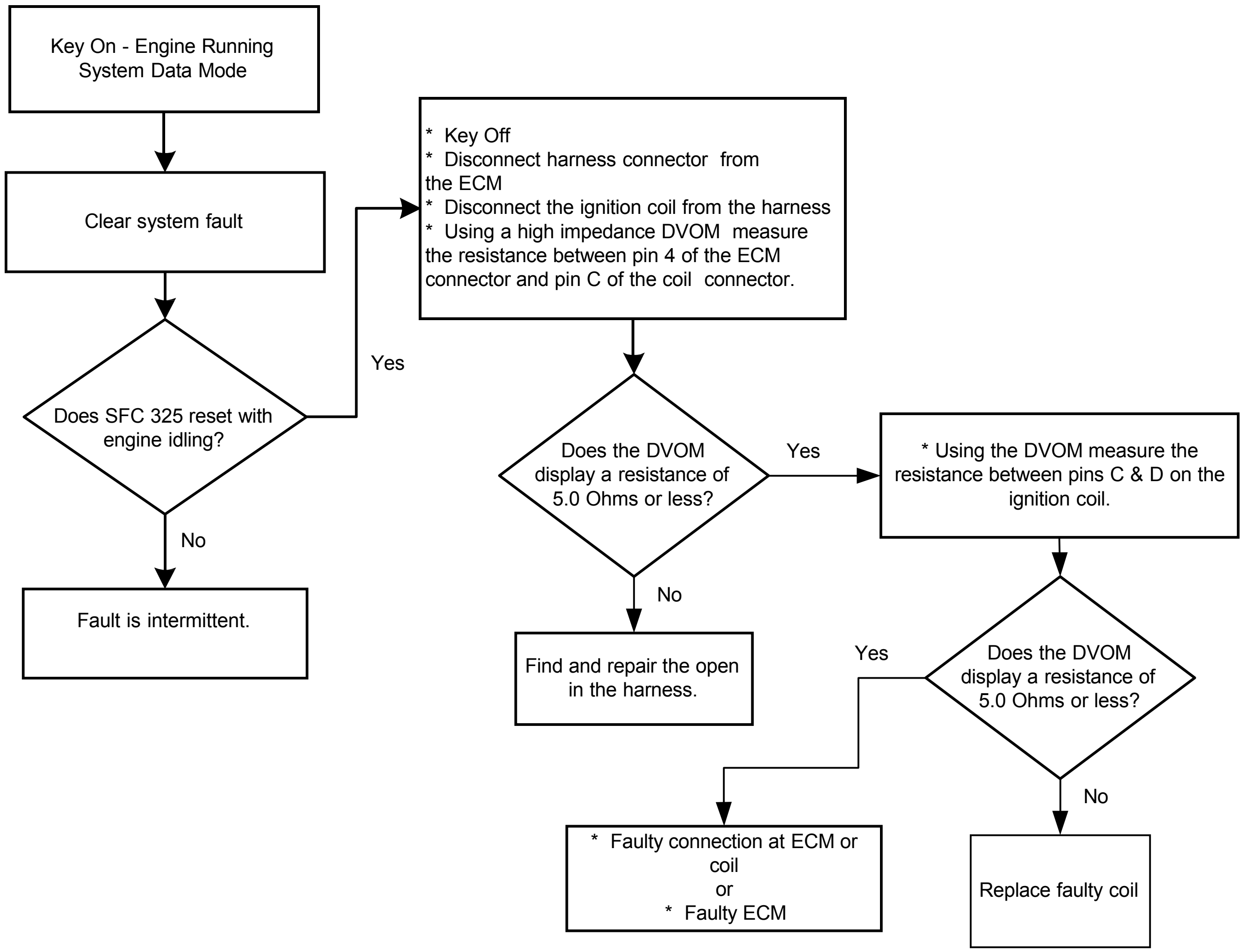
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is an open circuit or shorted-to-ground
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #6 fires either the 6th cylinder in the firing order or the 6th cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

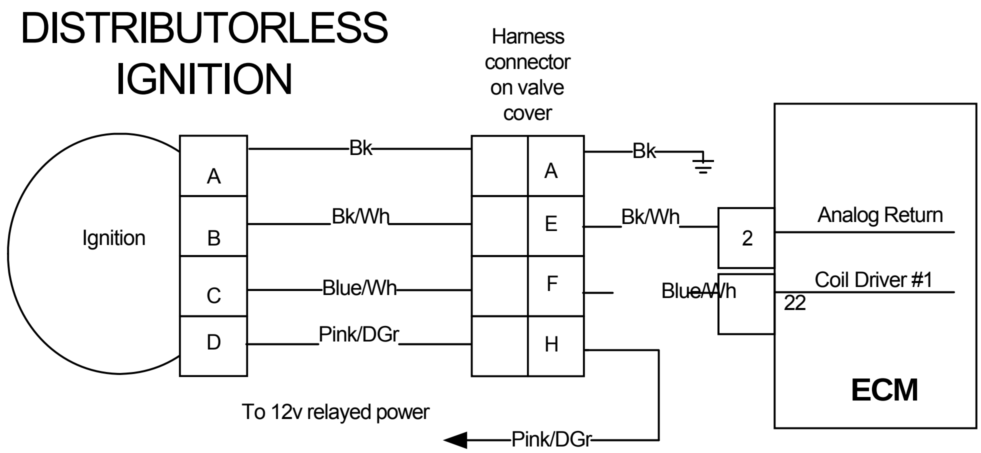
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is greater than y ms. or the total dwell is greater than w ms. and battery voltage is greater than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-ground or open circuit in the harness or internal to the primary coil.

SFC 325-Coil Driver #6 Open



SPN 1273, FMI 6 - Spark Coil #6 Primary Short-to-Power



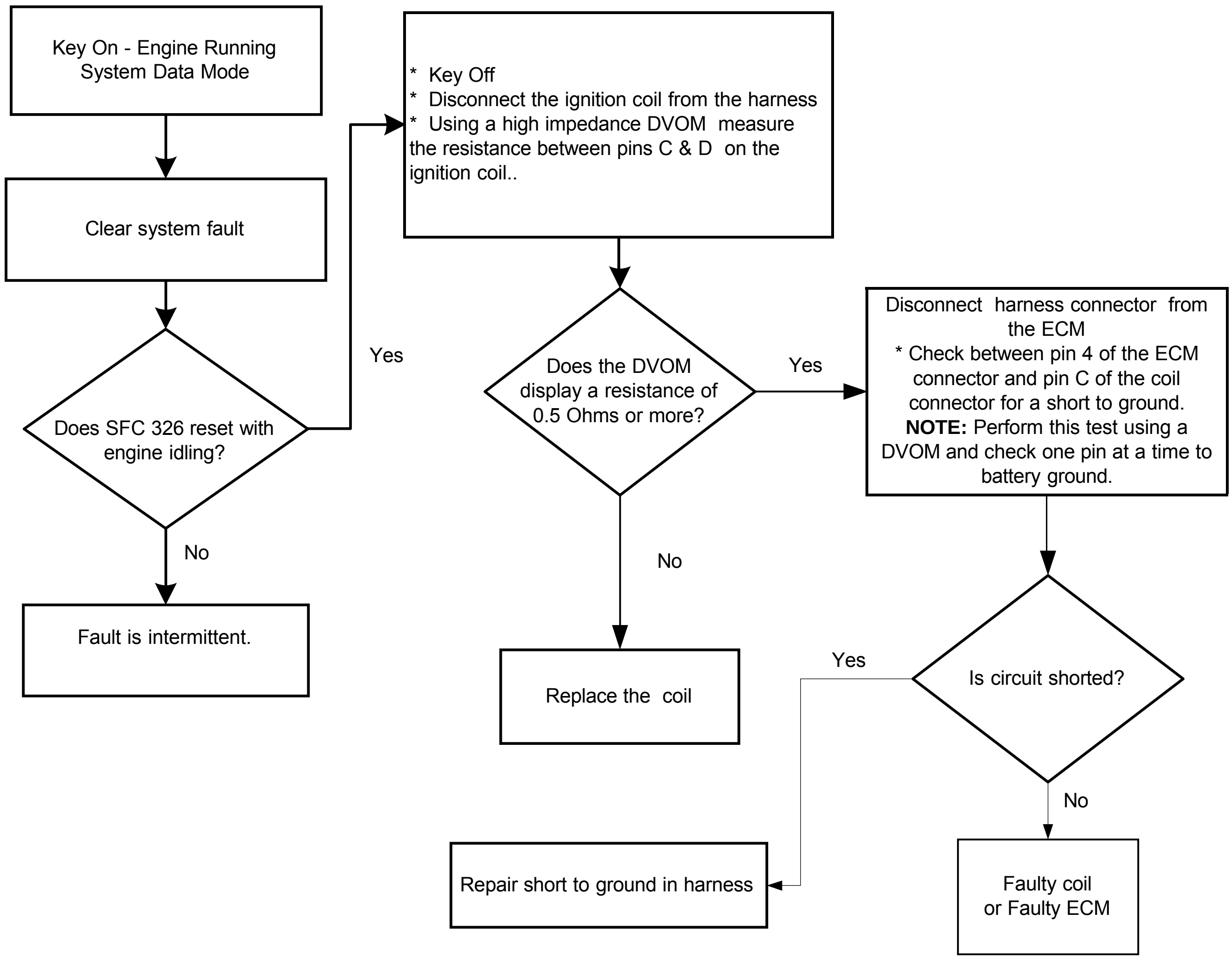
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is shorted-to-power
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #6 fires either the 6th cylinder in the firing order or the 6th cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

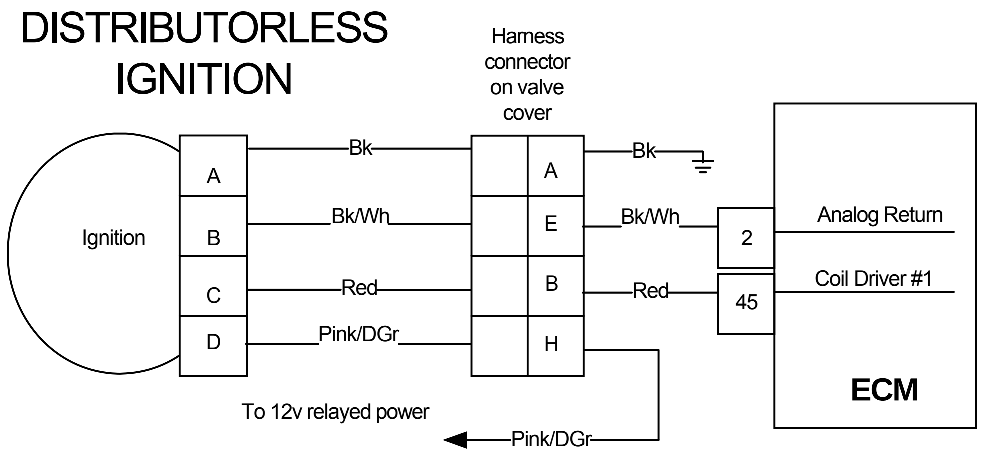
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is less than y ms. or the total dwell is less than w ms. and battery voltage is less than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-power in the harness or internal to the primary coil.

SFC 326-Coil Driver #6 Shorted



SPN 1274, FMI 5 - Spark Coil #7 Primary Open/Short-to-Ground



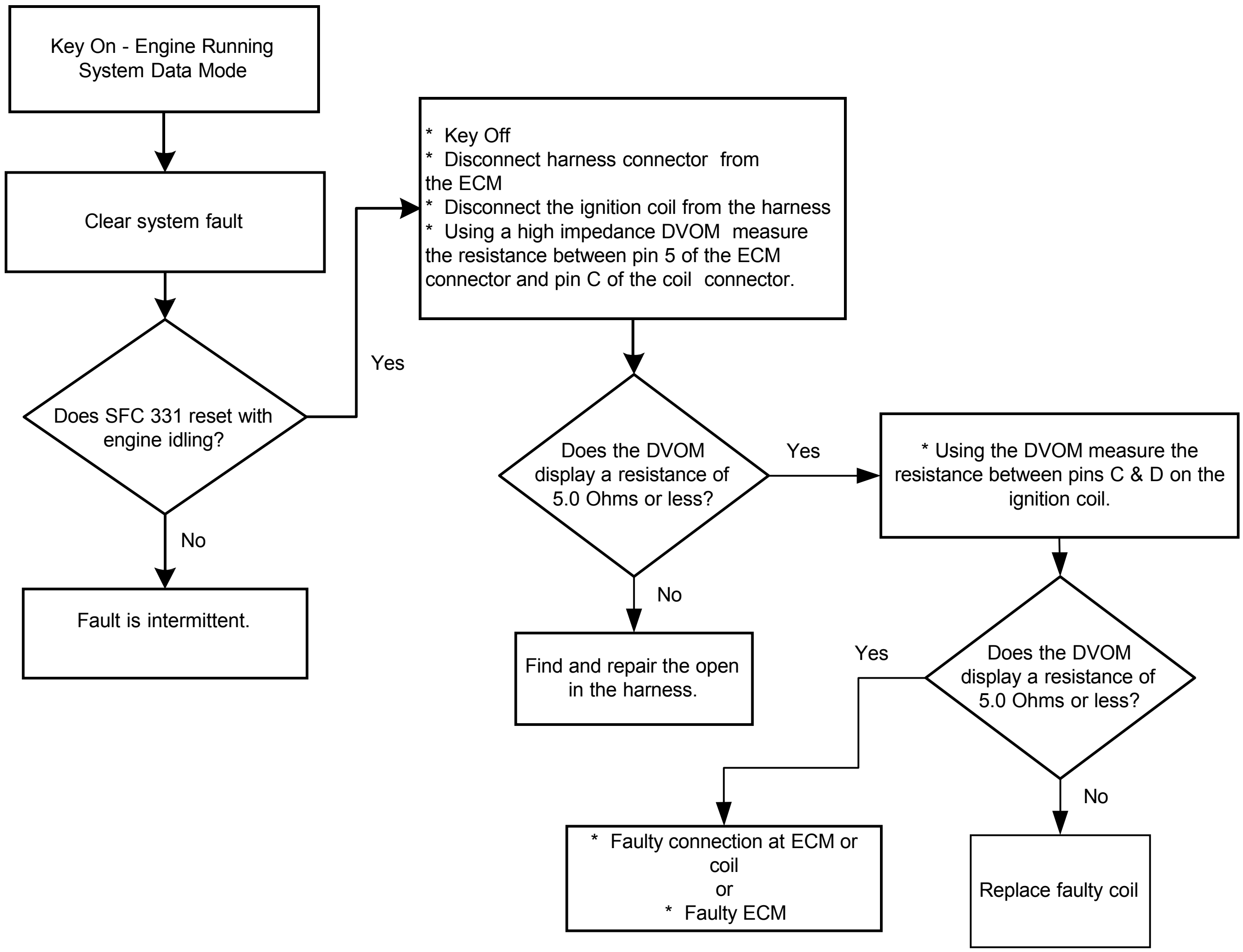
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is an open circuit or shorted-to-ground
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #7 fires either the 7th cylinder in the firing order or the 7th cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

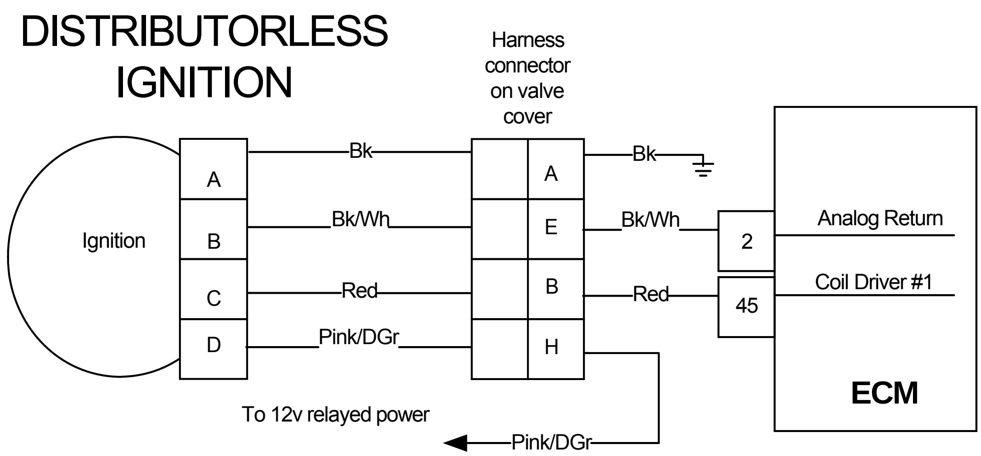
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is greater than y ms. or the total dwell is greater than w ms. and battery voltage is greater than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-ground or open circuit in the harness or internal to the primary coil.

SFC 331-Coil Driver #7 Open



SPN 1274, FMI 6 - Spark Coil #7 Primary Short-to-Power



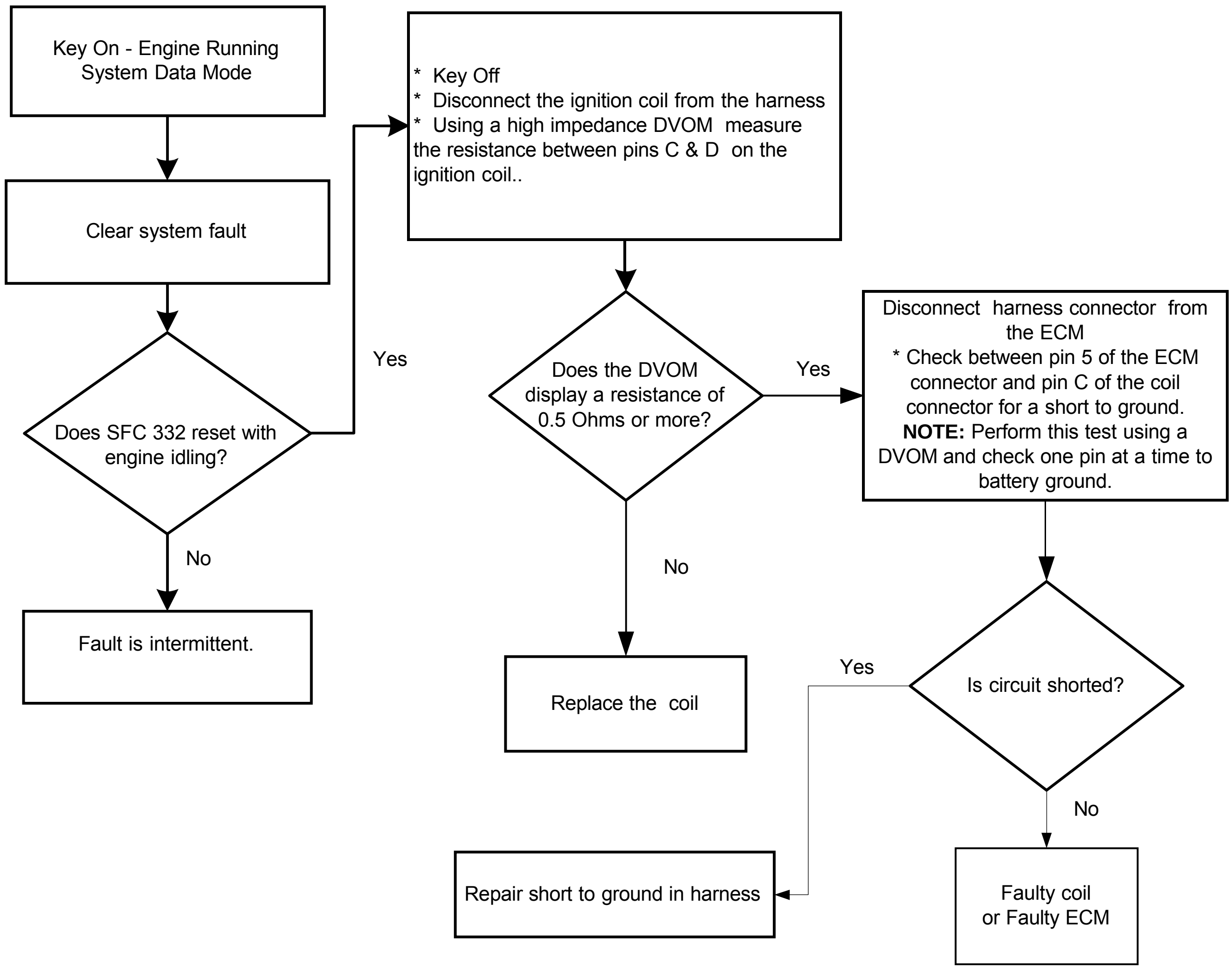
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is shorted-to-power
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #7 fires either the 7th cylinder in the firing order or the 7th cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

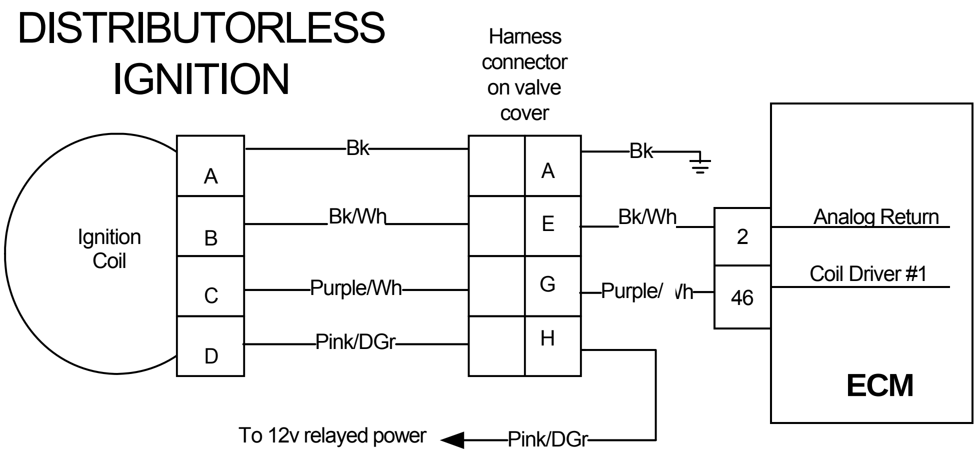
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is less than y ms. or the total dwell is less than w ms. and battery voltage is less than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-power in the harness or internal to the primary coil.

SFC 332-Coil Driver #7 Shorted



SPN 1275, FMI 5 - Spark Coil #8 Primary Open/Short-to-Ground



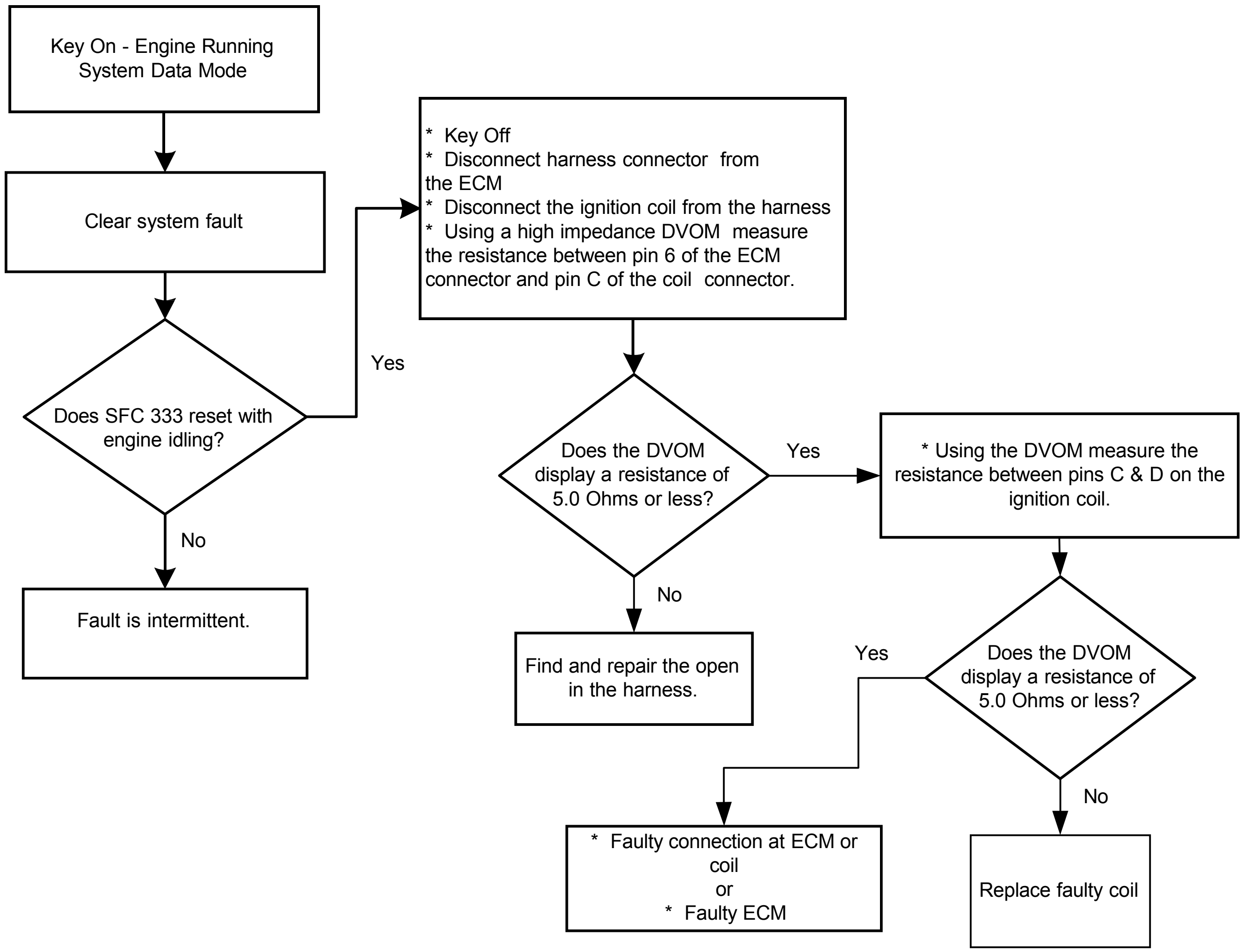
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is an open circuit or shorted-to-ground
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit, especially when run in an application that includes a catalyst.
- Emissions related fault

Coil driver #8 fires either the 8th cylinder in the firing order or the 8th cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

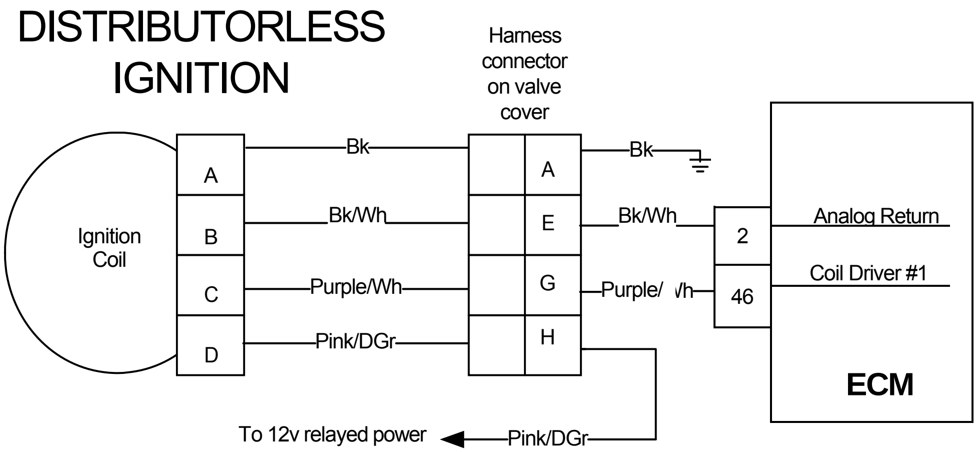
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is greater than y ms. or the total dwell is greater than w ms. and battery voltage is greater than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-ground or open circuit in the harness or internal to the primary coil.

SFC 333-Coil Driver #8 Open



SPN 1275, FMI 6 - Spark Coil #8 Primary Short-to-Power



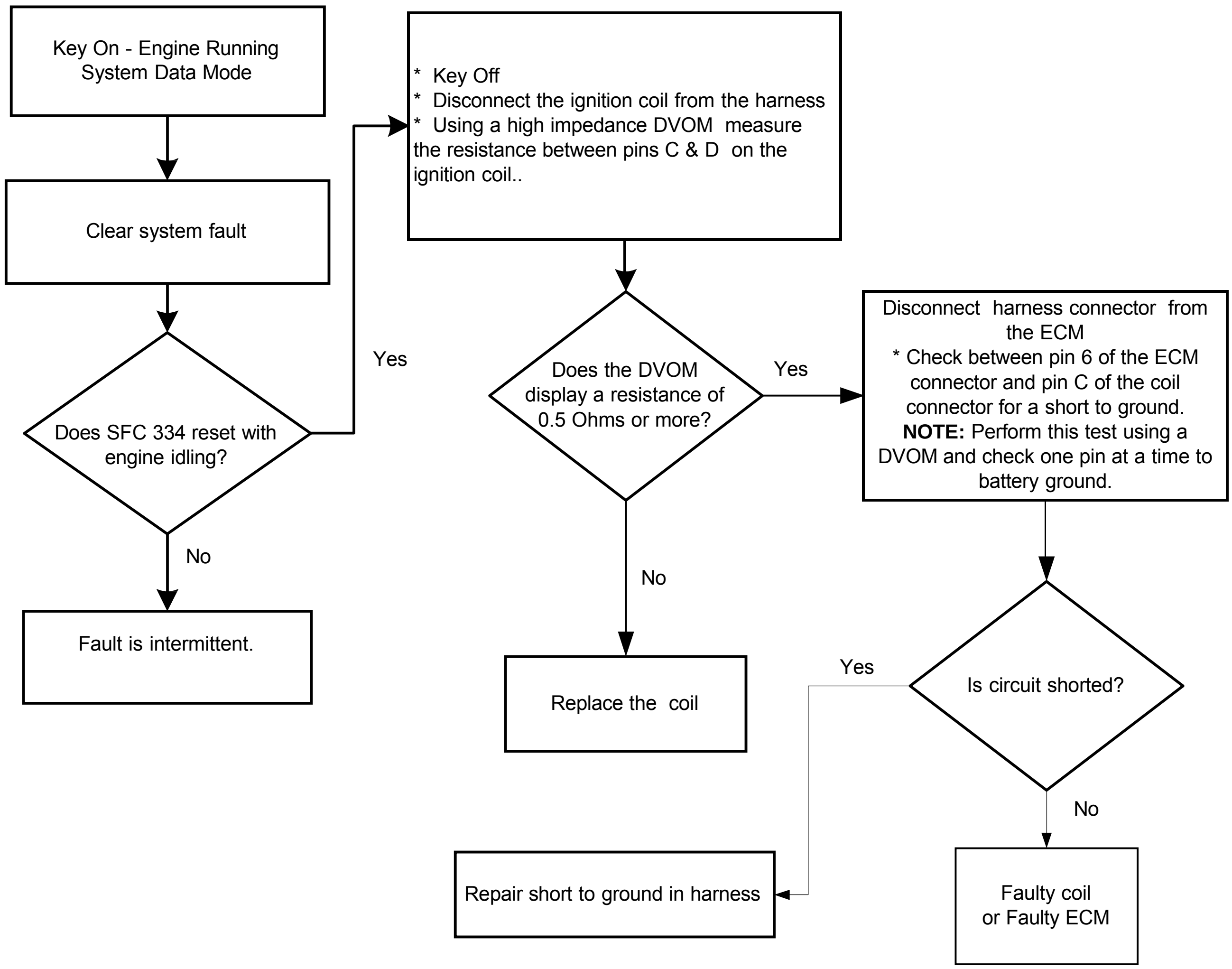
- Ignition/Spark Coil (Dumb-coil ONLY)
- Check Condition- Key On, Engine On
- Fault Condition- Primary circuitry of the ignition coil is shorted-to-power
- Corrective Action(s)- Illuminate MIL and sound audible warning or illuminate secondary warning lamp, disable closed-loop and adaptive-learn fueling corrections. Generally configured in conjunction with power derate or low rev limit.
- Emissions related fault

Coil driver #8 fires either the 8th cylinder in the firing order or the 8th cylinder in the block order depending on the configuration of the 'Injector/Spark Diagnostic Numbering' scheme as set in calibration.

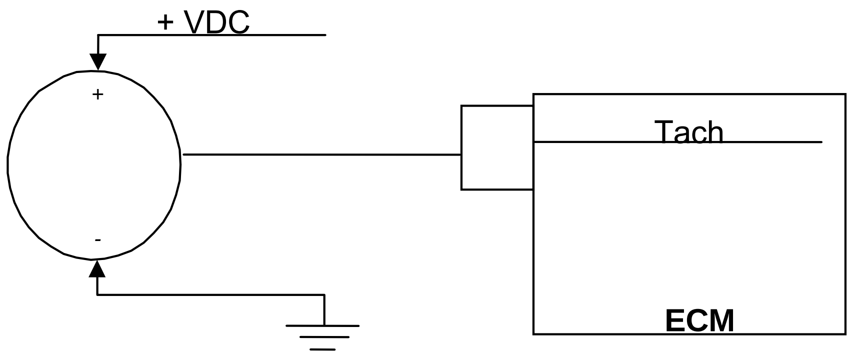
This fault will set if the ECM detects x number of coil firings in which the adaptive dwell adjustment is less than y ms. or the total dwell is less than w ms. and battery voltage is less than z volts as defined in the diagnostic calibration.

The purpose of this fault is to detect a short-to-power in the harness or internal to the primary coil.

SFC 334-Coil Driver #8 Shorted



SPN 645, FMI 4 - Tach Output Ground Short

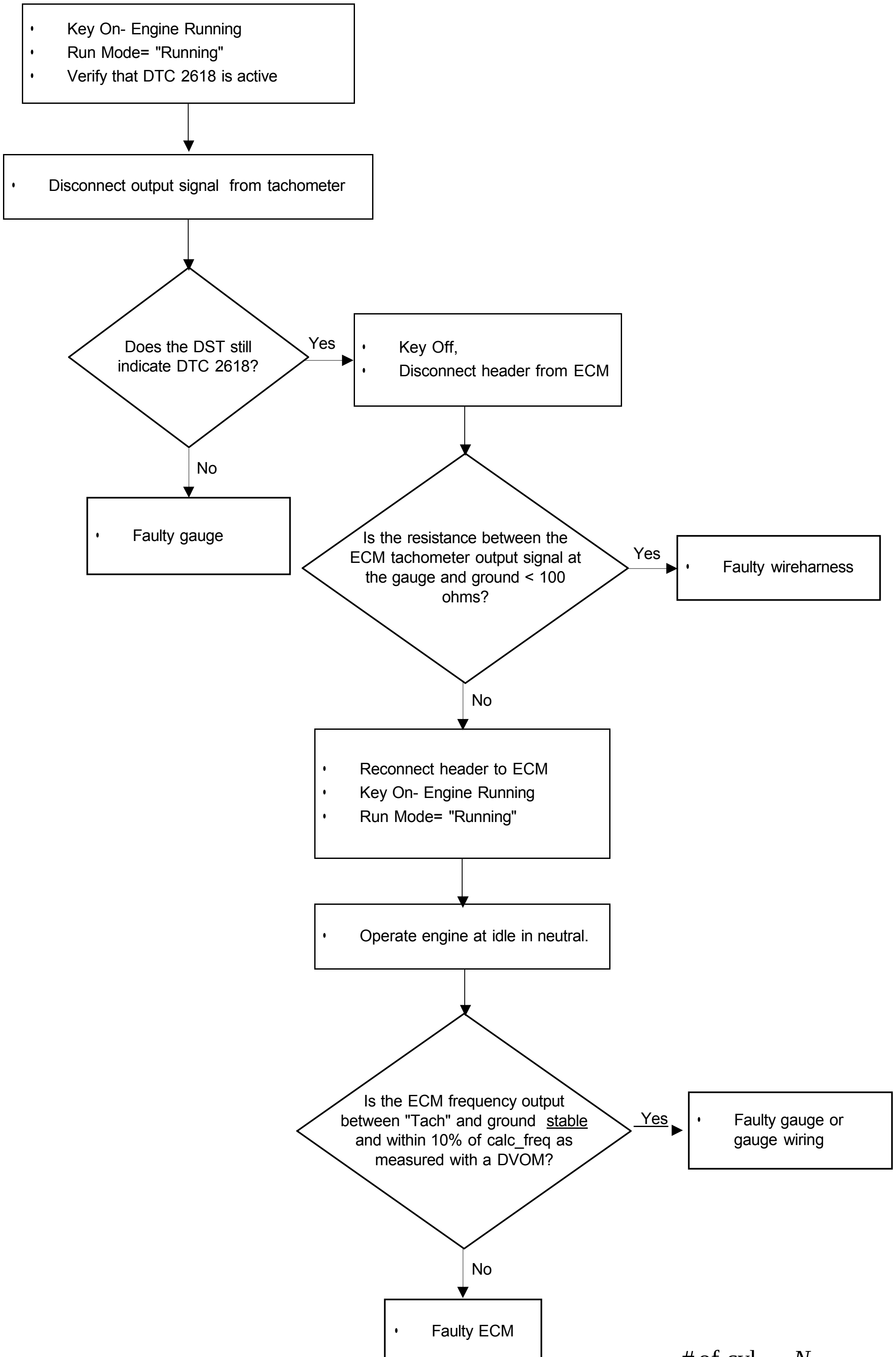


- Tachometer Gauge
- Check Condition- Key On, Engine On
- Fault Condition- ECM tachometer output shorted to ground
- Corrective Action(s)- Sound soft warning or illuminate secondary warning lamp
- Non-emissions related fault

This output is a 0-12 VDC constant duty-cycle, variable frequency square-wave used to drive a digital tachometer.

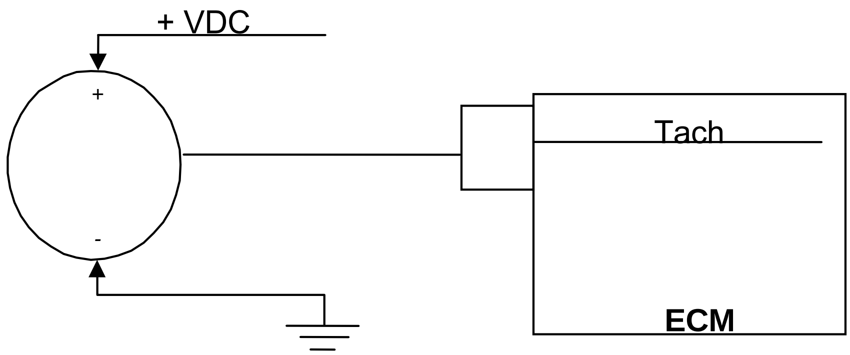
This fault sets if the ECM tachometer output senses a short to ground.

SPN 645, FMI 4 - Tach Output Ground Short



$$\text{calc\_freq (hz.)} = \frac{\#\text{ of cyl}}{2} \times \frac{N}{60}, \text{ where N = engine speed in RPM}$$

SPN 645, FMI 3 - Tach Output Short to Power

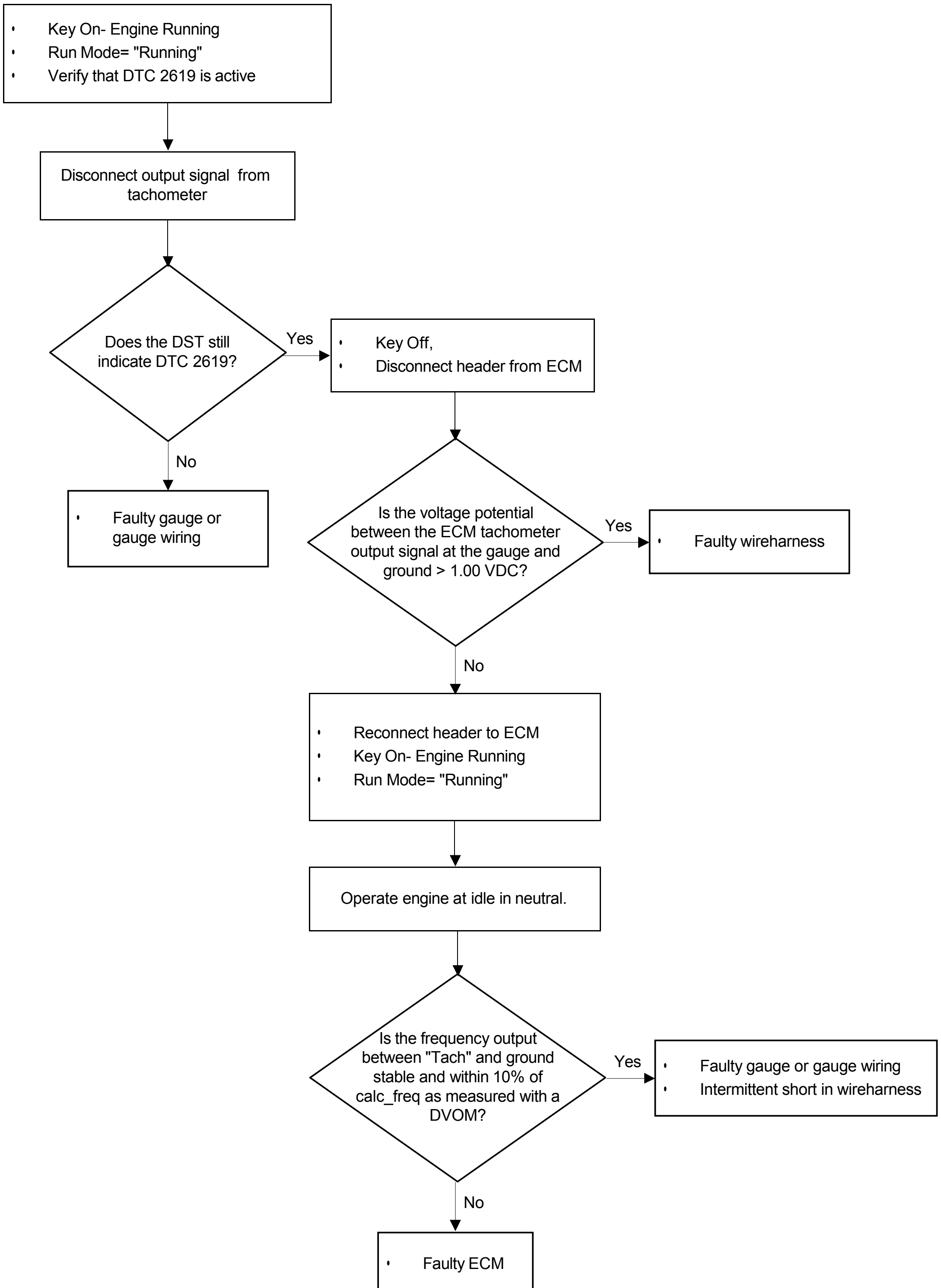


- Tachometer Gauge
- Check Condition- Key On, Engine On
- Fault Condition- ECM tachometer output shorted to power
- Corrective Action(s)- Sound soft warning or illuminate secondary warning lamp
- Non-emissions related fault

This output is a 0-12 VDC constant duty-cycle, variable frequency square-wave used to drive a digital tachometer.

This fault sets if the ECM tachometer output senses a short to power.

SPN 645, FMI 3 - Tach Output Short to Power



$$\text{calc\_freq (hz.)} = \frac{\#\text{ of cyl}}{2} \times \frac{N}{60}, \text{ where N} = \text{engine speed in RPM}$$

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Note: If this manual wears out from normal use, Indmar will replace it at no charge. Call 901-353-9930 for replacement.

SMP0503-09