COMPREHENSIVE COMPONENTS MONITORING
Description
Lamborghini OBD II system detects malfunctions of input or output components/systems that can affect emissions due to a lack of circuit continuity (open circuit), out of range values, and where feasible, rationality faults. Rationality faults are separately detected and store different fault codes than the open circuit and out of range diagnostics. Out of range diagnostics are separately detected and store different fault codes for each distinct malfunction (e.g. low input and high input check). The open circuit check do not store a separate fault code since it cannot be distinguished from the out of range faults. However, the open circuit check is detected in low input or high input checks (e) (16.2.1).

Some of the diagnosis are based on feedback analysis.

Feedback analysis

Feedback analysis is performed continuously, every time the Mosfet of the Lamborghini Lie 2003 ECU is closed or opened.

Due to its structure, when a tension is applied by the \( \overline{p} \) the wiring side is forced down to ground; vice versa when no tension is applied by the ECU the wiring side is at high tension Battery Voltage (Vbatt).

A hardware integrated circuit called FPGA, with a Boolean logic (EXOR for this function) checks continuously that this congruence is respected:

In case of \( \overline{\text{sc}} \) to Vbatt, to avoid damage to the transistor, \( \overline{p} \) command is switched off.
Exhaust pressure sensor
The Lamborghini L-140 and L-147 is equipped with two exhaust pressure sensor, one for each bank.

To monitor proper functioning of the sensor, a low input check, a high input check, an open circuit check and a functional check are performed.

**LOW INPUT, HIGH INPUT AND OPEN CIRCUIT DIAGNOSIS**

The ECU stores a pending fault code if the sensor output is less than a threshold value for more than a fixed time (low input check).

Similarly, if sensor output is greater than a threshold value for more than a fixed time, a high input/open circuit pending fault code is stored (high input/open circuit check).

**FUNCTIONAL CHECK**

A logic evaluation is performed by checking the result of FFT (Fast Fourier Transform) pressure signal output. If the characteristic engine cycle’s frequency is lower than a threshold for a fixed time and instantaneous misfire not occurs, a pending fault code is stored.

For diagnostic constants see OBDII MALFUNCTION CRITERIA CHART.
Manifold absolute pressure (MAP) sensor / barometric pressure
The Lamborghini EMS has one absolute pressure sensor (two for L147, one for each bank) in the intake manifold and one barometric pressure sensor inside the auxiliary ECU.

A low input, a high input and an open circuit check of all sensors are performed. A logic evaluation of the MAP signal of both Lamborghini Lie 2003 ECUs and a logic evaluation of the manifold absolute pressure signal compared to the barometric pressure signal is performed as well.

**LOW INPUT, HIGH INPUT AND OPEN CIRCUIT DIAGNOSIS**

If the pressure signal is below a threshold\_min for more than a fixed time a pending fault code is stored (low input check).

If the pressure signal is above a threshold\_max for more than a fixed time a pending fault code is stored (high input/open circuit check).

**FUNCTIONAL CHECKS**

The first logic evaluation is performed from engine start by a comparison of the MAP output signal of the two ECUs. If the difference is greater than a fixed value for an extended time then the pending fault code is stored.

The diagnostic isn’t performed if one of the following diagnostics are already in fault:

- Manifold Absolute Pressure Low input diagnosis
- Manifold Absolute Pressure High input/Open circuit diagnosis
- DBW diagnostic

The second logic evaluation is performed at “key on with engine off” by a comparison of the output signals of the barometric pressure with the manifold absolute pressure. If the difference is greater than a fixed value for an extended time, then the relative pending fault code is stored.

The diagnostic isn’t performed if one of the following diagnostics are already in fault:

- Intake manifold pressure Low input diagnosis
- Intake manifold pressure High input/Open circuit diagnosis

For diagnostic constants see OBDII MALFUNCTION CRITERIA CHART.
Intake air temperature sensor
Lamborghini EMS has one intake air temperature sensor (two for L147, one for each bank) located in the engine intake manifold. The sensor is integrated with the absolute pressure sensor. To monitor proper functioning of the sensor, a low input check, high input check, open circuit check and a logic evaluation monitoring are executed.

**LOW INPUT, HIGH INPUT AND OPEN CIRCUIT DIAGNOSIS**

If the sensor output is less than a threshold value for more than a fixed time) an error counter increases. When this counter overcomes a calibration threshold of 3 times, the fault is detected and the pending fault code is stored (low input check).

Similarly, if the sensor output is higher than a threshold value for more than a calibration time, an error counter increases. When this counter overcomes a calibration threshold of 3 times, the fault is detected and the pending fault code is stored (high input/open circuit check).

**FUNCTIONAL CHECK**

A logic diagnosis is performed by an evaluation of the derivative value of the air temperature. The air temperature derivative value is checked on a time base; if the difference between the derivative and the threshold is greater than a fixed value for an extended time, then the pending fault code is stored.

This functional diagnosis is not performed if one of the following diagnostics are already in fault:

- Air temperature Low input diagnosis
- Air temperature High input/Open circuit diagnosis

For diagnostic constants see OBDII MALFUNCTION CRITERIA CHART.
CRITERIA CHART.
Engine coolant temperature
The Lamborghini EMS has two coolant temperature sensors, but their mounting is different between L147 and L140.

In the L147 both sensors are read by the EMS.

In the L140 one sensor is read by Engine Management System and the other one by the instrument cluster, which sends the engine coolant temperature value to the EMS via CAN line.

To monitor proper functioning of the sensors a low input check, high input check, open circuit check and a logic evaluation monitoring is executed.

**In the L1 47 the following diagnosis is performed for each sensor.**

**Low input, high input and open circuit diagnosis**

If the sensor output is lower than a threshold value for more than a fixed time (low input check), an error counter increases. When this counter overcomes a calibration threshold of 3 times, the fault is detected and the pending fault code is stored.

Similarly, if the temperature sensor output is higher than a threshold value for more than a fixed time, an error counter increases. When this counter overcomes a calibration threshold of 3 times, the fault is detected and the pending fault code is stored (high input /open circuit check).

**Functional check**

The diagnostic check compares the difference between the temperature values of the two sensors, each read from the corresponding Lamborghini Lie 2003 ECU, and if the difference is greater than a threshold for more than a calibration time, an error counter increases. When this counter overcomes a calibration threshold of 10 times, the fault is detected and the pending fault code is stored.

This functional diagnosis is not performed if one of the following diagnostics are already in fault:

- Engine coolant temperature Low input diagnosis
- Engine coolant temperature High input/Open circuit diagnosis

**In the L1 40 the following diagnosis is performed.**

**Low input, high input and open circuit diagnosis**

For the sensor read by Engine Management System:

If the sensor output is lower than a threshold value for more than a calibration time (low input check), an error counter increases. When this counter overcomes a calibration threshold of 3 times, the fault is detected and the pending fault code is stored.

Similarly, if the temperature sensor output is higher than a threshold value for more than a calibration time, an error counter increases. When this counter overcomes a calibration threshold of 3 times, the fault is detected and the pending fault code is stored (high input /open circuit check).
For the sensor read by instrument cluster:
If the sent value from the instrument cluster to the EMS, via CAN line, is lower than a threshold value for more than a calibration time (high input / open circuit check) the pending fault code is stored; is present a calibrated delay from engine on because the lower value of this sensor is -10°C.

If the temperature sensor output is higher than a threshold value for more than a calibration time (low input check), the pending fault code is stored; in this case the delay time from engine on is’nt applied.

**Functional check**

The diagnostic check compares the difference between the value read from the EMS and the value coming from the CAN BUS, and if the difference is greater than a threshold for more than a calibration time, an error counter increases. When this counter overcomes a calibration threshold of 10 times then a pending fault code is stored.

This functional diagnosis is not performed if one of the following diagnostics are already in fault:

- Engine coolant temperature Low input diagnosis
- Engine coolant temperature High input/Open circuit diagnosis

For diagnostic constants see OBDII MALFUNCTION CRITERIA CHART.
Catalyst temperature sensors
The Lamborghini L-140 is equipped with two catalyst temperature sensor, one for each bank. The low input, high input, open circuit and functional checks are performed.

In addition, the over temperatures above two different levels are checked.

**LOW INPUT, HIGH INPUT AND OPEN CIRCUIT DIAGNOSTIC**

The Lamborghini Lie 2003 ECU stores a pending fault code if the sensor output is lower than a threshold value for more than a fixed time after a time from cranking (low input/open circuit check).

If the temperature sensor output at the “key on and engine off” is higher than a threshold value for more than a fixed time, a high temperature fault is detected and corresponding pending fault code is stored (high input check).

**FUNCTIONAL CHECK**

A functional monitoring is performed by the evaluation of the difference of the temperature of the two sensors, if this difference is higher than a threshold for a fixed time, then the fault is detected and the corresponding pending fault code is stored.

The functional check isn’t performed if one of the following diagnostics are already in fault:

- Catalyst temperature Low input/Open circuit diagnosis
- Catalyst temperature High input diagnosis

For diagnostic constants see OBDII MALFUNCTION CRITERIA CHART.
Oil temperature sensor
If the oil temperature sensor output is lower than a threshold value for more than a calibration time an error counter increases. When this counter overcomes a calibration threshold of 3 times, the fault is detected and the pending fault code is stored (low input check).

Similarly, if the oil temperature sensor output is higher than a threshold value for more than a calibration time, an error counter increases. When this counter overcomes a calibration threshold of 3 times, the fault is detected and the pending fault code is stored (high input/open circuit check).

For diagnostic constants see OBDII MALFUNCTION CRITERIA CHART.
VARIABLE VALVE TIMING SYSTEM
The Lamborghini EMS is equipped with a Variable Valve Timing (VVT) system that operates for each bank on the intake valves and on the exhaust valves.

Lamborghini OBD II system monitors the components and the performance of VVT system. It monitors:

1) every cam sensor;
2) the crankshaft position sensor;
3) the Signal Sequence;
4) every solenoid oil control valve (OCV);
5) the alignment between crankshaft and camshaft;
6) the performance of VVT system.
CAMSHAFT POSITION SENSOR DIAGNOSTIC

One intake camshaft position sensor and one exhaust camshaft position sensor are present on each bank. Therefore, the following diagnostic is performed for each sensor.

The diagnosis of the camshaft position sensor is based on the crankshaft signal. If there is the same sector of the cam signal after a crankshaft revolution, an error counter increases. When this counter overcomes a calibration threshold of 20 times, the fault is detected and the pending fault code is stored.

E.g. Looking at the picture 16.8.1, in the correspondence of “an hole-tree teeth-one hole” pattern on the flywheel, the cam signal must be one time high and in the following one it must be low. If both of times the signal is low (or high) the corresponding error counter increases.

CRANKSHAFT POSITION SENSOR DIAGNOSTIC

In the present diagnostic if between two falling edges of the cam signal (90°, Camshaft degrees) the counter of the teeth of the flywheel is less than a number of 16, an error counter increases. When this counter overcomes a calibration threshold of 30 times, the fault is detected and the pending fault code (P0336) is stored.

SIGNAL SEQUENCE DIAGNOSTIC

The signal sequence diagnosis is performed to check the signals which allows to define the ignition TDC of cyl. N° 1. If a pattern of flywheel teeth (one hole – two teeth – one hole – 6 teeth) occurs when the intake cam sensor signal is low, on the 6th tooth we have an ignition TDC.

If this pattern can’t be recognized (more than two flywheel holes for every 90° camshaft, or more than 16 teeth every 90° camshaft, or only low camshaft signal after the above mentioned pattern) for more than a calibration threshold of 20 times, the P1310 error is activated.

Pic.16.8.2 Lamborghini L140 Signal Sequence

16.8.4 OIL CONTROL VALVE DIAGNOSIS

The diagnosis of the solenoid valve is an electric, continuous one based on a feedback circuit. If the command on the valve is high but the feedback circuit gives an inappropriately high signal, a short circuit to battery voltage (Vbatt) is present, and an error counter increases. When this counter overcomes a calibration threshold of 10 times, the fault is detected and the corresponding pending fault code is stored.

Vice versa if the command on the valve is low but the feedback circuit gives an inappropriately low signal, a short circuit to ground or open circuit is present, and an error counter increases. When this counter overcomes a threshold of 10 times, the fault is detected and the corresponding pending fault code is stored.

The Pcodes for this diagnosis are:

P0076: Intake VVT control solenoid valve circuit low bank 1
P0077: Intake VVT control solenoid valve circuit high bank 1
P0079: Exhaust VVT control solenoid valve circuit low bank 1
P0080: Exhaust VVT control solenoid valve circuit high bank 1
P0082: Intake VVT control solenoid valve circuit low bank 2
P0083: Intake VVT control solenoid valve circuit high bank 2
P0084: Exhaust VVT control solenoid valve circuit low bank 2
P0085: Exhaust VVT control solenoid valve circuit high bank 2

ALIGNMENT BETWEEN CRANKSHAFT AND CAMSHAFT

A cog shift means a mistake of 28.8 crankshaft degrees for the L140 and 30° for the L147. So the system can detect a cog jump with the following diagnosis.

During cranking the, with VVT solenoid valve off, the cam phase transformer is mechanical locked. The reference position (distance between flywheel tooth 6 (the one on the TDC of cylinder 1) and the end of the second segment of camshaft flywheel) is 230 crankshaft degrees. If a difference (positive or negative) of 10 crankshaft degrees is detected among the reference position and the measured one, an error counter increases. When this counter overcomes a threshold of 1 time, the fault is detected and the pending fault code is stored.

The Pcodes for this diagnosis are:

P0016: Crankshaft Position – Camshaft Position Correlation Sensor A
P0017: Crankshaft Position – Camshaft Position Correlation Sensor B
P0018: Crankshaft Position – Camshaft Position Correlation Sensor A
P0019: Crankshaft Position – Camshaft Position Correlation Sensor B

PERFORMANCE OF THE VARIABLE VALVE TIMING CONTROL DIAGNOSTIC

The OBD II system monitors the VVT system for target error and for slow response malfunction.
Battery voltage
The Lamborghini EMS monitors the battery Voltage. If the output is lower than a threshold value for more than a fixed time, a low voltage fault is detected and an error counter increases. When this counter overcomes a threshold of 3 times, the fault is detected and the corresponding pending fault code is stored (low input check).

Similarly, if the output is higher than a threshold value for more than a fixed time, a high voltage fault is detected and an error counter increases. When this counter overcomes a threshold of 3 times, the fault is detected and the corresponding pending fault code is stored (high input check).

For diagnostic calibration constants see OBDII MALFUNCTION CRITERIA CHART.
Drive by Wire
The Lamborghini EMS is equipped with a Drive – By – Wire (DBW) system which controls the throttle plate instead of the traditional Bowden mechanical system.

Lamborghini defined a system of error codes, stored in the Lamborghini Lie 2003 ECU, which allows both to check the behavior of the throttle bodies and pedal sensors.

Circuit low and high input is checked both in the pedal position sensor and in the throttle position sensors, while for the L140 car are checked in the actuators of the throttle short to ground and to Vbatt, open circuit and high temperature; safety strategies check the consistency of the circuit performance.

For the diagnostic constants see the OBDII Summary Table.
SCHEMATIC DRAW (DBW) L147

DRIVE BY WIRE SYSTEM - SCHEMATIC DRAW (DBW)
Idle control system
The Lamborghini EMS engines are equipped with a closed loop idle control system, based on spark advance timing control and Drive-By-Wire throttle position control.

The target idle speed is variable according to the engine coolant temperature and the time from engine on. During this period the idle rpm is continuously monitored. Strategy verifies that the engine idle speed would not be 100 Rpm lower or would not be 200 Rpm higher than the target one. If the Rpm is 200 rpm higher than idle speed target for a time over 6 seconds, the “Rpm Higher Than Target” counter increases. When this counter overcomes a calibration threshold of 10 times, the fault is detected and the pending fault code (P0507) is stored. If the Rpm is 100 rpm lower than idle speed target for a time over 6 seconds, the “Rpm Lower Than Target” counter increases. When this counter overcomes a calibration threshold of 10 times, the fault is detected and the pending fault code (P0506) is stored.

As said, the idle speed control uses Drive-By-Wire throttle position and spark advance timing in order to reach the idle speed target. When the idle condition are met, the control adjust the throttle position also to have the spark advance timing into a narrow range (around the basic idle spark advance). In this case a throttle position self learning strategy works. At the end of it, the difference between the basic throttle position and the present one is stored in eeprom (as TPSL). Every time the idle condition are met this strategy works.

Also the stored TPSL is monitored. The difference between the new offset and the one stored on the previous trip, must be lower than a calibration threshold. If that’s not true an error counter increases. When this counter overcomes a threshold of 1 time, the fault is detected and the pending fault code (P0507) is stored.

In this way the diagnosis is capable to detect any accidental/forced tube disconnection (e.g. tube B of the Positive Crankcase Ventilation System, also when the idle control system is capable to reach the target idle speed.

The idle control has a lower saturation for the Drive-By-Wire throttle position. This saturation value is calibrated to low that is never reachable in normal condition of the manifold (also when it is completely new). But if the idle control system adjust the throttle position and this value is equal to saturation value (also if the idle speed is not 200 higher than target) for a time over 35 seconds the Idle DBW error counter increases. When this counter overcomes a threshold of 1 time, the fault is detected and the pending fault code (P0507) is stored.
The only difference between L140 and L147 is that in the L147 the manifold is divided in two parts, on for each bank. At idle, a strategy adjusts the DBW throttle position in the bank2 in order to balance the two MAP values. The T.A. difference is called Idle_MAP_Comp. This variable is monitored with an upper threshold and a lower one, if it exceeds one of those thresholds for a time of 6 seconds a counter increases. If this counter overcomes a threshold of 10 times a pending fault code is stored.

This is another way to detect a tube disconnection in one of the two parts of the L147 manifold.

Exhaust Noise Control System (ENCS)
The Lamborghini L-140/L-147 exhaust system lay-out are fitted with two by-pass valves (one for each bank) in order to improve sound and obtain less backpressure. The valve’s control is managed by ECU in function of RPM and MAP thresholds. See picture below for L147 exhaust system lay-

The diagnosis of right opening/closing bypass valves is actuated for both L140/L-147 exhaust system, but is really needful only for L-147. In fact when bypass valve (who’s normally open when not actuated) switch from close to open, the exhaust gas flow don’t pass through rear catalyst and muffler (for L-140 only muffler is skipped).
**Functional Check**

This check detects the correct actuation of Bypass valves. A functional monitoring is performed by the comparison between instantaneous airflow through the engine and corresponding exhaust backpressure.

- The airflow is a value calculated in ECU in function of RPM and MAP.
- The exhaust backpressure can be detected with the pressure sensors (the same employed for misfire detection; see section 3) positioned before the close coupled catalytic converter.

The conditions for diagnosis are:
- airflow value > threshold value (for could appreciate the different backpressure with open/closed valves configurations). The threshold of airflow value is several exceed during a FTP driving cycle. In order to avoid unauthentic fault check, the threshold is also function of maximum value of backpressure obtained when bypass is open.
- instantaneous misfire not occurs

If ECU actuation is Bypass_Closed (high backpressure condition) and exhaust backpressure is lower than a threshold for a fixed time, means that the exhaust valve is blocked open. It’s an emission relevant condition because the rear catalysts are skipped so the relative pending fault code is stored.

If ECU actuation is Bypass_Open (low backpressure condition) and exhaust backpressure is higher than a threshold for a fixed time, means that the exhaust valve is blocked closed. It’s not an emission relevant condition but can be dangerous for the correct functionality of exhaust bypass valves at high RPM and MAP. In this case a pending fault code is stored.

For diagnostic constants see OBDII MALFUNCTION CRITERIA CHART.

**Feedback check**

In order to ensure the correct functionality of by pass valves a feedback is performed continuously on the electro-valve vacuum actuator.
Electronic Transmission
Introduction on the electronic transmission.

The Lamborghini Gallardo and Murcielago can be equipped with an electronic transmission; the system is the same for both cars and consists in a manual transmission (no changes on the clutch and gear-box) coupled with an electronic-hydraulic control for the movements of the clutch and for the selection and engage of the gears. The system is managed by a dedicated TCM.

In the following picture is described the OBDII system.

![Picture 1.](image-url)
16.13.2 Gear selection and gear engage.

The gear shift is done with two steering wheels mounted special levers (Up and Down shift) connected to the TCM instead of the traditional clutch pedal and shift lever. The actuation of the gear requested is performed by the hydraulic system.

The hydraulic system commands with one hydraulic actuator mounted on the gear-box two pistons for the movement of the selection and the engage of the gear. The two pistons are actuated by one electro pump through one set of electro valves; in the same set is present also the electro valve that moves the clutch; as said, the traditional pedal clutch is not present.

16.13.3 Hydraulic unit: components and functionality.

The movements of the clutch and of the gear lever is performed by the hydraulic unit composed out of the power unit (see picture 2.), the electro pump (showed in picture 3.) and the gear and clutch actuators (see picture 4.); picture 5. shows the hydraulic components mounted on the gear-box.

Picture 2.
Picture 3.

Picture 4.
Picture 5.
The engage of the different gear is possible with the actuation of the electro valves as showed in the picture 6., while through the input of the two sensors “gear select” and “gear shift” is possible to knows which gear is engaged, as showed in picture 7.

The movement of the clutch is actuated by one of the 6 electro valve with the additional information of the input of the clutch position sensor.

Electro valve N°1: engage 2., 4., 6. gear
Electro valve N°2: engage 1., 3., 5. gear
Electro valve N°3: select 1. and 2. gear
Electro valve N°4: select 5. and 6. gear
Electro valve N°3 + N°4: select 3. and 4. gear
Electro valve N°5: reverse gear
Electro valve N°6: clutch actuator

picture 6.

picture 7.
16.13.4 Electronic: components and OBD II system.

The electronic powertrain components subject to the comprehensive component monitoring requirements of the OBD II regulation are:

- Hydraulic pressure sensor
- Gear select and gear shift sensor
- Clutch position sensor (see picture 8.)
- Clutch speed sensor (see picture 9.)
- Set of the electro valves
- Electric pump relay
- TCM power relay

In addition are monitored the CAN communication, the engine speed and the vehicle speed signals coming from the ECM too.

*picture 8.*
In the following pages are the flow charts of the diagnosis. For diagnostic constants see the OBDII Summary Table.
16.13.4.1 Rationality monitoring on the engaged gear.

Two functional monitorings are present in order to detect the incorrect gear ratio and the shift error.

16.13.4.1.1 Incorrect gear ratio.

The diagnosis is performed when a gear shift is not in progress with the clutch closed and the vehicle is moving with engine on; the fault is detected if all the following conditions are true:

\[ \text{Driveline speed} \times \text{gear ratio} \neq \text{Engine speed} + \text{DltNWrong3P} \]
\[ \text{Driveline speed} \times \text{gear ratio} \neq \text{Clutch speed} + \text{DltNWrong3P} \]

The parameter \text{DltNWrong3P} is the speed tolerance for set the error.

The gear ratio used in the calculation is based on the gear box position read by the shift and gear position sensor.

In the comparison all the speed information are used (engine, clutch and driveline), in order to avoid false diagnosis when one of the speed information is wrong.

For diagnostic constants see the OBDII Summary Table.

16.13.4.1.2 Shift error

The diagnosis is performed when a gear shift is in progress with all the gear valves activated; if the gear position area read by both gear position sensor and shift position sensor is different from the requested one the fault is stored.

For diagnostic constants see the OBDII Summary Table.