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Basic LS1 components

LS1 RPO codes for the Gen III Chevy Small Block Engine

RPO	Displacement, Usage	Bore Diameter in/mm	Stroke in/mm	Block material
LS1	5.7L (346 cid) Corvette, Camaro, Firebird, GTO	3.898" 99 mm	3.622" 92 mm	Aluminum
LS6	5.7L (346 cid) Corvette	3.898" 99 mm	3.622" 92 mm	Aluminum
LQ4	6.0L (377 cid) GMC/Chevrolet Full Size Trucks	4.000" 101.6 mm	3.622" 92 mm	Iron
LQ9	6.0L (377 cid) Escalade and Silverado SS	4.000" 101.6 mm	3.622" 92 mm	Iron
LM4	5.3L (322 cid) Mid and Full Size Trucks and SSR	3.779" 96 mm	3.622" 92 mm	Aluminum
LM7	5.3L (322cid) '99 and later and Full Size trucks	3.779" 96 mm	3.622" 92 mm	Iron
LR4	4.8L (291 cid) Full Size trucks	3.779" 96 mm	3.270 83 mm	Iron

Firing order: 1-8-7-2-6-5-4-3

The firing order of the LS1/Vortec V8 has been revised from the Gen I and Gen II engines. This was done to provide more power, less crankshaft rotational stress and better emission and idle qualities.

Camshaft sensor (CMP)

The camshaft sensor is a 1X pulse sensor which is synchronized to the #1 firing of the engine (Whether or not it is on its firing or exhaust stroke). The reluctor is located on the back of the camshaft. As the reluctor rotates, it interrupts the magnetic field produced by the sensor and the pcm interprets this as a pulse, after the signal is buffered by the internal circuitry of the CMP. The pcm uses this signal in conjunction with the crankshaft sensor (CKP) to determine the crank position and stroke. The pcm monitors this signal for any problems and sets the appropriate DTC (diagnostic trouble code) for loss or degraded signal. The pcm provides the +12V power, ground and signal return for the CMP.

A loss of this signal will result in longer starting times.

The LS1-Vortec V6 camshaft sensor (CMP)

The location of the CMP is on the top rear center of block

Crankshaft sensor (CKP)

The crankshaft sensor is a 24X (58X on 2004 and later engines) pulse sensor that controls ignition coil firing and injector pulse. The 24 tooth reluctor wheel is mounted on the back of the crankshaft. This location is known as the "quiet" deflection zone that minimizes any false signals to the pcm that can be misinterpreted as a fault. As with the CMP, the crankshaft sensor is a magnetic sensor that has the field interrupted by the passing the the teeth on the reluctor. This signal is conditioned by the sensor circuitry so I can be properly used by the pcm.

The pcm constantly times the pulse intervals it receives, in conjunction with the CMP to resync the point of the #1 firing stroke. Any changes to the timed intervals at each firing order stroke is read by the pcm as a change in crankshaft velocity. Using the other sensors such a MAP, and TPS, the pcm can determine the changes in crankshaft speed when the engine is accelerating or decelerating, within normal operating conditions, and when the changes are outside the normal parameters, the pcm detects this as a misfire, and the appropriate DTC is set.

A loss of this signal will result in a no-start condition

The LS1-Vortec V8 Crank sensor (CKP)

The location of the CKP is on the right hand side above the starter.

The 24X reluctor crank sensor has a black connector plug, the 58X reluctor sensor connector is gray in color. This does not interchange and must be used with the proper reluctor shown below.

Crankshaft Reluctors:

The 24X reluctor is on the left, the 58X reluctor on the right.

Knock sensors (KS1 and KS2)

The LS1 and the Vortec V8 engines use two knock sensors, the part number is the same for both, but they have two distinct lines to the pcm. the front sensor (KS1) monitors the first 4 cylinders (2 each left and right) while the KS2 monitors the back 4 cylinders. based on information from the crankshaft sensor, the pcm can detect which cylinder is firing, each cylinder is causing a knock situation, the information broken down into a trouble code can tell the technician which cylinder is not receiving fuel, or spark or is under knock conditions.

The LS1-Vortec V8 knock sensors

Location for the sensors is on the top of the block under the intake

Intake Air Sensor (IAT)

Depending on the type of MAF sensor, the IAT can be either located in the air intake tract or internal to the MAF sensor. The LS6 and Vortec V8 engines that use the 85mm MAF has the IAT integral to the sensor.

The IAT (which is also the same as the MAT on older Fuel Injected engines) uses a thermistor which changes resistance based on the air temperature entering the engine. The normal range is from 100K ohms @ -39F, to 70ohms at +266F. At room temperature, this can be from 1500 to 2500 ohms.

The pcm supplies a 5V signal to the sensor and monitors the signal on the return. This voltage variation is used by the pcm along with the MAF to determine air density and therefore alter the spark timing accordingly.

When the engine is completely cooled down, the scan tool should read a temperature close to the ambient air temperature. When the engine is started and running, the temperature should rise as under hood temperature increases.

IAT sensors used in the air duct (LS1)

The Vortec V8 and LS6 has the IAT integral with the MAF sensor.

Engine Coolant Temperature (ECT) sensor

The ECT, like the IAT is a thermistor sensor, so it also changes the resistance based on temperature. The same range of resistance (ohms) is used as in the IAT. The pcm also sends a 5V signal to the sensor and monitors the return voltage. When the engine has not been run for several hours, the scan tool should read the IAT and ECT temperatures close to each other.

The PCM uses the signal for many of the control systems that affect fuel economy, emissions and idle, so any degraded or loss of signal has a great impact on the engine performance.

There are two different ECT sensors. One is a three wire used on very early (1997-98) LS1 engines, where the third wire (usually green) goes directly to the temperature gauge on the instrument panel. The later engines use a two wire sensor and the pcm conditions the signal and a separate signal from the pcm goes to the gauge on the instrument cluster.

If you are doing a LS1 retrofit in a older vehicle you will need the three wire sensor. GM part number 12551708. Make note, that this sensor is only compatible with GM production gauges or aftermarket gauges that are compatible.

ECT location in the front of driver's side cylinder head.

Manifold Absolute Pressure (MAP) sensor

The MAP sensor is used to measure the amount of pressure change inside the intake manifold. When the vacuum signal is high (idle and deceleration) the voltage is low, while under load and acceleration, when the vacuum signal is low, the voltage from the MAP sensor is high. Just remember that the MAP is inversely proportional to what is measured with a vacuum gauge. This signal is used for the following operations:

- Altitude compensation
- Ignition timing control
- Speed density fuel management default (MAF sensor failure).

Typical MAP sensor used on many post' 96 GM cars. Location of the LS1/LS6 MAP sensor, Vortec V8's located on top of intake.

Mass Air Flow (MAF) sensor

The MAF sensor is used to measure the amount of air entering the engine. Idle conditions equal a low air flow, and engine under acceleration indicates a high air flow. The pcm uses the MAF to determine the amount of fuel delivery to the engine.

The MAF sensor has a ignition +12V power source, a ground and signal return. The sensor is a hot wire

type that the MAF frequency output is a function of how much power it takes to keep the sensing wire at a preset temperature above the ambient temperature. Air flowing across the heated sensing wire cools the wire, and the current increases to maintain this preset temperature. The current increase or decrease is proportional to the air flow. The MAF sensor converts this current into a frequency which is read by the pcm and calculates the air flow in grams per sec (gm/sec). The scanner should display around 9-14 gm/sec, on a fully warmed up engine at idle.

The pcm monitors this voltage to determine if the MAF is performing properly and sets the appropriate DTC based on this information.

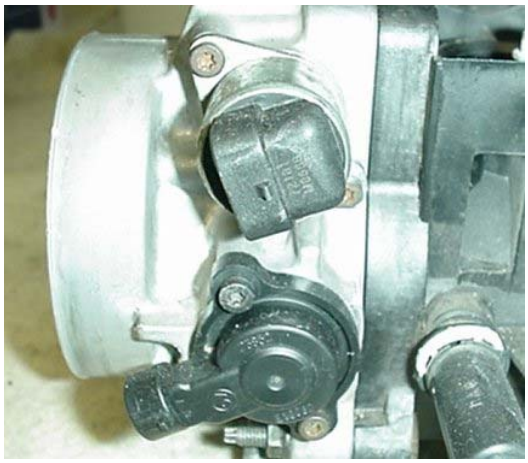
There are two types of MAF sensors. One is he 75mm used on the early LS1 engines, which is a three wire type and the 85MM version, used on the LS6 and Vortec V8 which has the integral IAT sensor (5pin sensor).

The MAF on the left (75mm) 3 pin connector, the MAF on the right (85mm- 5pin) used on later LS1, Ls6 and Vortec V8 engines.

Throttle Position (TP) sensor

Like the older engines, the TP (or TPS) is mounted on the throttle body throttle shaft. The sensor is a potentiometer that varies the voltage output based on position (in this case, the angle of the throttle blade). At idle, the output voltage is around 0.6V, and at WOT this voltage is around 4.0V. The pcm sees the signal, along with the CMP, CKP, MAP and MAF to determine if the engine is accelerating or not. This affects many systems, including emission system and fuel calibration control. An erratic or faulty TP sensor will cause erratic engine performance. A DTC will be set depending on the type of fault condition the pcm sees.

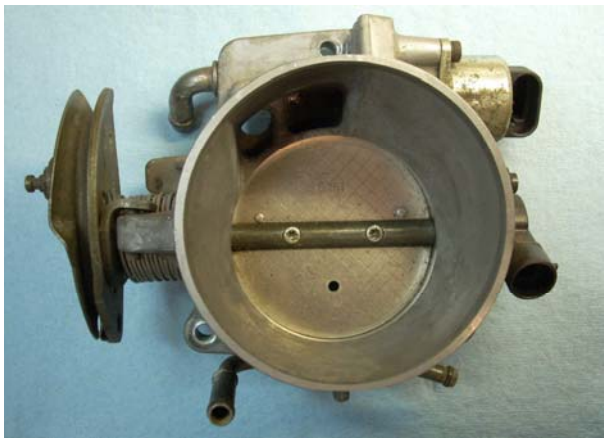
Typical TP sensor for the LS1-LS6-Vortec V8



The location of the TP sensor (bottom). IAC is above it.

Throttle Bodies

There are 4 common throttle bodies used on the Gen III engines, the one you use will be dictated by what configuration your are using and the parts availability. This is especially true if you are desiring to use the DBW (Drive By Wire) throttle.



The most common will be the throttle body used on the F-body LS1 from 1998 through 2002. The next picture is for the throttle body that was used on the Vortec 4.8, 5.3 and 6.0L 1999 through 2002 trucks. Note the differences between the two as it will have an impact on the type of throttle cable, coolant line hose routing. The LS1 throttle actuator is narrower and has a longer cable groove, though it seems that with the proper cable bracket and cable either one would work. The coolant lines under the throttle body are different and each one has it own unique piping associated with it. There are these style of

throttle bodies that have different flow rates, whether they use a 75 or 85 mm MAF sensor.

Corvette DBW 1997-2004, if you plan to use this, you will need the TAC (Throttle Actuator Controller) module and accelerator pedal to make this work, not to mention the associated wiring and programming in the computer to make it work. See Drive By Wire link

This style of DBW throttle body was common to the Vortec Trucks and like the Corvette throttle body, this has its own unique TAC module and accelerator pedal that must match. See Drive By Wire link.

Idle Air Control (IAC) Valve.

The IAC is a pcm controlled stepper motor location the throttle body, just above the TP sensor. The IAC has pintle that moves back and forth controlling idle speed based on temperature and external loads imposed on it such as the alternator output and AC compressor load. Basically the IAC bypasses air from the outside through a opening just behind the throttle blades. Thus, it acts as a "controlled vacuum leak". The pintle moves away from its seat, to bypass more air and increasing idle speed (on cold engine start up, or when loads are added that would cause the engine to stall), and moves toward its seat, decreasing the amount of bypass air and lowering idle speed (with engine warming up).

The pcm moves the pintle in steps, called "counts". The higher the number, the higher the idle speed and lower counts result in decreased idle speed. The idle speed is determined on:

- Battery voltage
- Coolant temperature

- Engine load
- Engine rpm (as determine by the CKP)

If the rpm drops below specification with the throttle closed, the pcm will increase the pintle position and calculate this in its memory to prevent stalling. Engines speed is a function of total air intake into the engine (IAC pintle position + throttle angle + bypass air + calibrated vacuum loss through accessories).

The controlled idle speed is programmed into the pcm and the correct IAC position is determined for all engine operating parameters. The minimum air rate is set at the factory with a stop screw. This setting allows just enough air to bypass the throttle blade to cause the IAC pintle to be positioned in a calibrated number of steps.

NOTE: Do not attempt to adjust idle speed by turning the screw on top of the right side of throttle body, you will damage the IAC motor.

IAC control stepper motor.

Vehicle Speed Sensor (VSS)

The VSS is an important sensor used by the pcm to determine how fast the vehicle is moving. Located at the back end (tailshaft) of the transmission on either the automatic (4L60E) or manual (T56), this sensor is basically an a signal generator that puts out a AC signal that the voltage also increases proportional to how fast the vehicle is moving. The reluctor in the transmission is a 40 tooth wheel. The VSS can be miscalibrated by not using the factory calibrated tire size and gear ratio that was originally installed with the vehicle. Any LS1 retrofit into another vehicle will certainly mean that the pcm will have to be recalibrated for the new tire size and/or gear ratio.

VSS sensor used on stock transmissions.

Ignition Control (IC).

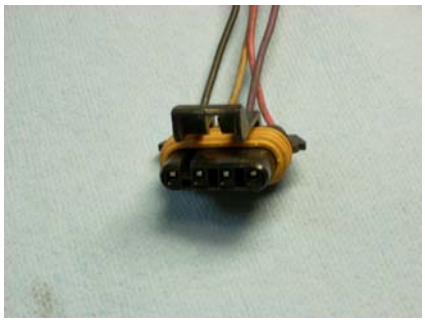
The ignition control for the LS1-LS6/Vortec V8's consists of the following systems:

- One ignition coil for each cylinder
- Separate IC control circuit for each coil
- CMP
- CKP
- PCM

To control the proper firing order of the ignition coil, the pcm bases the information of the following:

- Engine load based on MAP sensor signal
- Air intake based on MAF signal input
- Intake air temperature
- Crankshaft position
- Engine speed (RPM)

The 24X(58X on 2004 and later engines) signal from the CKP not only determines the firing of the ignition coils, but the firing of the injectors as well. The pcm ground the circuit of the IC and this triggers the ignition coil to fire. The timing is not adjustable.



Each cylinder has its own coil. The early 1997-98 LS1 engines with perimeter valve cover bolts had the coils mounted directly to the valve cover, later engines that used the center bolt covers has coil mounting brackets. The center picture is the coil pack connector found on the Vortec V8 engines. The picture on the right is the coil pack connector found on the LS1/Ls6 engines.

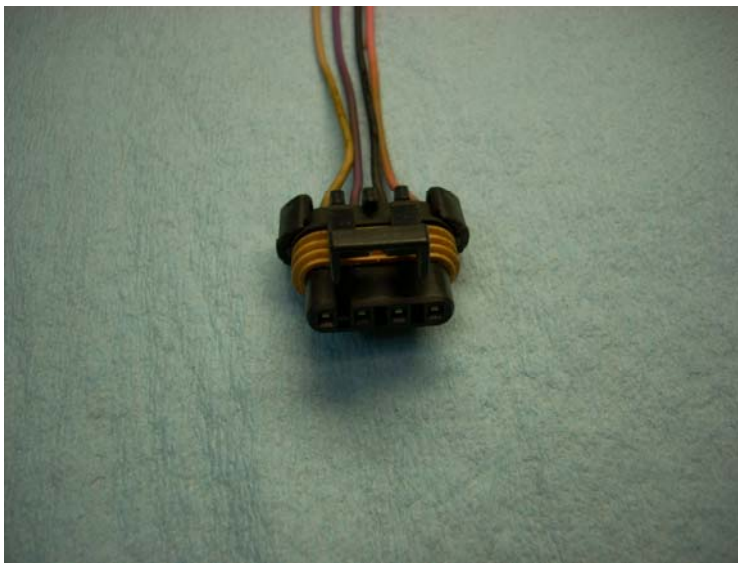
O2 Sensors

The O2 sensors on the LS1 and Vortec V8 are used to monitor the oxygen content in the exhaust gasses. The optimum mixture is to keep to close as a 14.7 to 1 ratio as possible. The LS1-Vortec engines use 4 sensors, 2 on each side, one ahead of the catalytic converters, the other one is called the post catalytic sensor. The first sensor in the stream ahead of the converter is use to trim the fuel calibration to keep the emissions to a minimum, the post-cat sensor is to monitor the efficiency of the converter. The first sensor swings from about .250V to .900V, adjusting from rich to lean detection. The post-cat sensor should have barely any voltage swing at all, if it does, it means the catalytic converter is defective and not cleaning up the exhaust. Any deficiency in any sensor will set a DTC.

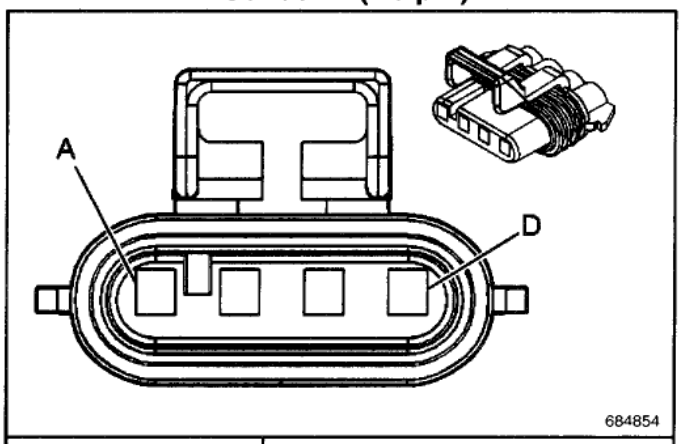
Most retrofits will not use the post-cat sensor if legal to do so, but the pcm will have to be reprogram to ignore the two post cat sensors, but the first two sensor will have to be retained.

Vortec Gen III Truck O2 sensors
'97-'04 Corvette

Common O2 sensor types (L) '98-'02 F-body (R)

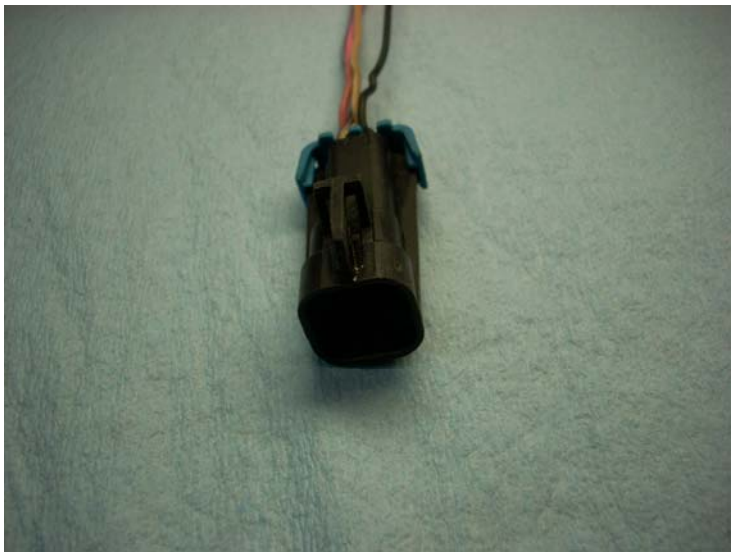


Heated Oxygen Sensor (HO2S) Bank 1 Sensor 1 (Delphi)

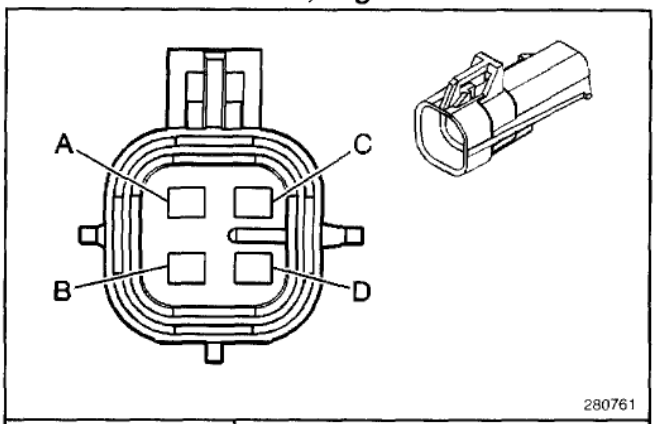


Connector Part Information		• 12162144 • 4 Way F Metri-Pack 150 Series (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	TAN/WHT	1653	HO2S Low Signal - Bank 1 Sensor 1
B	PPL/WHT	1665	HO2S High Signal - Bank 1 Sensor 1
C	BLK	550	Ground
D	PNK	539	Ignition 1 Voltage

O2 sensor connector (male- harness side) used on the LS1 Corvette and the rear sensors for the 1999 and up Vortec Truck, and the LS2 rear sensors.



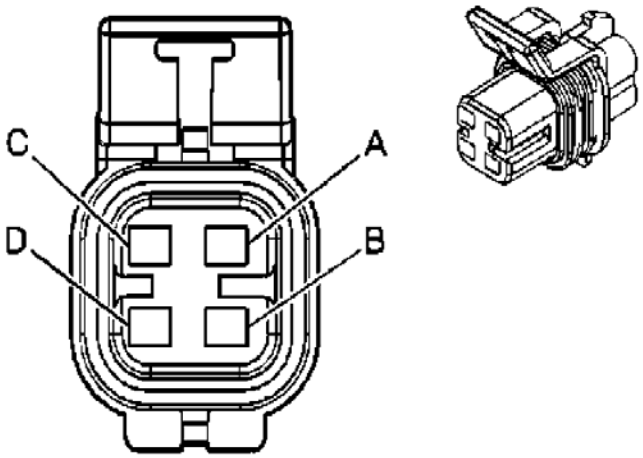
Heated Oxygen Sensor (HO2S), Bank 2, Sensor 1, Right Front



Connector Part Information		• 1216-0825 • 4-Way M Metri-Pack 150 Series Sealed (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	TAN	1667	HO2S Low Signal [Bank 2 Sensor 1]
B	PPL	1666	HO2S High Signal [Bank 2 Sensor 1]
C	BLK	450	Ground
D	PNK	539	Ignition 1 Voltage

O2 sensor connector (female-harness side) used on the front and rear O2 sensors for the LS1-LS6 Camaro/Firebird.

Heated Oxygen Sensor (HO2S) Bank 1 Sensor 1

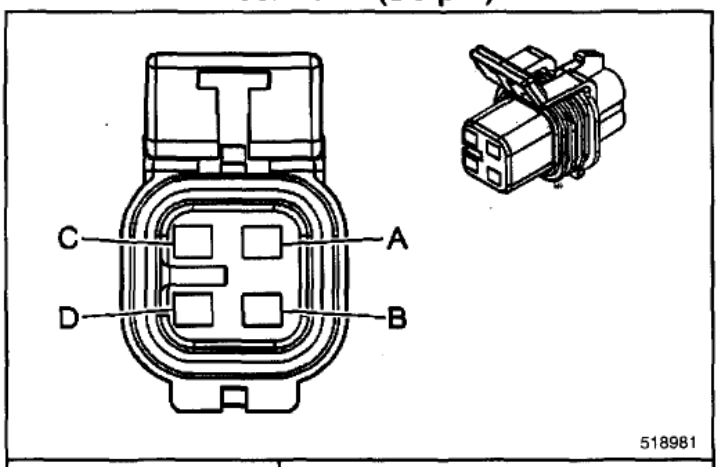


Connector Part Information	• 9723-6897-40 • 4-Way F (GY)

Pin	Wire Color	Circuit No.	Function
A	BU/BK	1664	HO2S Low Signal Bank 1 Sensor 1
B	PU	1665	HO2S High Signal Bank 1 Sensor 1
C	BK/WH	1050	HO2S Bank 1 Sensor 1 Heater Low Control
D	PK	439	Ignition 1 Voltage

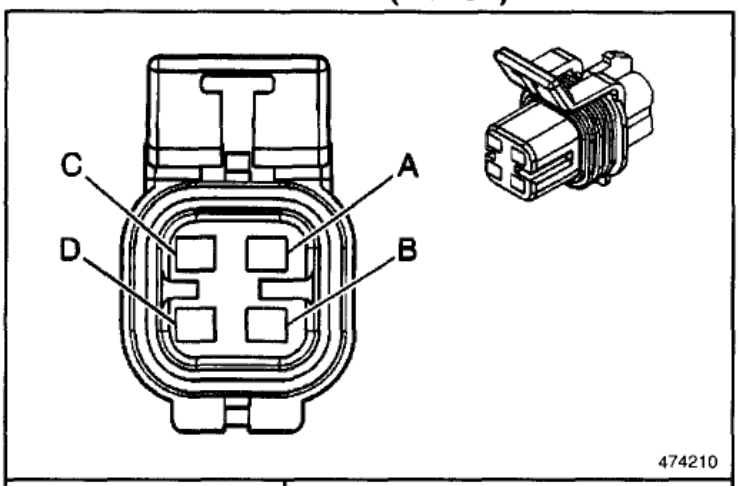
O2 Sensor connector (male end-harness side) that is used the rear sensors for the Vortec truck and LS2 engines. First diagram is for the LS2.

Heated Oxygen Sensor (HO2S) Bank 1 Sensor 2 (Delphi)



Connector Part Information	• 12160482 • 4 Way F Metri-Pack 150 Series (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	TAN/WHT	1669	HO2S Low Signal - Bank 1 Sensor 2
B	PPL/WHT	1668	HO2S High Signal - Bank 1 Sensor 2
C	BLK	550	Ground
D	PNK	1539	Ignition 1 Voltage

Heated Oxygen Sensor (HO2S) Bank 1 Sensor 2 (Denso)

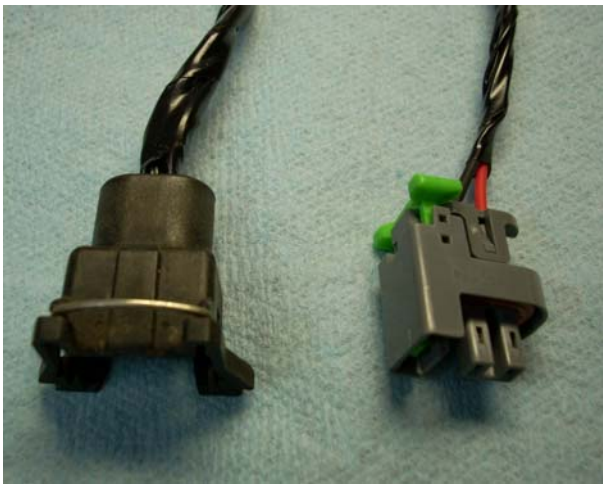


Connector Part Information	• 12176897 • 4 Way F Metri-Pack 150 Series (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	TAN	413	HO2S Low Signal
B	PPL/WHT	1668	HO2S High Signal [- Bank 1 Sensor 2]
C	PNK	1539	Ignition 1 Voltage
D	BLK	550	Ground

Vortec 1999 and up sensor connectors used for the rear sensors. Note the orientation of the Ignition Voltage and grounds to the respective terminal.

Fuel Injectors-Connectors:

There are three different type of fuel injector connectors used, The most common ones are the LS1 style, which is essentially the same as the TPI and LT1 injectors , the injector connector used for the 1999 and up Vortec V8 engines and the third design which is for the flex fuel engines.



LS1/LS6 injector connector 4.8-5.3-6.0 Vortec injector connector. Flex fuel injector connector (my 2006 Silverado)

The design of the LS1-Vortec fuel injector is the same, only the terminal end may be different depending on the application.

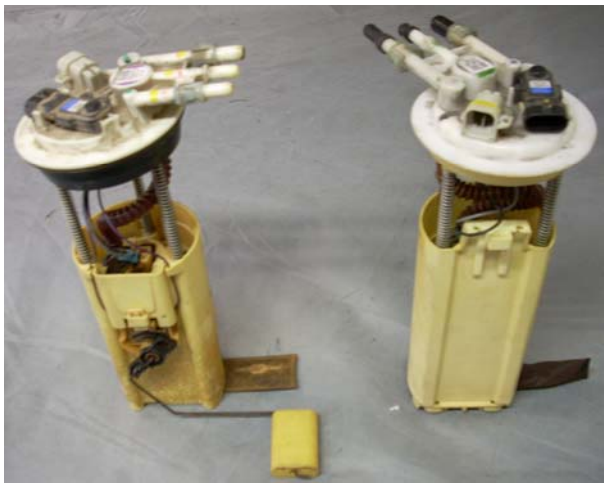
Fuel Pump:

When you are installing a late model power plant, the most difficult hurdle; is the design, set up and installation of the fuel delivery system. The most common intake manifold you will come across will be the 1999 and later design which has a *single* fuel line to the injector rail and this incorporates the fuel regulator in the fuel pump/sender assembly which installs in the fuel tank.

The 1997-98 LS1 manifold with a *supply and return* fuel lines are hard to come by. So if you are lucky to have one of these, hold on to it, as the only thing you will need is the fuel pump assembly, fuel lines, fittings and brackets.

1999 and later manifold-single supply fuel line.

The 1999 and later manifolds, though requiring just a single fuel line, will require a fuel pump assembly that has a built in regulator, or the other two options you may explore is to purchase the fuel filter/line assembly that allows you to install the two fuel lines into it with a single line out to the fuel injectors *or* can have your single line fuel rail modified for the two fuel lines and regulator added. Street and Performance of Mena, Arkansas provides this service.



Fuel pump assemblies for the LS1 engines with dual lines. The fuel pump assembly on the right has had the fuel sending unit removed for installation in a retrofit LS1 project. Even though it is possible to use these assemblies from the GM FWD cars from 1996 up, you will need to replace the fuel pump for proper pressure and volume requirements. these can be installed in a tank with a flat top and it will require ingenuity to mount and seal. Always use a gasket (cork/rubber) for a seal and you can use small sheet metal screws to install the pump to the tank. These is also possible if you have a single line fuel pump assembly from a 2002 and later vehicle.

Another good source of information for the LS1 GEN III engine can be found here at: http://www.enginebuildermag.com/Article/1096/gen_iii_gm_small_block.aspx.

Transmission Retrofits

Installing a LS1 engine with another transmission such as a early 200/700R4, THM350/400 will require the installation of flywheel GM part number 12551367.

If using the F-body and C/K trucks with the 300 mm bolt pattern will require the flexplate with PN 12563136.

The 4L80E or 6 lug converters will require PN 12551367. This flexplate is flat and will require the use of a spacer (PN 12563532) and bolts (PN 125635330 which is included with flexplate assembly.

If using a early manual transmission will require, which will use a 11.7" (298mm) clutches:

- PN 12562765: 6 speed flywheel assembly
- PN 12561680 Early style 4 speed flywheel

The LS1 crankshaft is also shorter relative to the bell housing than the earlier small-blocks. Special pilot bearing PN 12557583 is needed to compensate for this difference.

Locating the harness, hint and tips click here: **ls1pcm**

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