

Displacement on Demand (DoD) System Description

To provide maximum fuel economy under light load driving conditions, the engine control module (ECM) will command the displacement on demand (DoD) system to deactivate engine cylinders 1 and 7 on the left bank, and cylinders 4 and 6 on the right bank, switching to a V4 mode. The engine will operate on 8 cylinders, or V8 mode, during engine starting, engine idling, and medium to heavy throttle applications.

When commanded ON, the ECM will determine what cylinder is firing, and begin deactivation on the next closest DoD cylinder in firing order sequence. The Gen IV engine has a firing order of 1-8-7-2-6-5-4-3. If cylinder number 1 is on its combustion event when DoD is commanded ON, the next cylinder in the firing order sequence that can be deactivated is cylinder number 7. If cylinder number 5 is on its combustion event when DoD is commanded ON, then the next cylinder in the firing order sequence that can be deactivated is cylinder number 4.

Cylinder deactivation is accomplished by not allowing the intake and exhaust valves to open on the selected cylinders by using special valve lifters. The deactivation lifters contain spring loaded locking pins that connect the internal pin housing of the lifter to the outer housing. The pin housing contains the lifter plunger and pushrod seat which interfaces with the pushrod. The outer housing contacts the camshaft lobe through a roller. During V8 mode, the locking pins are pushed outward by spring force, locking the pin housing and outer housing together causing the lifter to function as a normal lifter. When V4 mode is commanded ON, the locking pins are pushed inward with engine oil pressure directed from the valve lifter oil manifold (VLOM) assembly solenoids. When the lifter pin housing is unlocked from the outer housing, the internal pin housing will remain stationary, while the outer housing will move with the profile of the camshaft lobe, which results in the valve remaining closed. One VLOM solenoid controls both the intake and exhaust valves for each deactivating cylinder. There are 2 distinct oil passages going to each DoD lifter bore, one for the hydraulic lash-adjusting feature of the lifter, and one for controlling the locking pins used for cylinder deactivation.

Although both intake and exhaust valve lifters are controlled by the same solenoid in the VLOM, the intake and exhaust valves do not become deactivated at the same time. Cylinder deactivation is timed so that the cylinder is on an intake event. During an intake event, the intake cam lobe is pushing the valve lifter upwards to open the intake valve against the force of the valve spring. The force exerted by the valve spring is acting on the side of the lifter locking pins, preventing them from moving until the intake valve has closed. When the intake valve lifter reaches the base circle of the camshaft lobe, the valve spring force is

reduced, allowing the locking pins to move, deactivating the intake valve. However, when DoD is commanded ON, the exhaust valve for the deactivated cylinder is in the closed position, allowing the locking pins on the valve lifter to move immediately, and deactivate the exhaust valve.

By deactivating the exhaust valve first, this allows the capture of a burnt air/fuel charge or exhaust gas charge in the combustion chamber. The capture of exhaust gases in the combustion chamber will contribute to a reduction in oil consumption, noise and vibration levels, and exhaust emissions when operating in V4 mode. During the transition from V8 to V4 mode, the fuel injectors will be turned OFF on the deactivated cylinders. The ignition system secondary voltage or spark is still present across the spark plug electrodes on the deactivated cylinders. If all enabling conditions are met and maintained for DoD operation, the ECM calibrations will limit cylinder deactivation to a cycle time of 10 minutes in V4 mode, and then return to V8 mode for 1 minute.

Switching between V8 and V4 mode is accomplished in less than 250 milliseconds, making the transitions seamless and transparent to the vehicle operator. The 250 milliseconds includes the time for the ECM to sequence the transitions, the response time for the VLOM solenoids to energize, and the time for the DoD valve lifters to deactivate, all within 2 revolutions of the engine crankshaft.

The DoD system consists of the following components:

- The valve lifter oil manifold (VLOM) assembly
- Eight DoD valve lifters, 2 per deactivating cylinder
- The engine oil pressure regulator valve for DoD operation
- Gen IV DoD engine block
- The ECM

Valve Lifter Oil Manifold (VLOM) Assembly

The DoD system uses an electro-hydraulic actuator device called the valve lifter oil manifold (VLOM) assembly. The VLOM is bolted to the top of the engine valley, below the intake manifold assembly. The VLOM consists of 4 electrically operated Normally Closed Solenoids. Each solenoid controls the application of engine oil pressure to the intake and exhaust valve lifters on the cylinders selected to deactivate. Engine oil pressure is routed to the VLOM assembly from a passage on the rear of the cylinder block.

All 4 VLOM solenoids are connected in parallel to a fused ignition 1 voltage circuit, supplied by the powertrain relay. The ground or control circuit for each solenoid is connected to the engine control module (ECM).

When all enabling conditions are met for DoD operation, the ECM will ground each solenoid control circuit in firing order sequence, allowing current to flow through the solenoid windings. With the coil windings energized, the solenoid valve opens, redirecting engine oil pressure through the VLOM into 8 separate vertical passages in the engine lifter valley. The 8 vertical passages, 2 per cylinder, are connected to the valve lifter bores of the cylinders to be deactivated. When vehicle-operating conditions require a return to V8 mode, the ECM will turn OFF the control circuit for the solenoids, allowing the solenoid valves to close. With the solenoid valves closed, engine oil pressure in the control ports is exhausted through the body of the solenoids into the engine block lifter valley. The housing of the VLOM incorporates several bleeds in the oil passages to purge any air trapped in the VLOM or engine block.

To control any contamination to the DoD hydraulic circuits, a small replaceable oil screen is located in the VLOM oil inlet passage, below the oil pressure sensor. The oil pressure sensor is a 3-wire sensor which provides oil pressure information to the ECM.

During service, use extreme care in keeping the VLOM assembly free of any contamination or foreign material.

Engine Control Module (ECM)

The engine control module (ECM) is responsible for the management and control of all engine functions. Each ECM comes equipped with a specific set of software/calibrations designed for that engine and vehicle application. The ECM will determine engine operating parameters, based upon information from a network of switches, sensors, modules and communication with other controllers located throughout vehicle. Internal to the ECM is an integrated circuit device called a low-side driver. The low-side driver is designed to operate internally, like an electronic switch. An individual low-side driver controls each valve lifter oil manifold (VLOM) solenoid. When enabling conditions for V4 mode are met, the ECM will command the low-side driver to ground each VLOM solenoid control circuit, in firing order sequence. Internal to the low-side driver is a fault detection circuit, which monitors the solenoid control circuit for an incorrect voltage level. If an incorrect voltage level, such as an open, high resistance, short to ground, or short to power, is detected, the low-side driver, along with the fault detection circuit, will communicate the condition to the central processor in the ECM. The ECM will then command a return to V8 mode, set a corresponding DTC, and illuminate the malfunction indicator lamp (MIL) on the instrument panel.

Displacement on Demand (DoD) Inhibit Reasons

Listed below are the powertrain conditions that will inhibit V4 mode, while operating under light load driving conditions:

- Engine manifold vacuum low
- Brake booster vacuum pressure low
- Accelerator pedal position rate of increase too high, electronic throttle control
- Accelerator pedal position too high, electronic throttle control
- Ignition voltage out of range
- Engine oil pressure out of range
- Engine oil temperature out of range
- Engine RPM out of range
- Transmission gear incorrect
- Transmission range incorrect
- Transmission gear shift in progress
- All cylinders activated via scan tool output control
- Minimum time in V8 mode not met
- Maximum V4 mode time exceeded
- Engine oil aeration present
- Decel fuel cutoff active
- Fuel shut-off timer active
- Minimum heater temp low, HVAC system
- Reduced engine power active, electronic throttle control
- Brake torque management active
- Axle torque limiting active
- Engine metal over temperature protection active
- Catalytic converter over temperature protection active
- Piston protection active, knock detected
- Hot coolant mode active
- Engine over speed protection active
- Fault Active or Fault Pending--DoD is disabled for the following faults:
 - Manifold Absolute Pressure Sensor
 - Brake Booster Vacuum Sensor
 - Engine Oil Pressure Sensor
 - Engine Coolant Temperature Sensor
 - Vehicle Speed Sensor
 - Crankshaft Position Sensor
 - Engine Misfire Detected
 - Displacement On Demand Solenoid Driver Circuit

The scan tool output control is used to deactivate half of the engine cylinders, V4 mode, by commanding all of the solenoids ON, or deactivate one cylinder switching to a V7 mode, by commanding ON one solenoid. Listed below are the

powertrain conditions that will inhibit V4 mode, or V7 mode, with the engine running, while using the scan tool output control function:

- Engine speed out of range
- Manifold absolute pressure (MAP) sensor fault
- Accelerator pedal position too high, electronic throttle control
- Piston protection active, knock detected
- Engine oil temperature out of range
- Engine oil pressure out of range
- Engine oil aeration present
- Engine metal over temperature protection active
- Accelerator pedal position rate of increase too high, electronic throttle control
- Displacement on demand solenoid driver circuit fault
- Engine coolant temperature sensor fault
- Catalytic converter over temperature protection active
- Brake booster vacuum pressure low
- Brake booster vacuum pressure sensor fault
- Axle torque limiting active
- Brake torque management active
- Vehicle speed sensor fault
- Engine coolant temperature too high
- Engine not running
- Vehicle speed not zero
- Engine coolant temperature low
- Reduced Engine Power Active, electronic throttle control
- Transmission gear incorrect
- Transmission range incorrect
- Ignition voltage out of range
- Maximum V4 mode time exceeded

Listed below are the powertrain conditions that will inhibit a DoD solenoid from being energized, with the ignition ON and the engine OFF, while using the scan tool output control function:

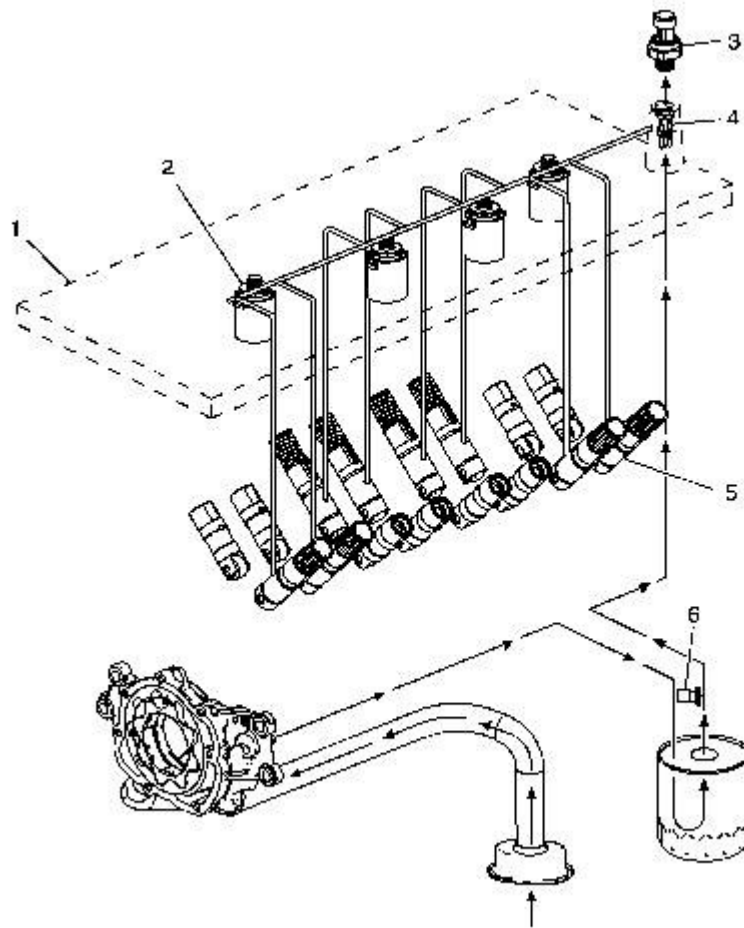
- Engine speed not zero
- Vehicle speed not zero
- Transmission not in park or neutral
- Ignition voltage out of range

Displacement on Demand (DoD) System Description

System Operation

General Motors Displacement on Demand® (DoD) engine control system has the ability, under certain light load driving conditions, to provide maximum fuel economy by deactivating four of the engine's eight cylinders. The engine will normally operate on eight cylinders in V8 mode during starting, idling, and medium or heavy throttle conditions. When commanded ON, the powertrain control module (PCM) will direct the DoD system and deactivate cylinders one and seven on the left bank and cylinders four and six on the right bank, forcing V4 mode. Refer to [Lubrication Description](#) and [Displacement on Demand \(DoD\) System Description](#) in Engine Controls - 5.3L.

Valve Lifter Oil Manifold Assembly



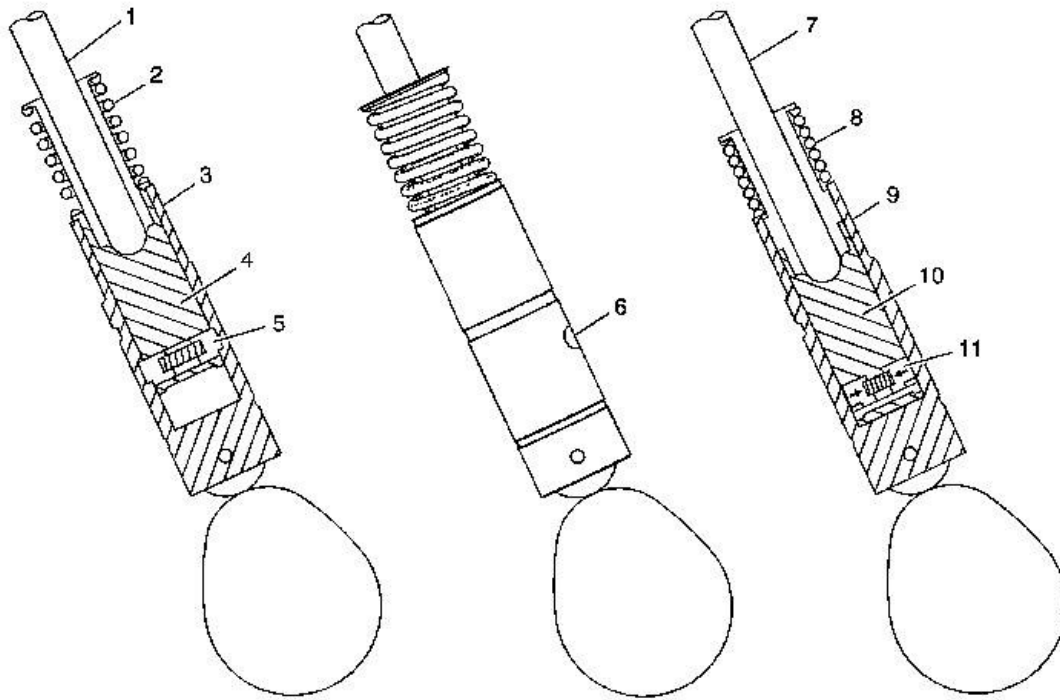
The valve lifter oil manifold assembly (1) is bolted to the top of the engine block beneath the intake manifold assembly. The oil manifold consists of four electrically operated and normally-closed solenoids (2). Each solenoid directs the flow of pressurized engine oil to the DoD intake and exhaust valve lifters (5). The oil pressure relief valve (6), located in the left rear area of the oil pan, regulates engine oil pressure to the lubrication system and the oil manifold.

When enabling conditions are met for DoD operation, the PCM will ground each solenoid control circuit in firing order sequence, allowing current to flow through the solenoid windings. With the windings energized, the solenoid valves open and direct pressurized engine oil through the manifold into eight vertical passages in the engine block lifter valley. The eight vertical passages, two per cylinder, direct pressurized oil to the valve lifter bores of the cylinders to be deactivated. When vehicle operating conditions require a return to V8 mode, the PCM will turn OFF the ground circuit for the solenoids, allowing the solenoid valves to close. When the solenoid valves are closed, remaining oil pressure is

exhausted through the bleed passages of the manifold into the engine block lifter valley. The housing of the oil manifold incorporates several oil bleed passages that continually purge trapped air from the manifold and engine block.

To help control contamination within the DoD hydraulic system, a small replaceable oil filter (4) is located in the manifold oil inlet passage. The oil pressure sensor (3) monitors engine oil pressure and provides information to the PCM.

Displacement on Demand Valve Lifters



When operating in V8 mode, the DoD valve lifters function similar to the non-DoD valve lifters. The DoD oil manifold solenoids are in the closed position with no pressurized oil directed to the valve lifters. The pushrod (1) travels upward and downward to actuate the rocker arm and valve. The spring loaded locking pins (5) of the lifter are extended outward and mechanically lock the pin housing (4) to the outer body of the valve lifter (3).

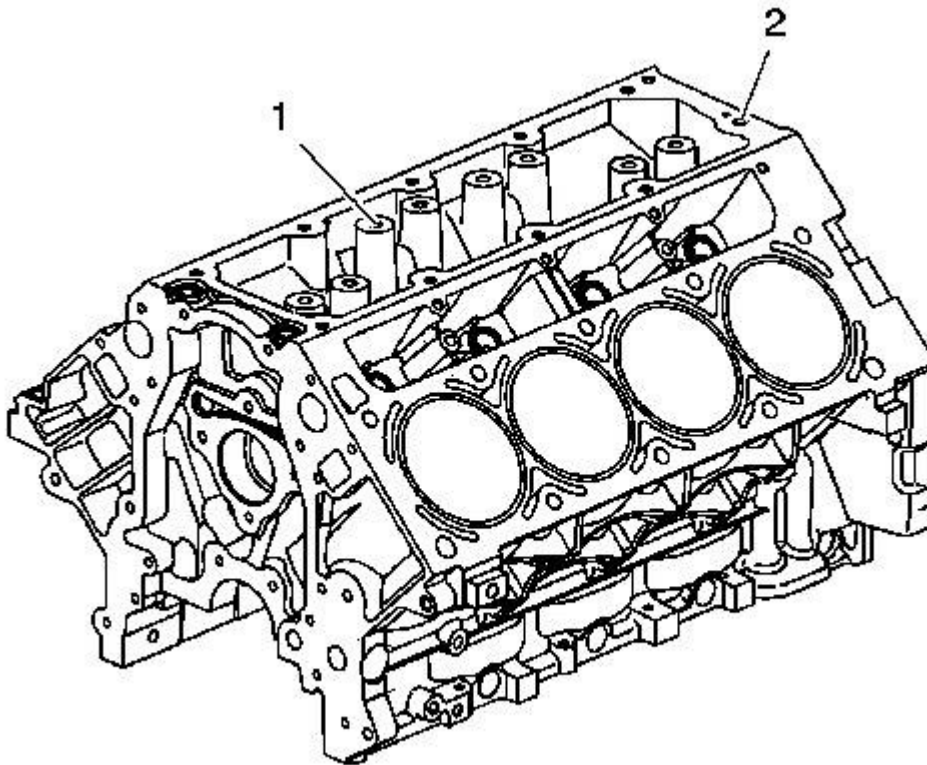
When the DoD system is commanded ON, the PCM will direct the solenoids of the oil manifold to open and direct pressurized oil to the valve lifters. Oil travels

through the manifold and engine block oil galleries and enters the inlet port (6) of the valve lifter.

When operating in V4 mode, pressurized oil forces the locking pins (11) inward. The pushrod (7) remains in a constant position and does not travel upward and downward. The outer body of the lifter (9) moves upward and downward independently from the pin housing (10). The valve lifter spring (8) retains tension on the valve train components to eliminate valve train noise.

When the DoD system is commanded OFF, the PCM directs the solenoids of the oil manifold to close, stopping the flow of pressurized oil to the valve lifters. The oil pressure within the lifter will decrease and the locking pins will move outward to mechanically lock the pin housing and outer body.

Engine Block



The DoD engine block incorporates additional features to support DoD system operation. Engine oil pressure is routed to the manifold assembly from an oil gallery (2) in the rear of the cylinder block. Cylinders one, four, six, and seven

each have two vertical, cast-in-block oil passages (1). The vertical oil passages permit oil flow from the manifold assembly to the valve lifter bores.