



# Direct Ignition Operation and Diagnosis

**A**ll Subaru Legacy, Forester, Impreza models use a 'direct' ignition system. This is a distributorless design that features a crankshaft position sensor mounted at the front of the engine behind the crankshaft and a camshaft position sensor mounted behind the left camshaft sprocket.

Secondary ignition is supplied to the spark plugs by two separate coils contained in a common housing. Each coil supplies voltage to two cylinders. Coil number 1 supplies voltage to cylinders 1 and 2. Coil number 2 supplies voltage to cylinders 3 and 4. The SVX 'coil on plug' ignition system which will not be covered in this article.

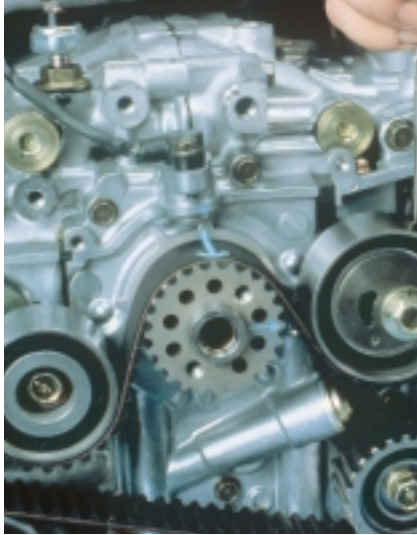
The ECU processes signals from the crankshaft position sensor and camshaft position sensor, as well as other engine management system inputs (throttle position sensor, coolant temperature sensor, knock sensor, etc.). The ECU then sends a control signal to the igniter.

The solid state igniter is located on the firewall on early Subaru direct ignition systems, and is integrated into the coil assembly on more recent Subaru vehicles.

The control unit also supplies primary current to the coils and interrupts the primary ground circuit to the coils via the igniter. The coil then sends secondary voltage to the spark plugs at two cylinders simultaneously: one cylinder on the firing stroke and one cylinder on the exhaust stroke.

The spark occurring on the exhaust stroke is called a *wasted* spark and requires a voltage of only 3-4 kV. The remaining coil secondary energy is available to fire the companion cylinder on the compression stroke.

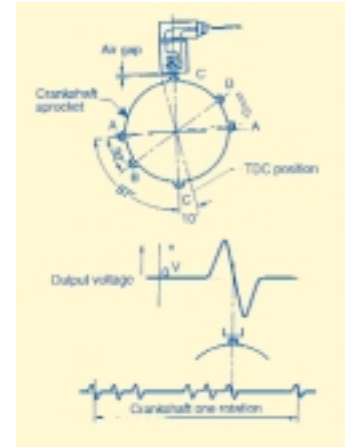
**Note:** Care must be taken during cylinder power balance tests to prevent excessive fuel from entering the exhaust system. It is therefore mandatory that power balance tests be performed by disconnecting the appropriate fuel injector harness, not by shorting the secondary voltage to the cylinder. Should the latter method be used, fuel will enter the cylinder, and may fire on the exhaust stroke when ignition voltage is restored. This may cause severe damage to the exhaust system.



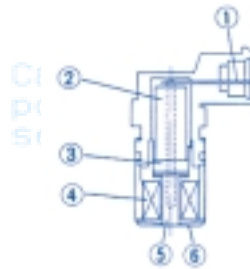
Crankshaft Position Sensor

### Crankshaft Position Sensor

The crankshaft position sensor is an inductive pickup type which uses a six tooth reluctor ring located on the crankshaft sprocket. As the reluctor teeth pass the crankshaft position sensor, they cause the sensor to generate a weak inductive voltage signal. This signal is forwarded to the control unit, which uses this information to determine the proper dwell and timing advance for changing engine operating conditions.



Crankshaft Position Sensor Operation



Crankshaft Position Sensor Cutaway

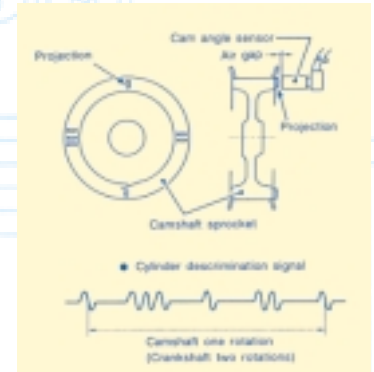
- 1. Terminal
- 2. Yoke core
- 3. Magnet
- 4. Coil
- 5. Core
- 6. Cover

### Camshaft Position Sensor

The camshaft position sensor is also an inductive pickup type. A reluctor ring is built into the left camshaft sprocket. The notches on the ring cause the camshaft position sensor to generate a weak inductive signal as the notches pass the sensor.



Camshaft Position Sensor



Camshaft Position Sensor Operation



Cam Pulley Reluctor

The control unit uses this signal information to determine the position of the pistons in each cylinder and to determine which cylinder is on the firing stroke.

### Igniter

The igniter is a solid state device containing two power transistors that are used to ground the primary circuits of the ignition coils. The engine control unit turns the igniter power transistors ON and OFF. As noted earlier, the igniter may be a separate component mounted on the firewall, or it may be integrated with the ignition coil unit at the top of the engine.



Igniter



Ignition Coil-Igniter Combination



# Direct Ignition Operation and Diagnosis



Electronic Control Unit

## Electronic Control Unit

In addition to controlling secondary ignition and timing, the electronic control unit also uses the cam position sensor signal as an input for sequential fuel injection control. The cam position sensor signal identifies the cylinder that is on its compression stroke, allowing precise timing of individual fuel injector operation.

Because this system does not have a distributor housing, no adjustment of the ignition timing is possible or necessary.

## Ignition System Diagnosis

Ignition system component malfunctions can have a variety of effects on engine performance. If it fails, almost every ignition component will cause reduced engine power and fuel economy, and increased exhaust emissions. Components that help to develop or carry the high voltage for a single spark plug can cause that cylinder to misfire if they malfunction. The engine will then run rough because it is missing one of its usual power pulses.

If components that develop and carry the voltage for all spark plugs malfunction or fail completely, they will stop the engine from running. However, if they are only marginally defective, they will quite possibly cause an intermittent misfire for one or more cylinders.

The reason they may not affect all cylinders at all times is because the strength of the spark needed to ignite the fuel mixture varies with changes in engine speed, throttle setting and the mechanical condition of the individual cylinders and spark plugs. For example, a coil that is beginning to develop a defect could have no noticeable effect on engine performance at idle when the running compression pressures are low, but will cause a cylinder misfire under acceleration when cylinder pressures are high. Higher engine speeds increase the likelihood of misfire because there is less time for the coil to build up its electromagnetic field.

Engine starting can be the first thing affected by an ignition component failure, such as an ignition wire. Coil output voltage may be high enough to overcome this resistance when the engine is running, but coil output will be lower during engine starting when the voltage supplied to the coil is at its lowest. Corrosion in low voltage circuits, such as the wiring between the igniter and the engine control unit, is also more likely to cause *starting* rather than *running* problems.

Items that influence only ignition timing usually will not cause an engine misfire if the spark is occurring on the right stroke at approximately the right time. Engine performance, fuel economy and emissions will be affected, but possibly not as much as by a defect that causes a regular misfire. Secondary ignition defects, such as ignition wires, spark plugs or the ignition coil may also produce radio static.

## No-Start Diagnosis

For an ignition system to operate and produce spark to fire the sparkplugs, the primary ignition circuit must be switched ON and OFF. On Subaru vehicles, this is accomplished by the electronic control unit controlling the igniter, which in turn controls the ground circuit to the ignition coil primary windings. If a no-start condition exists, and there is no spark at the spark plugs when the engine is cranked with the starter, a logical sequence of diagnosis must be employed to determine the cause of the no-start.



Igniter Harness Connector

continues on pg. 12

# Direct Ignition Operation and Diagnosis

- Is voltage available to power the coil?
- Is the ECU switching the igniter?
- Is the igniter switching the ground to the ignition primary circuit?

A digital volt-ohm meter (DMM) should be used to conduct the following tests.

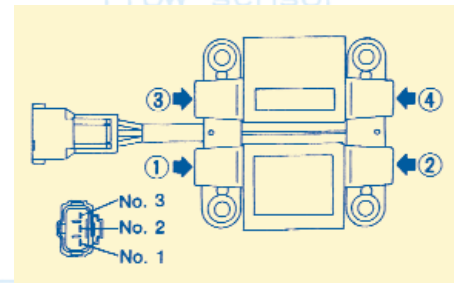
- Begin by looking for battery voltage at the positive terminal at the coil and the igniter. Consult a vehicle wiring diagram to locate the proper wiring harness terminals.
- If positive voltage is present at both locations, connect the DMM to the negative side of the coil, or the control terminal at the igniter.
- Crank the engine. The DMM should read some value between available voltage and zero. A dwell meter would give a value between zero and its maximum value. An electronics-safe test light would flicker.
- If battery voltage is available and the igniter is not switching, perform the same test at the ECU control terminal. The ECU should switch the igniter ON and OFF in a similar manner.
- If the igniter is switching but there is no spark, the resistance of the ignition coil windings must be tested.

## Ignition Coil Testing

Use an accurate DMM to inspect the ignition coil primary and secondary resistance. Replace the ignition coil if it is found to be defective.

**Caution:** If the resistance is extremely low, this indicates the presence of a short circuit.

The specified secondary resistance between test points 1 and 2 as well as between test points 3 and 4 should be 0.70 ohms  $\pm$  0.3 ohms. The test point pairs are the opposing secondary output terminals of the ignition coil. The specified primary resistance between coil wiring harness terminals 1 and 2 and between terminals 2 and 3 should be 21.0 K ohms  $\pm$  3 K ohms.



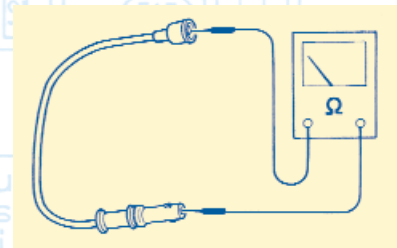
Ignition Coil Testing



Ignition Wire

## Spark Plug Wires

Check the spark plug wires for damage, deformation, burning or corrosion at the terminal ends. The proper resistance value for spark plug wires is 5.12-12.34 K ohms.



Spark Plug Wire Testing

## Diagnostic Trouble Codes

1995 and later OBD-II compliant Subaru vehicles monitor several important ignition system components. Ignition system diagnostic trouble codes (DTCs) include:

- P0301 Cylinder 1 Misfire Detected
- P0302 Cylinder 2 Misfire Detected
- P0303 Cylinder 3 Misfire Detected
- P0304 Cylinder 4 Misfire Detected
- P0325 Knock Sensor Circuit Malfunction
- P0335 Crankshaft Position Sensor Circuit Malfunction
- P0340 Camshaft Position Sensor Circuit Malfunction

Diagnostic trouble codes can be retrieved using the Subaru New Select Monitor, or a generic OBD-II compliant scanner. Troubleshooting procedures for specific DTCs can be found in the appropriate Subaru vehicle service manual.