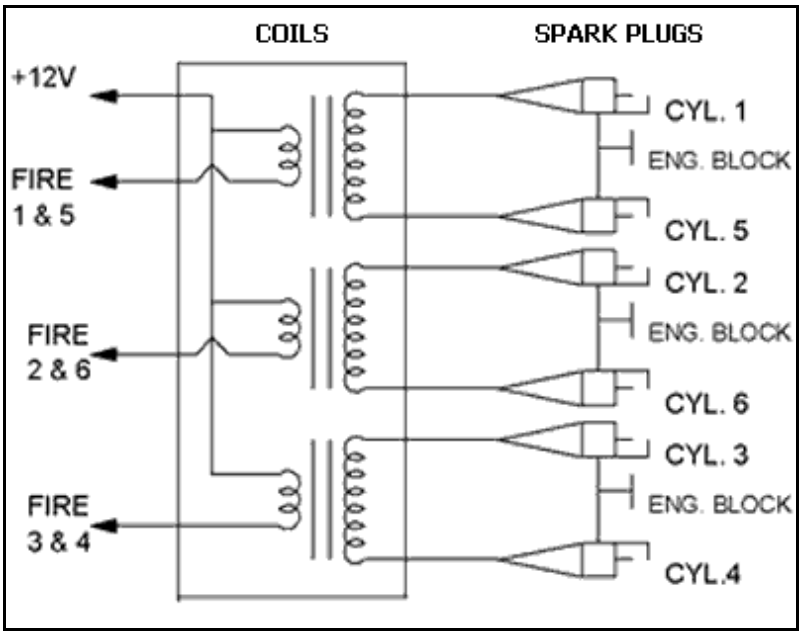
Ford DIS/EDIS "Waste Spark" Ignition Systems

Overview

Ford DIS & EDIS ignitions are electronically controlled, distributorless systems. Instead of using a conventional rotating distributor, they both employ a primary/secondary electronic coil system that converts battery voltage into the much higher voltage needed to fire the spark plugs and ignite the compressed air/fuel mixture. The firing of the coils and plugs is controlled by the EEC computer ("PCM" in today's terms) which utilizes sensor signal feedback to help calculate and maintain proper timing and dwell.

Both DIS & EDIS are of a *waste spark* design. In other words, a single coil fires two seperate cylinders at the same time. The spark plugs in the two cylinders are in series electrically, with the circuit being completed through the cylinder block. When a coil fires, high voltage current flows INTO the top of first plug and OUT the top of the second plug, completing a big loop in each case. This means that the firing voltage of one spark plug is negative with respect to ground, while the other is positive with respect to ground. Half the spark plugs actually see a different polarity than the others do.

Figure 1 - DIS/EDIS "Waste Spark" Design (6 Cylinder)



In Ford waste-spark systems, the spark plug on the compression stroke uses the majority of the coil’s stored energy, while the other spark plug, on its exhaust stroke, uses very little of that energy. This occurs because of the much higher cylinder pressure that is generated on the compression stroke. The higher the pressure, the greater the electrical

resistance. Accordingly, more voltage is necessary to overcome the increased resistance of the highly-compressed air/fuel mixture. In a nutshell, the amount of pressure in a cylinder - and the associated electrical resistance that it creates - determines which spark plug (compression stroke) gets the majority of the coil's voltage, and conversely, which plug (exhaust stroke) gets the "waste" voltage.

Spark is generated as follows: an electronic switch-to-ground is employed in the coil primary circuit. When the switch is closed, battery positive voltage (+12v) is applied to the primary circuit and builds a magnetic field around the primary coil. When the switch opens, the power is interrupted and the primary field collapses, inducing high voltage pulses into the secondary coil windings. These high voltage pulses are carried by the plug wires to the spark plugs which create spark at the gap, igniting the compressed air/fuel mixture.

A kickback voltage spike occurs when the primary field collapses, creating an Ignition Diagnostic Monitor (IDM) signal which is used by the PCM to keep tabs on the overall health of the ignition system (for more on the IDM, see "System Monitoring" below).

Coil switching - including timing and dwell - is ultimately determined by the PCM, although it is carried out by a separate Ignition Control Module in many applications, as discussed below.

Difference Between DIS and EDIS

DIS and EDIS systems are similar in that they are electronically controlled and operate according to a waste spark design, and they both utilize coils contained in coil packs to fire the spark plugs. So what exactly is the difference between them?

Well, **the DIS system** utilizes inputs from *both* the crankshaft position sensor *and* the cylinder identification sensor (often referred to as the *camshaft position sensor*) to control ignition timing. On DIS applications, both of these sensors employ a “Hall Effect” type of signal generator which utilizes the "vane-switch" design.

On all DIS applications, the crankshaft position sensor generates a PIP (Profile Ignition Pickup) signal from its location on the crank. The CID (Cylinder Identification) signal, however, is generated a couple of different ways, depending on the design of the engine. For example, on the DOHC V6 Taurus SHO engine, the CID sensor assembly is located at the end of the rear exhaust camshaft and it spins off of that. On a 3.8L T-Bird with DIS, the CMP sensor assembly is driven by a synchronized shaft installed where the distributer used to be on earlier applications. On other setups, such as the 2.3L Ranger, the PIP and CID signals are both generated from the crankshaft by virtue of a "dual vane actuator" which is essentially a doubled-up Hall-Effect sensor.

Virtually all DIS systems employ a separate Ignition Control Module ("ICM" or "DIS Module") which carries out the actual firing of the coils, as directed by the PCM.

The DIS Module receives the following inputs:

- 1. The PIP signal from the crankshaft position sensor. During normal operation, the PIP signal is sent to both the PCM and the DIS Module, providing base ignition timing and RPM information.

- 2. The CID signal from the camshaft position sensor. The CID signal provides the DIS Module with the information it needs to synchronize the ignition coils in the proper sequence.

- 3. The SPOUT (spark out) signal back from the PCM. The SPOUT signal contains optimal spark timing and dwell time data.

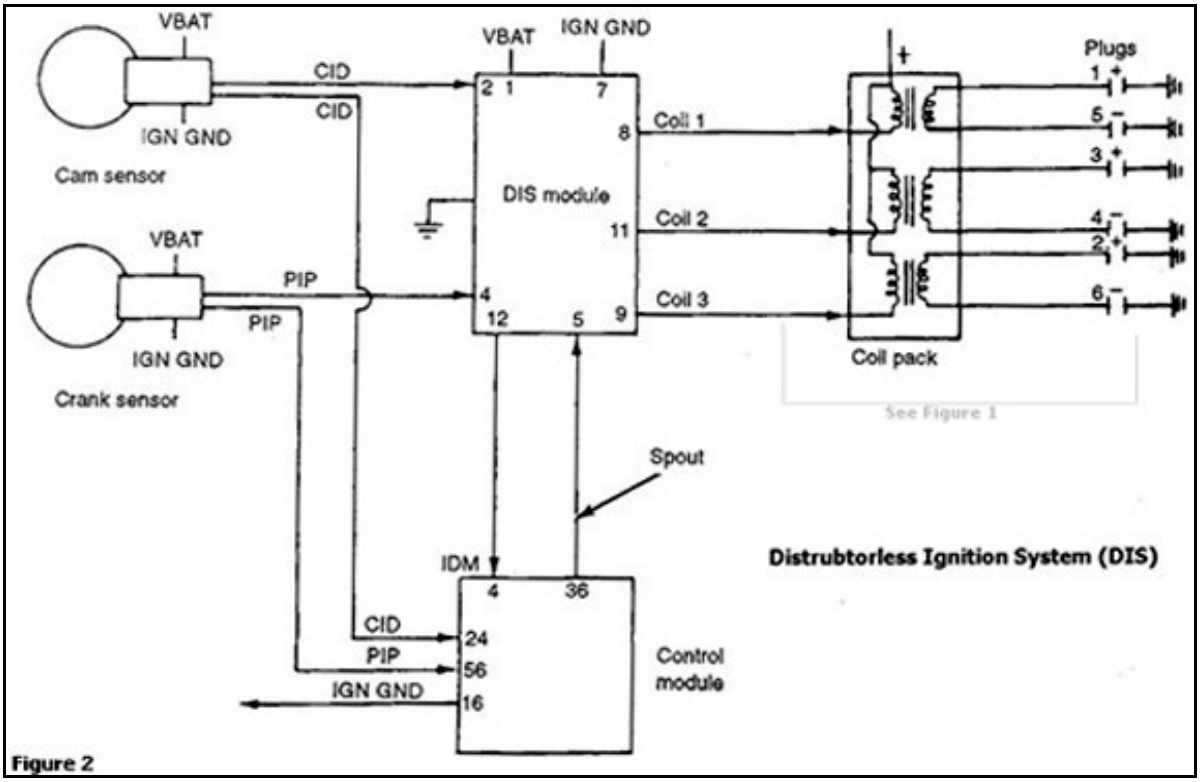
- 4. An IDM (voltage kickback) signal when a primary coil collapses. The DIS takes this IDM data - which includes system failures - and sends it to the PCM, which in turn stores the information for EEC diagnostic self tests.

A loss of the PIP signal will result in complete engine shut-down and/or a no-start condition.

A loss of the CID signal will not result in shutdown. Instead, the system will remember the proper sequence and continue to fire the coils in order to maintain engine operation. If the DIS Module does not receive valid CID input during engine cranking, random coil synchronization will be attempted. Therefore, several start attempts (cycling the ignition switch from OFF to START) may be required to start the engine.

A loss of a valid SPOUT signal back from the PCM will cause the DIS Module to automatically turn the ignition coils on and off using the PIP signal. This results in a fixed spark timing and dwell (10 degrees BTDC) and the performance hit is usually quite noticeable.

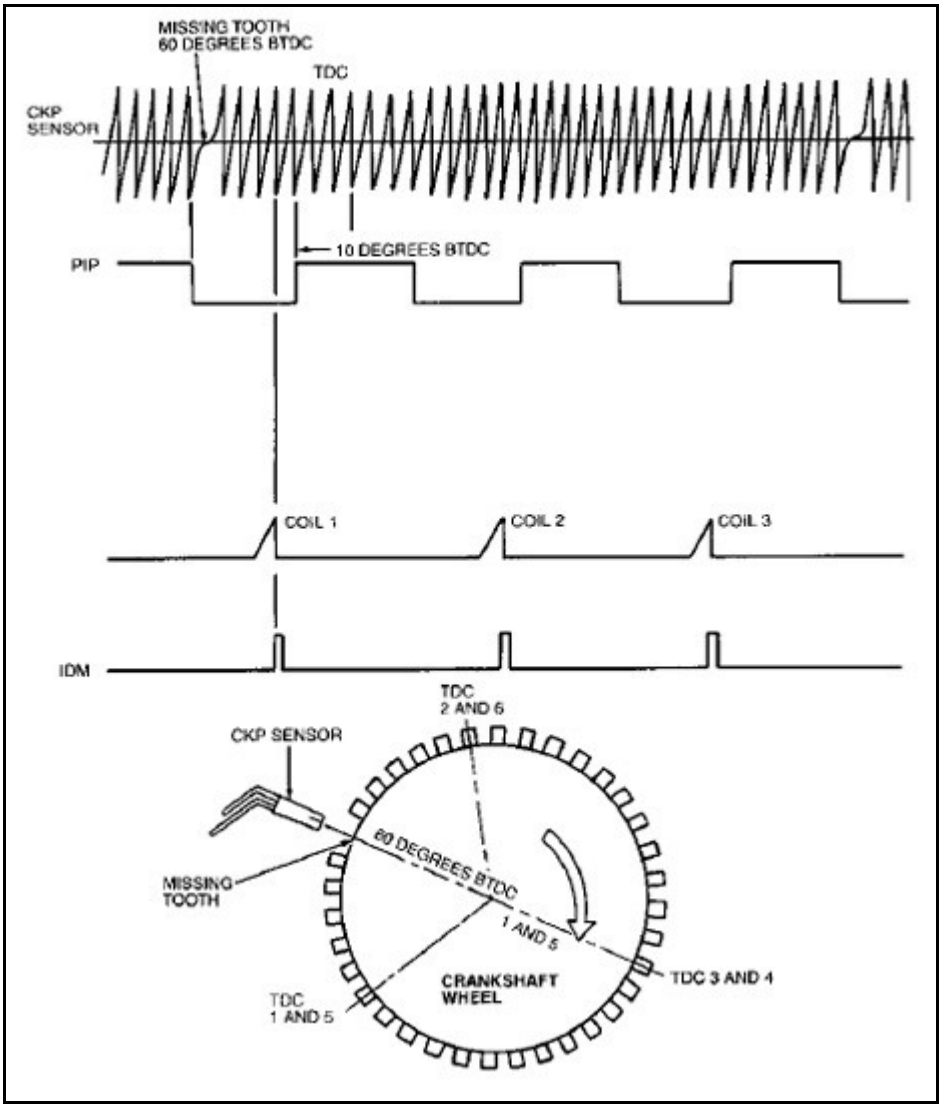
Figure 2 - DIS Ignition System (6 Cylinder)



EDIS, on the other hand, utilizes a *single* input from the crankshaft position sensor. It's a more complicated crank sensor in this system (variable reluctance type that uses a "wheel - missing tooth" trigger design) which generates a more precise PIP signal that allows for even more accurate spark timing, particularly during acceleration.

By monitoring the trigger wheel overall, the EDIS crank sensor (CKP) tracks crankshaft position and speed and passes that information along to the PCM. By counting teeth and monitoring the location of the missing tooth @ 60 degrees BTDC, the CKP also tracks #1 piston travel, allowing for synchronization of the coils. Because of this, EDIS systems do not use the camshaft position (CID) sensor signal for spark timing; it's only needed for sequential fuel injection (SFI) timing.

Figure 3 - CPK Sensor Operation - EDIS Ignition System (6 Cylinder)



Once a CKP signal is generated, fuel and spark functions are enabled. The system is able to calculate a specific spark target utilizing the information garnered from the CKP signal, and the coil associated with that target is fired accordingly.

Early EDIS systems (like the first few years of the 4.0L Ranger, for example) make use of a separate Ignition Control Module which performs similar functions and has similar duties as the stand-alone ICM used in most DIS systems. The one big difference is that the EDIS Module is also responsible for "pre-processing" the CKP signal prior to it being sent to the PCM.

In most of today's EDIS applications, there is no longer a stand-alone ICM. Instead, the ICM has been integrated into the PCM (meaning the PCM fires the coils directly). Ford refers to this as an "Integrated Electronic Ignition System", but regardless, the basic functionality of DIS/EDIS remains the same.

DIS/EDIS System Monitoring

The PCM continuously checks the health of the DIS/EDIS ignition system by monitoring three different signals during normal vehicle operation:

- 1. Profile Ignition Pickup (PIP/CKP) signal, derived from the crankshaft position sensor;

- 2. Camshaft Identification (CID/CMP) signal, derived from the camshaft position sensor;

- 3. Ignition Diagnostic Monitor (IDM) signal, which is derived from the kickback voltage spike that occurs when the primary side of a coil has fired.

First, the relationship between successive PIP events is evaluated to determine whether the PIP signal is rational. Too large a change in 3 successive PIP indicates a missing or noisy PIP signal (DTC 14, 211, P0320).

Next, the CMP edge count is compared to the PIP edge count. If the proper ratio of CMP events to PIP events is not being maintained (for example, 1 CMP edge for every 8 PIP edges for an 8-cylinder engine), it indicates a missing or noisy CMP signal (DTC 19, 214, P0340).

Then, the relationship between IDM edges and PIP edges is evaluated. If there is not an IDM edge (coil firing) for every PIP edge (commanded spark event), the PCM will look for a pattern of failed IDM events to determine which ignition coil has failed. If the ignition coil cannot be identified or if the engine is running and there are no IDM edges, then the IDM circuit is malfunctioning (DTCs 16/18/19, 212/218/226, P0350-P0360).