The Basics of Crank and Cam Sensors and How to Test Them

Cran**k**shaft **P**osition (CKP) Sensors and **C**a**m**shaft **P**ositions (CMP) Sensors used on cars and trucks today come in all sorts of different shapes, sizes and configurations. All this variety might make you think that testing them is difficult and/or impossible. Well, nothing could be further from the truth since they can be easily tested with simple tools and testing techniques.

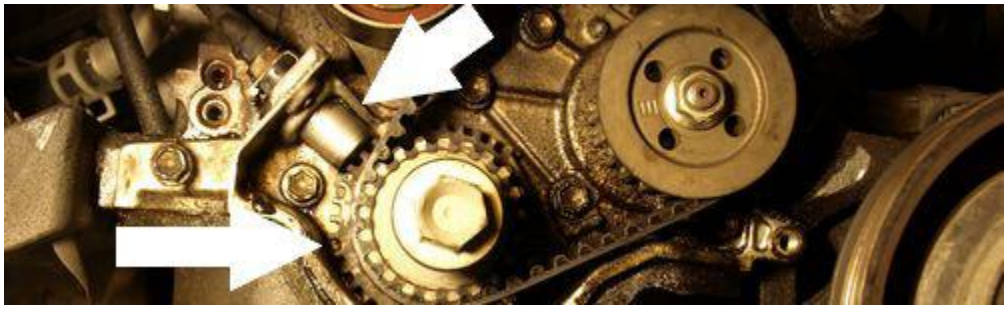

Photo 3 of 3

This Crank Sensor belongs to a 95 Toyota Tercel. One arrow points to the Crank Sensor and the other to the toothed wheel that 'excites' it.

This article is a primer that will help you to learn and understand the essentials of testing the Crankshaft Position Sensor (Camshaft Position Sensors too). You'll learn basic working theory, do's and don'ts, what tools to use and how to test them, and a lot of other good stuff.

At the end of the article, in the section titled: Related Crankshaft Position Test Articles, I have included a list of test tutorials that will show you how to test the crank and/or cam sensor on several different makes (GM, Ford, Nissan, etc.) based on the info in this article.

How to Tell Them Apart

Another thing that can make testing the CKP and CMP Sensors seem intimidating is the fact that every make and model rolling around on pavement uses a different type of Position Sensor. For example, the Ford truck your neighbor might be driving will have a Position Sensor(s) that is (are) completely different in appearance than your GM (or Chrysler, or Honda, or Nissan or Suzuki, etc.) vehicle.

Not only that, but these sensors are called by so many different names like: Hall Effect Sensor, CKP Sensor, CMP Sensor, Pickup Coil, Magnetic Pulse Generator, Variable Reluctor, and the list goes on with a few more names. This may make it seem like every single one is tested in a different way. Well, the good news is that although they all differ from one another physically and are called so many god-knows-what names, they can usually be generalized into two basic categories: 2 wire type and 3 wire type. And this means that you only have to learn two specific testing methods.

So, before we dive into the rest of the article, I want to emphasize that the key to successfully testing and diagnosing all of the different Crank Sensors (and Cam Sensors) out there, is to know if they are either a two or three wire type! Now in case you're wondering what I mean by two and three wire types... I'm referring to the amount of wires in their connector (of course there's always an exception to every rule, but more about this later). Alright, let's jump into the next subheading and let's start learning more about this.

What does a Crankshaft (Camshaft) Position Sensor Do?

I'll start by explaining the specific role that the Crank (and Cam) Sensor play in the Electronic Ignition System of your car or truck. This info applies to whatever make and model you may be driving, so whether it's a Ford, a Chevy, a Chrysler/Dodge/Jeep, a Nissan, a Honda, a Toyota, or whatever, this primer will help.

In a nutshell, the Crankshaft Position Sensor's job is to help: 1) the Ignition System produce Spark and 2) the Fuel System to start injecting gasoline into the cylinders. All this so that the vehicle's engine will start and stay running. More specifically, the CKP Sensor produces a signal that tells the Fuel Injection Computer or the Ignition Control Module the exact position of the cylinder pistons as they come up or go down in the compression cycle. With this information the Fuel Injection Computer or the Ignition Control Module knows the exact time it has to make the Ignition Coil or Ignition Coils spark (not to mention when to start injecting fuel into the cylinders). Lastly, this signal can be either an Analog Voltage Signal of a Digital DC Voltage Signal... but more about this a little later.

The Camshaft Position Sensor is GENERALLY used in all modern Sequentially Fuel Injected engines to fine tune ignition timing and fuel injection timing after the vehicle has started. Although this article concentrates on the basics of Crankshaft Position Sensors, you can apply most of this info to the Camshaft Position Sensors too.

Since the Crankshaft Position Sensor's Signal triggers the Ignition Module (or Fuel Injection Computer) to start switching the Ignition Coil's Primary Current ground path On and Off... I usually refer to the sensor's signal as the **Triggering Signal**. Since the Crank Sensor (or Cam Sensor) is the one producing this Triggering Signal, I refer to it as the **Triggering Device**.

The signal that the Ignition Module (or Fuel Injection Computer) sends the Ignition Coil for it to start sparking is the **Switching Signal**. So, guess what... the Ignition Module (or the Fuel Injection Computer) is therefore the **Switching Device**.

Now, the Ignition Control Module really doesn't send a physical signal (like the Crank or Cam Sensor does to the Switching Device) to the Ignition Coil(s). Why? Well, because the term ‘Switching Signal’ is just a descriptive name for the turning on and off of the primary current passing thru' the Ignition Coil. And as stated above, this turning on and off only happens after the Ignition Module (or Fuel Injection Computer) receives the Crankshaft Position Sensor's Signal. As you may already know, it's this action that causes the Ignition Coil to start firing Spark.

You don't need to memorize all of these details, but it's very important to understand them. Why? Well because understanding and knowing how one Signal leads to the creation of another type of Signal will help you to diagnose a ton of makes and models. Or when you run across a specific testing step in your auto repair manual or in this site or any other that is not explained in painstaking detail (and you're feeling lost as to the ‘why’ of the test you just were asked to perform), knowing this info will help you see the ‘light’.

How do the CKP and CMP Sensors Work?

Since each of the two and three wire types of CKP (and CMP) Sensors produce a different type of Signal, I'll be explaining how both types work. Now, I realize that you're not wanting to know how to build one from scratch or how to reverse engineer one, so I won't go into all of the details of what materials they're made of, nor the fundamentals of electromagnetism (that apply to these sensors) nor the minute details of how they produce their Position Signal (a good Automotive Technology textbook, or Wikipedia and/or the rest of the Internet is where you can find this information if you need it). You'll learn just the ‘nuts and bolts’ to test them in the real world.

I'll start with the two wire CKP and CMP Sensors. These types of sensors are commonly known by several names: Magnetic Pulse Generator, Variable Reluctor, Pickup Coil, etc. It doesn't matter what they're called or where in the car or truck they're located in, they are all tested with a Multimeter in AC Volts mode. Why? Well, because the Signal that these sensors generate is an Analog Voltage Signal and this Signal can only be measured in AC Volts mode on your Multimeter (or Oscilloscope).

How do the Two Wire Type CKP Sensors Work?

When the Magnetic Pulse Generator type (remember, this is just one of the fancy names for the two-wire type sensors) is excited by the toothed disc it's in close proximity with, it starts to produce an Analog Voltage Signal. This Analog Signal is created without the help of an external power source! As long as the engine is turning, either because it's cranking or running, the Signal is being produced. When the engine is off, so is the Sensor.

So then what is an Analog Voltage Signal? As it applies to Crank and Cam Position Sensors, it's a signal that oscillates between lows and highs the whole time it's being produced WITHOUT ANY ABRUPT FALLING OR RISING EDGES. When the signal goes low, it never completely turns off. And when it goes high, it must come down again. This process is repeated over and over as long as the toothed disc is exciting it.

Looking at the oscilloscope waveforms below of three different Crankshaft Positions Sensors below will help you to put it all in perspective.

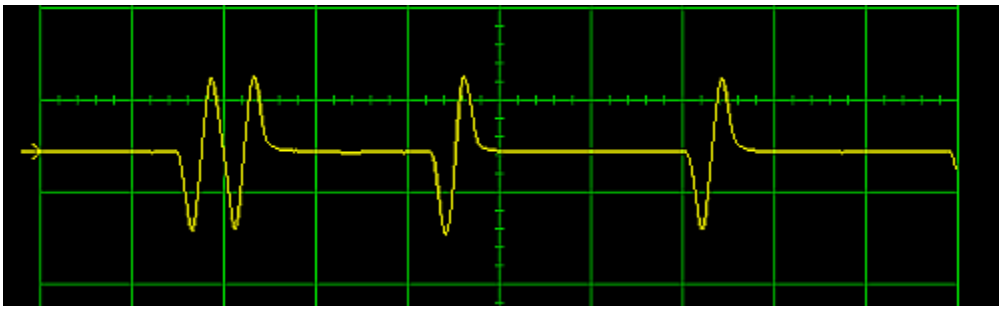

Photo 3 of 3

This is an Analog Signal waveform of a
Crank Position Sensor of 2004 Chevrolet Malibu

Did you notice in the above Crankshaft Position Sensor Signal waveforms that the AC Analog Signal produces a ‘wavy’ up and down line. Now, to test this signal you don't need an oscilloscope. But knowing what this signal looks like and how it behaves will help you to test it with a digital multimeter (an analog one will work too). So to further explain this concept I'm gonna' compare this Analog Signal to a light bulb that is cycled on and off yet **never completely turning off**.

Let's imagine that we have a light bulb whose switch permits us to slowly apply power or slowly take it away but never allows us to completely turn it off. When you start applying the juice (to the light bulb), the bulb's brilliance starts to get stronger till you reach the maximum amount of power that can be applied. Then, you slowly start to take the power away, which results in its brilliance dimming. Now imagine repeating this cycle endlessly the whole time you need the room lit. Well, this is pretty much how the two wire type Crankshaft Position Sensors produce their signal.

On a last note... you've probably noticed (in the slide show above) that each type of Crankshaft Position Sensor waveform looks different from one another. And in case you've wondered why, well this is due to the amount, the shape, and how far spaced apart the teeth are on the ‘toothed disc’ that excites the sensor. This is something that you don't have to worry about when you're testing these Crank and Cam Sensor with a Multimeter.

So far in this article you've learned that all **C**ran**k**shaft **P**osition (CKP) Sensors and **C**a**m**shaft **P**osition (CMP) Sensors can be divided into two categories: two wire type and three wire type. Since I covered the two wire type of Crankshaft Position Sensor (and by extension the Camshaft Position Sensor) in the first part of this article, in this one I'm gonna' talk about the three wire type of Crank Sensor.

A Digital Signal for a Digital Age

OK, so far you've also learned that the two wire type (also known as a magnetic pulse generator type sensor, among several names) produces an Analog Signal. By now you may be wondering what type of signal the three wire type (Hall Effect type sensor) produces? The answer is: a Digital Signal. Now you might be asking yourself... What the heck is a Digital Signal? Let's find out.

A Digital Signal is a DC voltage signal (remember that the Analog Signal is an AC voltage signal). This DC Voltage signal looks and behaves completely different from an Analog Signal. Not only that, to produce this Digital DC Signal, the three wire type Crank or Cam Sensor needs an external Voltage power source (unlike the two wire type Crank or Cam Sensor). When viewed in an oscilloscope's screen, it's displayed as a square wave, like the ones pictured below.

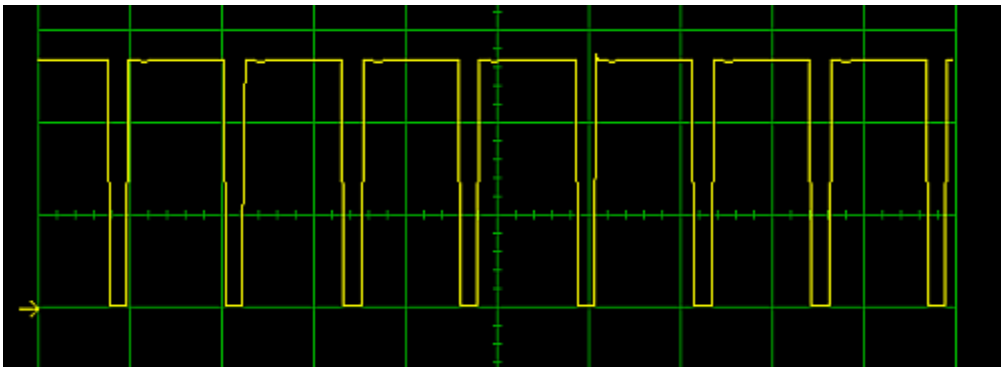

Photo 1 of 3

This Digital Crank Position Signal belongs to a 93 Ford Mustang. A big difference compared to an Analog Signal!

The Digital Signal that the three wire type (Hall Effect sensor type) produces is a true On/Off signal, very unlike the Analog Signal that the two wire type sensor produces. If we were to use the light bulb example from the previous page... the light bulb would turn on immediately (not gradually) and turn off abruptly (not gradually). This is what causes the Sensor Waveform to look squared instead of wavy. Also, this turning On and Off the signal happens the entire time the Hall Effect Position Sensor is being excited by whatever toothed disc it's in close proximity to.

Now, in case you're wondering if you need an oscilloscope to test these Crank and Cam Signals the answer is no. You don't need an oscilloscope and you definitely don't need an Automotive Scan tool to test the CKP Sensor or CMP Sensor Signals. Now, having said that... the absolute best way to test/verify the presence of these signals is with an oscilloscope, but since most folks don't own one, this article concentrates on using a Digital Multimeter (that can read Hertz Frequency)

OK, now for the really important ‘working theory’ part that you need to remember is that: the CKP and CMP Digital Signals **can be measured with a Multimeter either in DC Volts mode or in Hertz Frequency Mode** or with an oscilloscope and that **they need an external power source** to create their signal. As a side note... a simple LED light can also be used to verify this signal (although this method is not a 100% foolproof way of diagnosing a CKP or CMP Sensor)

What ‘Excites’ the Sensor to Produce its Signal?

Before leaving the ‘working theory’ alone, I need to talk about one more thing. I'm sure you've noticed the term ‘toothed disc’ thru' out this article. This is some sort of disc with teeth

that resembles a gear or a wheel with shutters on it. This disc is what ‘excites’ the Sensor into producing its signal. These discs go by names such as: shutter wheel, reluctor wheel, armature, interrupter ring, and the like. The name depends on who built the vehicle and/or the specific type of Position Sensor being used.

These toothed discs rotate only when the engine is cranking and/or running. They are directly or indirectly connected to the Crankshaft or Camshaft. Although they all perform the same basic job of exciting the CKP or CMP Sensor, they come in all shapes and sizes which are determined by the needs of the software and hardware of the Fuel Injection System installed in the vehicle.

Well, it doesn't really matter what they look like and it definitely doesn't matter one bit what they're called. The important thing to know is that the sensor works in conjunction with some sort of ‘toothed disc’ to produce its signal.

Where are The CKP and CMP Sensors Located?

These Sensors are located in several different places depending on the year, make and/or model that you're working on. Some of them are in very hard to reach places and this, in my opinion, is the only thing that complicates testing them.

Some of their more common locations are:

1. In the Distributors
2. On Timing Covers.
3. Behind Timing Covers.
4. On the Engine Blocks themselves. In this type of setup, the sensor goes thru' the Block to reach its toothed disc. Examples of this are the GM 3.1 and 3.4L V6 engines.
5. On transmission bell housings. Chrysler, Dodge, and Jeep cars and trucks are the major ones that use this setup.
6. Behind the Crankshaft Pulley.

Now, if you don't know where your particular car's (or truck's) Crank or Cam Sensor is at, this is where owning a good Repair Manual comes in handy (or Googling it on the internet).

Symptoms of a BAD Crankshaft Position Sensor

We can take for granted that when a CKP Sensor goes BAD, your vehicle will not start. It'll crank but not start. But hey, a car (or truck) could not start due to a ton of different reasons like: a BAD Fuel Pump, a BAD Ignition Coil, a BAD Ignition Control Module, BAD Spark Plug Cables, etc. Therefore, it's not enough to say that your car or truck won't start, what you need to know are some of the measurable/testable effects/symptoms that a BAD Crankshaft Position Sensor has on the Ignition System.

And so, if the Crankshaft Position Sensor isn't creating a Signal, then the measurable/testable effects of this condition are but not limited to:

1. No Fuel Injector Pulse
2. The Triggering Device (whether it's the Ignition Control Module or the F.I. Computer) will not produce a Switching Signal to the Ignition Coil.
3. No Spark coming out of the Ignition Coil or Coils.
4. On some makes, like Chrysler/Dodge/Jeep, the Fuel Injection Computer will not continue to power the Fuel Pump or the Ignition System with 12 Volts after an initial ten seconds or so.

What Tools do I Need to Test the Crankshaft and Camshaft Positions Sensors?

You don't need expensive tools and/or expensive testing equipment to test these CKP and CMP Sensors. Here's what you'll need:

1. The car or truck's battery must be fully charged.
2. A Digital Multimeter that can read Hertz Frequency.
3. A good Repair Manual. The Repair Manual will probably be just one of many information resources that you'll use to diagnose the CKP or CMP Sensors on your car or truck.
4. You'll need someone to help you crank the car's or truck's engine while you observe the readings on the Multimeter.
5. A Fuel Injector Noid Light.
6. You don't need an Automotive Scan Tool (commonly known as a Scanner).
7. You don't need oscilloscope.

Do I need an Automotive Scan Tool to test the CKP and CMP Sensors?

I've already covered this ground a bit, but I'll restate that these sensors are tested **without a Scan Tool**. Now before I ruffle some feathers... let me explain that the majority of cars and trucks on the road will not set a Crankshaft Position Sensor code when the sensor goes BAD. This is not an absolute truth, mind you. But in my experience, about 95% percent of the BAD Crankshaft Position Sensors that I've replaced, the vehicle's onboard self-diagnostics didn't leave any type of CKP Sensor code! As you might already know, such a code (or codes) can give you an idea of what is going on and/or where to start the diagnostic process.

OK, even if you tried using a Scan Tool, most makes and models will not let you have access to the live Data (to read the RPM's) that the Scan tool provides while you're cranking the car or truck. So if you have no live Data, you won't know/see if there is an RPM signal on the Scan Tool's display screen (in case you didn't know, the Scan Tool displays the RPM's from info from the CKP Sensor). Therefore, knowing how to test them with a multimeter (or an LED or an oscilloscope or whatever) independent of a Scan Tool becomes very important.

Now, when it comes to Camshaft Position Sensors... a Scan Tool does come in handy since a BAD CMP Sensor does register a diagnostic code. This code usually lights up your check engine light on your instrument cluster. But testing them requires a method that is

independent of the Scan Tool, and well, as I've mentioned before, the test steps that apply to a CKP Sensor also apply to a CMP Sensor.

The other thing that really sucks, when you're trying to diagnose a CKP or CMP sensor, is that most of the service literature does not have very specific test information. After all, these service manuals take for granted that the person reading them are professional service technicians that already know the basic working theory and/or tests.

Alright, let's jump into the next part where I get into some testing specifics.

You've covered a lot of information so far.. in this section I'll get into the basic flow of tests that are part of diagnosing the Crankshaft Position Sensor (and Camshaft Position Sensor).

Do's and Don'ts When Testing CKP and CMP Sensors

Testing the Crankshaft Position Sensors or Camshaft Position Sensors requires that you test them in action, **that is with the engine cranking**. So it goes without saying that you have to be very careful and use tons of common sense so that you won't get hurt.

One piece of advice that I have always followed religiously (and that you should too) has been to have my helper wait outside of the car or truck, I'm testing, till I need him or her to crank the engine up for me. This way, I can and have avoided losing a finger or getting hurt in case my helper thought he or she heard me say "crank it" and cranks the engine while I still have my hands in or around the engine.

When piercing the Signal Wire(s) of the CKP or CMP Sensor, you need to use wire-piercing probes. Why? Because using a wire-piercing probe is probably the safest way to keep from shorting out any of the wires that you're testing. Also, the wire-piercing probe will always leave a small puncture wound in the wire's insulation.

When performing the Spark test, always use a dedicated Spark Tester. The only one that I recommend you use is the HEI Spark Tester.

Everything always boils down to being alert and taking all necessary safety precautions!

What Does Each Wire (Circuit) in the Connector Do?

OK, now to get into the ‘meat and potatoes’ of testing these CKP and CMP Sensors, you need to know what each wire does in the connector that attaches to the Crank or Cam Sensor. Since you're dealing with two types of sensors, it's logical to conclude that each circuit will provide a different type of signal to or from their respective sensors and Fuel Injection Computer or Ignition Control Module.

In this primer, I can only go as far as to give you a basic general idea of what each circuit does. To find out what each circuit does (wire) in the CKP or CMP Sensor's connector of

your specific car or truck, you'll need to look at a wiring diagram of the Ignition System in a Professional Service Manual. The next best place, of course is to google it on the Internet.

Basic Circuit Description of a Three Wire Sensor?

On this type of sensor, each of the three wires has a specific job to do. Here's the breakdown:

1. One wire is the Power Source and it normally provides 12 Volts although some provide 9 Volts.
    - You'll test for this Voltage with your Multimeter in DC Volts mode.
2. One wire is the Ground Path for the above 9 or 12 volts. This Ground is generally provided inside the Fuel Injection Computer or the Ignition Control Module, but not always.
    - You'll test for this Ground with your Multimeter in DC Volts mode.
3. The third wire is the Triggering Signal wire. It's thru' this wire that the Crank (or Cam Sensor) sends the Signal it produces to the Fuel Injection Computer or Ignition Control Module.
    - It's on this wire that you'll connect/attach the Red Lead of your Multimeter to test for the Signal.
    - The Black Lead you'll connect to ground.
    - The Multimeter will have to be either in Volts DC mode or Frequency (Hz) mode to verify the Signal.
    - The rule of thumb, if you're using Volts DC mode, is that this Signal should output the amount of Voltage that come's into the Sensor on the Power Circuit. So, when you crank the engine, you should see anywhere between 9 to 12 Volts.
    - If the CKP or CMP Sensor is BAD, you'll get no reading.

Basic Circuit Description of a Two Wire Sensor

Since this type of Sensor only has two wires and no Power Supply, testing them is not that hard:

1. One of the two wires is the Signal wire that sends the Signal to the Fuel Injection Computer of Ignition Module.
2. The other wire acts as a Ground return. This Ground is always provided by the Fuel Injection Computer or the Ignition Control Module.
3. On this type of Sensor, you'll connect both Multimeter Leads to both wires. That is the Red Lead can be connected to either of the two. The Black Lead is connected to the remaining one. It doesn't matter which Lead goes where, since the polarity does not matter.
4. Your Multimeter has to be in Volts AC mode to see this Signal.
5. When your helper cranks the engine, the Multimeter will display about 1 Volt AC. Usually, this AC Voltage will move between .3 Volts AC to 1 Volt AC the whole time the engine is cranking, this is normal. If the Sensor is BAD, the Multimeter will not display any AC Voltage.

- This Voltage increases with Engine RPM's. So the faster the engine cranks, the higher the AC Voltage.

What are the Actual Testing Steps

Testing a CKP Sensor isn't hard and the diagnostic flow is pretty straightforward. The following testing path applies to a Cranks but does NOT START condition. Although the following tests only apply to a Crankshaft Position Sensor that has failed **completely**, with some modification you can also follow the same diagnostic path in diagnosing a CMP Sensor.

1. **Step One.**
    - Make certain that the Battery is in a fully charged condition.
    - Test for Spark.
        - You'll need to test for spark at all cylinders to acertain that there's no Spark present at all.
        - If Spark is present, the Crankshaft Position is working properly.
    - Test for Fuel Injector Pulse, although depending on the fuel system design this is not always possible.
        - If the Fuel Injector Pulse is present, the Crankshaft Position Sensor is working properly.
2. **Step two.**
    - Find the location of the Crankshaft Position Sensor.
    - Determine type of CKP Sensor (either a two or three wire type).
3. **Step three.**
    - On three wire type CKP Sensors:
        - Determine which wire is the Power Circuit.
        - Determine which wire is the Ground Circuit.
        - Determine which wire is the Signal Wire.
    - On two wire type CKP Sensors:
        - You don't have to determine which wire is which since you don't have to test for a power supply. Also, the Multimeter's leads are hooked up to both wires at the same time to read the Signal the Sensor produces.
4. **Step four.**
    - On three wire type CKP Sensors:
        - Probe the Power Circuit to verify the presence of the specified Voltage. This Voltage is usually verified with the key on or engine cranking.
        - Probe the Ground Circuit to verify that ground does exist. This Ground is usually verified with the key on or engine cranking.
        - Probe the Signal Wire. The presence of this Signal can only be verified with the engine cranking and with the Multimeter in Hertz (Hz) Frequency Mode or in Volts DC Mode.

- On two wire type CKP Sensors:
    - Probe both wires coming out of the Sensor with both leads of your Multimeter. The polarity of the leads doesn't matter. In other words, the red and black lead can go to any of the two wires.
    - The presence of this Signal can only be verified with the engine cranking and with the Multimeter in Volts AC.

5. **Step Five.**
    - If no Signal is present:
        - The Crankshaft Position Sensor is BAD, replace it.
    - If a Signal is present:
        - The Crankshaft Position Sensor is good.

As always, things on paper always seem easier than in their actual application... and this is sometimes true when you're testing CKP and CMP Sensors. For example, in some cars and trucks, it's next to impossible to verify the fuel injector pulses with a Fuel Injector Noid Light. Why? Well because the engineers have located them inside or underneath the Intake Manifold Plenum. Don't let this deter you... it's just a matter of skipping this test and going on with the rest.

Once you overcome these obstacles, you'll find that testing them is not that hard. The one thing I recommend you do, is to practice on a good working car to see how all of this works. Well, in closing, if you found this article helpful... please tell a friend!!!

Related Crankshaft Position Test Articles

Below you'll find a list of test tutorials that will show you how to test the crankshaft position sensor for several different types of makes:

- How to Test the Ignition Module and Crank Sensor (GM 2.2L).
- How to Test the Ignition Module & Crank Sensor (GM 2.4L).
- Testing the Ignition Module and Crank Sensor (GM 3.1L, 3.4L).
- How to Test the 24X Crank Sensor GM 3.1L, 3.4L (**at: troubleshootmyvehicle.com**).
- GM 3.8L Ignition Control Module and Crank (3X, 18X) Sensor Test .
- How to Test the 3.8L GM Crank Sensor With a Multimeter (**at: troubleshootmyvehicle.com**).
- How to Test the 3.8L GM Cam Sensor (P0341) (**at: troubleshootmyvehicle.com**).
- How to Test the Ford Ignition Control Module (Distributor Mounted)
    - This tutorial shows you how to test the PIP Sensor, which is Ford's name for the crank sensor located inside the distributor.
- How to Test the Ford Ignition Control Module (Fender Mounted)
    - This tutorial shows you how to test the PIP Sensor, which is Ford's name for the crank sensor located inside the distributor.

- Ignition Coil and Crank Sensor Tests (1.8L, 2.4L Mitsubishi).
- How to Test the Cam Sensor 2.4L Nissan Altima (1997-2001)
    - The cam sensor is actually the crank sensor in this Nissan ignition system.
- Power Transistor Test & Ignition Coil Test 3.3L Nissan Altima (1996-2004)
    - The cam sensor is actually the crank sensor in this Nissan ignition system.