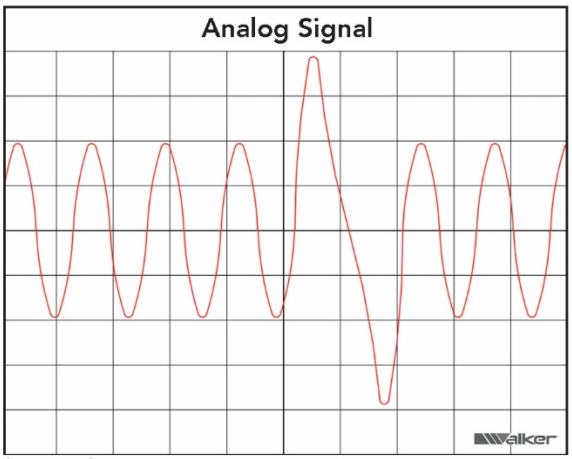
Walker Products Cam & Crank Position Sensors

Technical Editorial

Camshaft and crankshaft (also simply referred to as “Cam and Crank”) position sensors are some of the most crucial engine management devices on vehicles today. These controls have been present on modern vehicles for the better part of three decades and provide precision information needed for proper drivability. The vehicle’s onboard engine computer relies on these sensors to provide precise engine timing to ensure proper fueling, ignition, and internal engine operations. Without properly functioning camshaft and crankshaft position sensors, vehicles will notice significant loss in fuel economy, performance, and even catastrophic engine damage. For these reasons, the camshaft and crankshaft engine sensors are critical failure components that require proper diagnostics and repair.

While their purpose is understood to be crucial in the vehicle’s operation, their functions and internal workings may not be as well known. Walker Products is a global leader in camshaft and crankshaft position sensors and provides detailed insight on the operation of these components to educate the installers and technicians. Walker offers their ***“Walker Pro Tips”*** on common issues found when diagnosing, identifying, and on basic electrical designs of today’s cam and crank sensors – this gives us professional guidance to better understand the sensors in question and how to properly resolve common issues.



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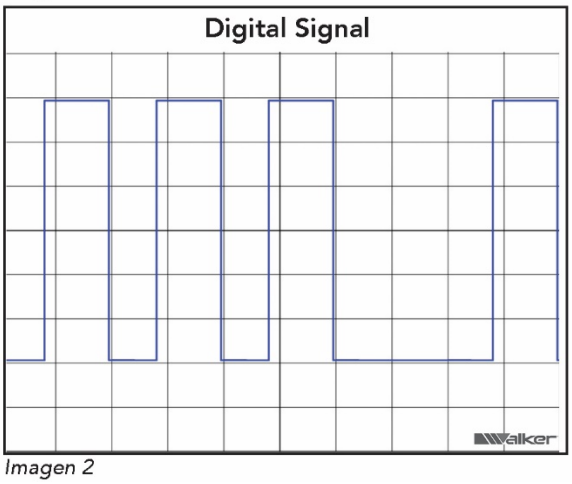

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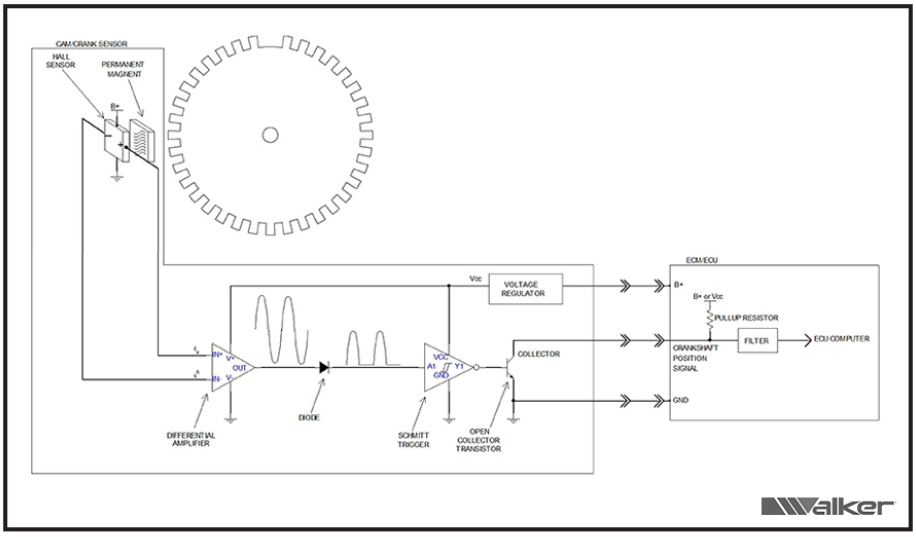
To begin, it is important to understand the basic terminology used within the engineering and design of camshaft and crankshaft position sensors and how the technology has evolved over time. We will then cover the different types or styles of cam and crank sensors, how to identify them, and how they operate.

There are five different styles of cam and crank position sensors: Variable Reluctance, Magneto-resistive, Pass-Through, Hall Effect, and Magnetic-less Hall Effect sensors. In this article, we will study these styles and how they are used within the vehicle and registered by the onboard engine computer.

Industry Terminology

Schmitt Trigger

The Schmitt trigger (figure 3) is a commonly used convertor that takes an electronic analog signal (figure 1) then conditions and converts it to a precise



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digital signal (figure 2). This digital signal is required by the vehicle's engine computer in order to effectively process the information.

Reluctor Wheel

The reluctor wheel is mounted to the camshaft or crankshaft and is made of ferrous material composed of several teeth (figure 3). The rotation of the wheel induces on-off or positive-negative signals within the cam or crank sensor as the teeth pass by. These signals are then delivered on to the engine computer to processing.

<u>Camshaft and Crankshaft Position Sensors – 5 Designs</u>

Variable Reluctance Sensor

Variable Reluctance (VR) sensors are the earliest and most simplistic technology used in the field of cam and crank sensors. Their internal design is composed of a wire wrapped around a magnetic core which faces the reluctor wheel. When the teeth on the reluctor wheel pass by the magnet, it will induce current flow in the wire. This current flow is an analog signal which must be conditioned and converted to a digital signal within the vehicle's engine computer – note that VR sensors do *not* contain Schmitt triggers. Once the signal is converted, the on-board computer interprets the information to determine the engine's internal timing, rotations per minute (RPM), and top dead center (TDC).

Without this signal, the engine computer would have no basis of the crucial timing measurements needed for proper combustion. In most instances of no signal, the engine computer would then prevent the engine from operating. This is a built-in safety feature designed to protect the engine from potential catastrophic failure.

<u>Walker Pro Tip</u>

VR sensors contain a strong magnet and are designed to operate in conjunction with the teeth on the reluctor wheel. This strong internal magnet makes these sensors susceptible to error caused by ferrous metal shavings, particles, and debris within the engine oil. Excessive debris can collect on the end of the sensor as

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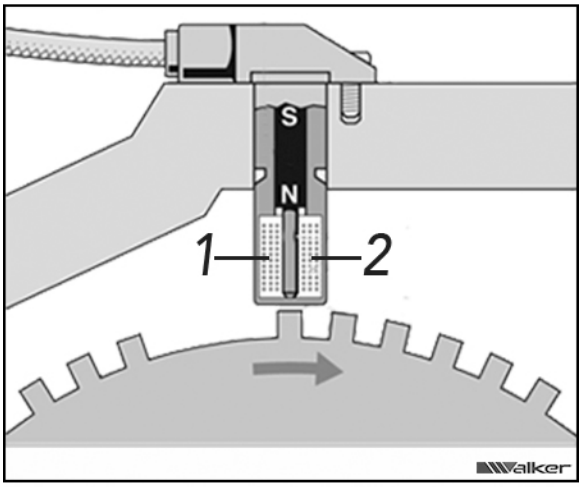
the internal magnet holds them to the end. Failure to regularly maintain clean engine oil could result in faulty operation of the VR cam and crank sensors. Technicians are recommended to inspect the magnetic end of the sensor for debris build up as one of their first steps in diagnostics (figure 4).

Magneto-resistive Sensor

The Magneto-resistive (MR) style sensors were developed to provide more accurate and precise information to the vehicle's engine computer. These sensors contain an internal magnet with two sensors on either side. The MR style sensors differ from VR sensors in a few areas. First, the engine control computer supplies constant power to the MR sensors, which allows them to internally convert the analog signal to a digital format using a Schmitt trigger. This internal function removes the need of an external transmitter in the engine computer to convert this electronic signal.

In addition, an advantage of MR style sensors is that they can measure low RPMs more accurately. This is a result of the constant power supply as well, which allows the MR sensors to output signals even when stationary so the rotational speed can be measured at all times, even at zero RPM.



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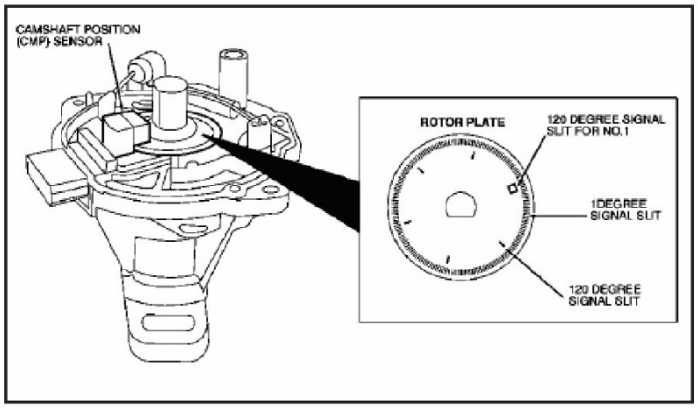
Lastly, MR sensors are able to determine the rotational direction because of the two sensors located on either side of the internal magnet. This benefit acts as an additional safety feature by ensuring proper crankshaft rotation (figure 5).

Walker Pro Tip

Common mistakes in diagnosing MR sensors is when checking for the sensor's resistance. Because MR and VR sensors appear similar externally, they can easily be mistaken. Their internal functions vary and can provide misleading information when performing diagnostics. Magneto-resistance sensors should show readings around 500,000 ohms whereas Variable Reluctance sensors should show readings from 800 to 1200 ohms. It is recommended to always consult the original manufacturer's specifications when performing these readings.

Pass-Through Sensor

The pass-through cam and crank sensors became a popular style during the introduction of multi-port fuel injection engines. This style of sensor was adapted to work with older engine architecture that was being converted to newer engine technologies and more sophisticated fueling and ignition systems. Because the introduction of these additional sensors utilized the engine's current design, they are generally found to be externally mounted.



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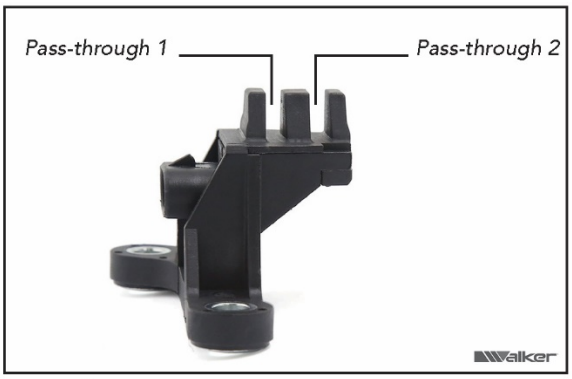
In addition, pass-through sensors also utilize a Schmitt trigger to condition and convert analog signals to digital signals for the engine computer to receive.

For camshaft sensors, the role of the pass-through design is to replace outdated distributor-style ignition systems. This was done by placing this new cam sensor where the distributor rotor would have been (figure 6).

For crankshaft sensors, they were typically found to be retrofitted to the front of the crankshaft behind the harmonic balancer. This is because the earlier engine block designs did not feature an internally mounted location for this type of sensor.

Pass-through style sensors operate differently from all other styles of cam and crank sensors. Rather than reading the edge of a reluctor wheel, pass-through sensors rely on the reluctor wheel to physically pass between the internal magnet and sensor. This means that the magnet and sensor are separated by a gap whereas other styles combine the two.

When the reluctor wheel passes through the gap, the teeth disrupt the magnetic field between the sensor and internal magnet. This disruption is measured as an analog signal which is internally conditioned and converted to a digital signal before being sent back to the onboard engine computer.



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Walker Pro Tip

On some applications, a pass-through style sensor located on the crankshaft can act as both the cam and crank sensor. In these instances, the sensor would have multiple pass through points, each of which would provide unique signals back to the engine computer. For example, one pass through point would relay signals pertaining to ignition timing, and the other would control the timing of the fuel injectors (figure 7).

Hall Effect Sensor

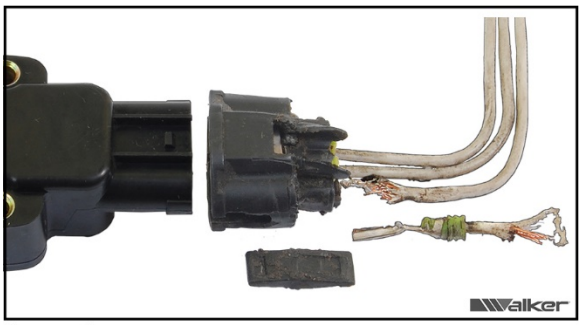
Hall effect style cam and crank sensors are the latest design in technology advancements in this field. Much like magneto-resistive and pass-through style sensors, Hall effect units also contain internal Schmitt trigger to condition and covert the analog signal to a digital signal.

The greatest advantage of a Hall effect style cam and crank sensor is the speed and accuracy. This style utilizes a Hall sensor which is designed to produce signals more efficiently than older sensor types. Because the internal circuitry of the Hall sensor can produce these signal outputs faster, the corresponding reluctor wheel utilizes additional teeth. With a faster sensor and more teeth, the system can generate more information for the engine computer to process. This can relate to an increase in precision ignition and fuel timing, which allows for an increase in engine horsepower and fuel economy.

Walker Pro Tip

For Hall effect style sensors, as well as all other types, one of the most common causes for failure is external connector contamination. Any time a sensor and its related connector become exposed to

foreign fluids or chemicals, there is a risk of connection malfunction. For instance, an external oil or antifreeze leak could easily find its way to the crank sensor and begin deteriorating the housing, seals, and wires. This event could cause faulty or inaccurate sensor readings. When diagnosing, always be sure to inspect the condition of these mating connections when servicing sensors exposed to these elements (figure 8).



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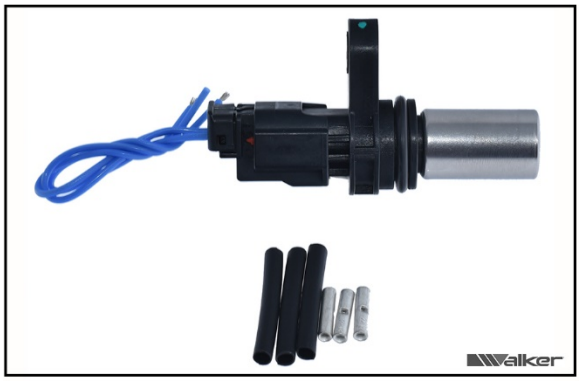
For all issues related to sensor and connector malfunctions, be sure to refer to Walker Product's exclusive Full Service Kits (FSK™) to repair the vehicle correctly (figure 9).



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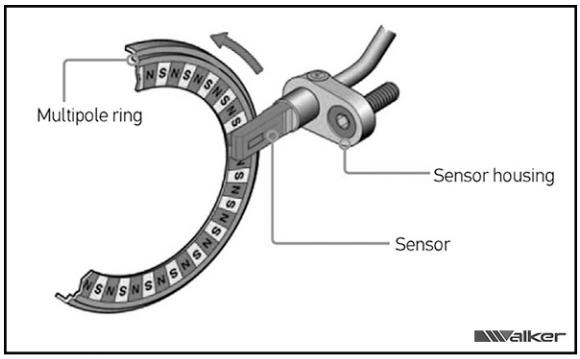
Magnet-less Hall Effect Sensor

Magnet-less Hall effect style sensors are simply a modified version of the standard Hall effect sensors. Rather than the sensor housing an internal magnet and Hall sensor, the magnet here has now been moved to the encoder wheel. The encoder wheel replaces the traditional reluctor wheel and has been removed of the toothed design. Now, the encoder wheel has alternating North and South magnetic fields which removes the need for teeth. Therefore, the sensor only contains the circuitry and Schmitt trigger.

The end result of this sensor evolution is the reduction of the system's weight, components, materials, and rotating mass. Here again, the goal was to increase efficiencies in all aspects to improve the engine's power output and fuel economy. Even the smallest engine sensors have evolved to meet the ever-growing demands for increased efficiency.



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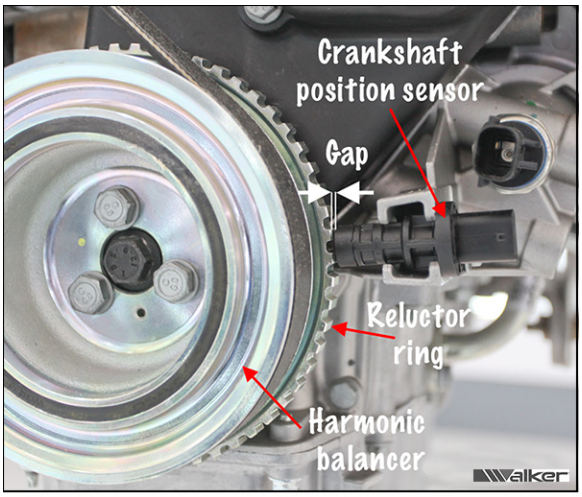
<u>Walker Pro Tip</u>

To identify these applications using magnet-less Hall sensors, you will first locate the encoder wheel attached to the crankshaft. Your first indications will be that there are no teeth on the wheel and the sensor body itself will be much smaller than the other styles. The most common issue with diagnosing these types of sensors is contamination or damage to the reluctor/encoder wheel. It is recommended to inspect the wheel when servicing the sensor (figure 10).

<u>BONUS Walker Pro Tip</u>

A common error when installing replacement cam and crank sensors is failing to fully seat the sensor in it's mounting location. The predetermined air gap between the sensor and reluctor wheel is critical for operation. Should the air gap be increased due to improper installation, the new or

replacement sensor would not be allowed to function as it was designed. It is highly recommended to lubricate all sensor O-rings and ensure all mounting surfaces are clean of any debris (figure 11).



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Summary

The fact of the matter is, when you break down the specific functions and internal workings of the cam and crank sensors, their duty on the vehicle remains justified. When diagnosing or troubleshooting a vehicle showing the signs of faulty engine sensors, it is always important to understand the underlying design of the system. These ***Walker Pro Tips*** can help save time by getting the job done right the first time.

Walker Products continues to lead the industry in automotive engine management, fuel delivery, and emissions control devices around the globe. Their facilities in Toluca, Mexico offer regional support throughout Mexico, Latin America, and South America for sales, distribution, technical assistance, and customer service inquires. For additional information regarding Walker Products and any of their product offerings, please visit www.walkerproducts.com or call 636-257-1700.