Spitronics ECU - Hall vs Variable Reluctance (VR) Sensors - Guide

Index

Hall and Variable Reluctance (VR) sensors are both widely used for crankshaft and camshaft position sensing.

Both can provide accurate engine-position information when correctly installed, but they operate differently and have different installation characteristics.

For existing factory trigger systems, the original sensor technology should normally be retained if it is known to work correctly.

For a new custom trigger system, Hall sensors are generally easier to implement because they provide a clean digital signal and are less sensitive to cranking speed, manufacturing tolerances and electrical interference.

Hall Sensors

A Hall sensor is an active electronic sensor.

It requires a power supply and produces a digital switching signal.

Typical connections are:

- Sensor supply.
- Ground.
- Signal.

Some Hall sensors use an internal output driver, while others require an external pull-up resistor.

The exact electrical arrangement depends on the sensor.

Back to Top

Hall Signal

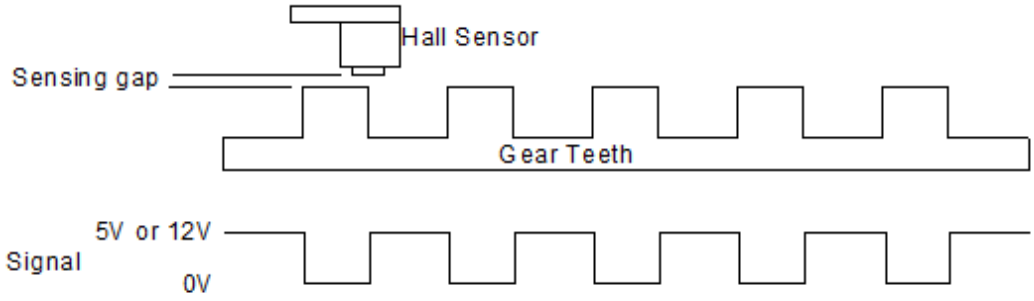
A Hall sensor normally switches between two defined voltage levels.

Typical behaviour is:

LOW → HIGH → LOW

as trigger teeth or slots pass the sensor.

The signal amplitude does not depend strongly on engine speed, provided the sensor has the correct supply voltage and the trigger passes within its specified operating gap.



Back to Top

Hall Sensor Advantages

Typical advantages include:

- Strong signal during cranking.
- Clean digital output.
- Good electrical-noise immunity.
- Good tolerance to trigger-wheel air gap.
- Good tolerance to manufacturing variation.
- Straightforward oscilloscope diagnosis.
- Suitable for complex and custom trigger patterns.

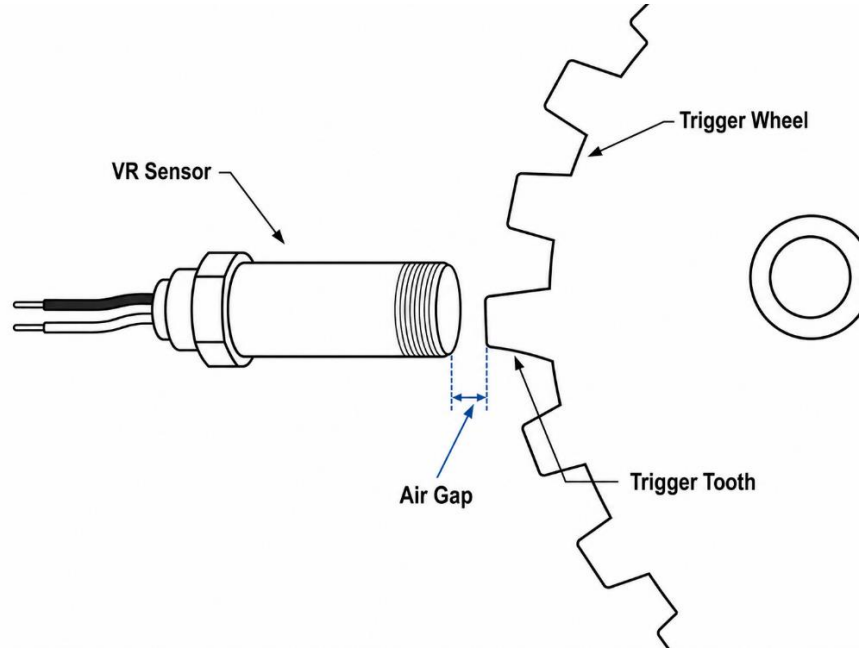
Hall sensors are particularly useful when designing a new trigger system.

Back to Top

Variable Reluctance Sensor

A Variable Reluctance sensor is a passive magnetic sensor.

It does not normally require an external power supply.



As a ferrous trigger tooth approaches and leaves the sensor, the changing magnetic field generates an alternating voltage.

The resulting signal is therefore an analogue AC waveform rather than a digital ON/OFF signal.

Back to Top

VR Signal

A VR signal changes with trigger speed.

At low RPM:

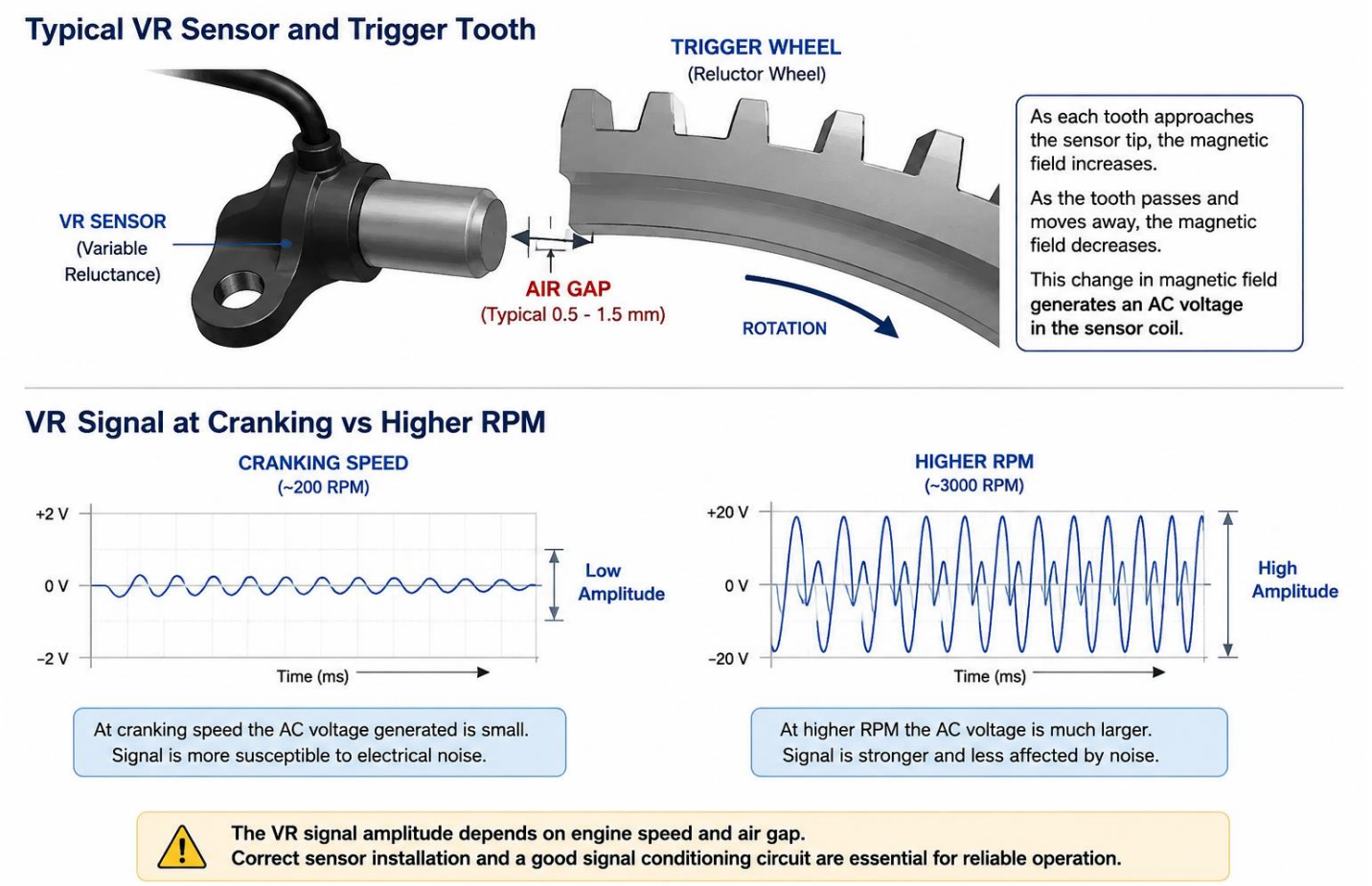
- Signal voltage is relatively low.
- Electrical interference becomes more significant.

As RPM increases:

- Signal amplitude increases.
- The waveform becomes much larger.

The ECU input must therefore condition the VR signal before it can be used as a reliable digital timing reference.

Back to Top



VR Sensor Advantages

Typical advantages include:

- Simple construction.
- No external sensor supply required.
- Good high-temperature capability.
- Long service life.
- Proven OEM technology.
- Very reliable when used with a correctly designed trigger and input circuit.

A good factory VR trigger system normally does not need to be replaced simply because Hall sensors are available.

Back to Top

Hall and VR Comparison

Feature	Hall Sensor	VR Sensor
Signal Type	Digital	Analogue AC
External Power	Required	Normally not required
Cranking Signal	Strong and stable	Lower amplitude
Signal Amplitude vs RPM	Mostly constant	Increases with RPM
Noise Immunity	Generally very good	More sensitive at low RPM
Air Gap Tolerance	Generally more forgiving	More critical
Trigger-Wheel Tolerance	More forgiving	Requires good geometry
Complex Trigger Shapes	Very suitable	More dependent on decoder design
Scope Diagnosis	Usually straightforward	Requires waveform interpretation
OEM Crank Use	Common	Very common
OEM Cam Use	Very common	Less common

Back to Top

Trigger Wheel Compatibility

Both Hall and VR sensors can be used with many common trigger arrangements, including:

- Single-tooth triggers.
- Multi-tooth wheels.
- Missing-tooth wheels such as 36-1 and 60-2.
- Distributor triggers.
- Cam synchronisation wheels.

The sensor type alone does not determine which trigger pattern can be used.

The ECU firmware and input-conditioning design must also support the pattern.

Back to Top

Complex Trigger Patterns

Hall sensors are particularly useful when the trigger pattern contains information in the shape or spacing of the pulses.

Examples include:

- Different tooth widths.
- Different slot widths.
- Variable gap lengths.
- Special synchronising teeth.
- Custom trigger patterns.

Because the Hall output remains a clean digital signal, the ECU can preserve edge and pulse-width information more easily.

A conventional VR interface is normally optimised primarily to detect tooth passages and zero crossings.

Advanced VR decoding is possible, but the trigger and signal-conditioning system must be designed for it.

Back to Top

Electrical Interference

Crank and Cam signals operate in an electrically noisy environment.

Possible interference sources include:

- Ignition coils.
- Spark plug leads.
- Injectors.
- Alternator wiring.
- Starter wiring.
- High-current Ground paths.

VR sensors are most vulnerable during cranking because their generated signal is at its lowest amplitude.

As engine speed increases, the VR signal normally becomes much stronger.

Hall sensors generally maintain a more consistent digital signal through the RPM range, but correct wiring is still important.

Back to Top

Installation Practice

Good trigger installation is important regardless of sensor type.

Use the following principles:

- Keep trigger wiring away from ignition and high-current wiring.
- Use screened cable where recommended.
- Maintain the correct sensor air gap.
- Ensure the trigger wheel runs true.
- Avoid excessive trigger-wheel run-out.
- Use sound Grounding.
- Make secure electrical connections.

A poorly installed Hall sensor can be less reliable than a correctly installed VR system.

Back to Top

Air Gap

The correct sensor air gap depends on the sensor and trigger design.

In general:

Hall Sensor

Hall sensors are often more tolerant of moderate air-gap variation, but excessive gap can still cause signal loss.

VR Sensor

VR output depends strongly on:

- Air gap.
- Tooth geometry.
- Trigger speed.

An excessive air gap can cause weak cranking signals even if the sensor produces a good signal at higher RPM.

Always follow known sensor specifications where available.

Back to Top

Sensor Polarity

Hall and VR sensors behave differently with polarity.

Hall Sensor

Hall wiring normally has defined:

- Supply.
- Ground.
- Signal.

Incorrect wiring may prevent operation or damage the sensor depending on the device.

VR Sensor

A two-wire VR sensor produces an AC signal, but the connection polarity still matters because reversing the wires reverses the waveform polarity.

This changes which edge or zero crossing the ECU sees at the trigger event.

Incorrect VR polarity can cause:

- Timing offset.
- Timing movement with RPM.
- Starting problems.
- Unstable triggering.

Detailed VR polarity testing belongs in the **Testing Magnetic Crank Sensors - Guide**.

Back to Top

Pull-Up Resistors and Hall Sensors

Some Hall sensors actively drive both HIGH and LOW states.

Others use an open-collector or open-drain output and require a pull-up resistor.

The required pull-up may be:

- Internal to the ECU.
- Internal to another controller.
- External in the harness.

This is particularly important when sharing a Hall signal between two Devices.

For shared Hall signal connections, refer to:

Spitronics ECU - Crank and Cam Sensor Tap-In - Guide

Do not assume every Hall sensor output can simply be connected to multiple controllers.

Back to Top

5 V and 12 V Hall Sensors

Hall sensors may operate from different supply voltages.

Common types include:

- 5 V Hall sensors.
- 12 V automotive Hall sensors.
- Sensors capable of operating over a wider supply range.

Use a sensor compatible with the applicable ECU input and installation.

For Spitronics custom installations, 12 V Hall sensors are generally preferred where the applicable trigger input is designed for a 12 V digital pulse. A 5 V Hall sensor may require additional harness or interface consideration depending on the Device.

Back to Top

Existing Factory Trigger Systems

If an engine already has a reliable OEM trigger system, keep the original sensor type where practical.

OEM VR systems have been used successfully for decades and can provide excellent reliability.

Changing a proven VR system to Hall does not automatically improve the installation.

Typical reasons to retain the OEM arrangement include:

- Known-good trigger wheel.
- Correct sensor bracket.
- Correct air gap.
- Proven timing stability.
- Existing firmware support.

Back to Top

New Custom Trigger Systems

Where a trigger system is being designed from scratch, Hall sensors are often the easier aftermarket choice.

Reasons include:

- Strong cranking signal.
- Digital output.
- Good noise immunity.
- Easier trigger-wheel manufacture.
- Greater tolerance to air-gap variation.

- Easier fault finding.
- Good support for custom trigger patterns.

This is a design preference, not an indication that VR technology is inferior.

Back to Top

Which Sensor Should I Use?

Existing OEM Trigger

Keep the original sensor technology where it is proven and supported.

New Custom Trigger

Hall is normally the preferred starting point.

Harsh High-Temperature Environment

A proven VR installation may be attractive because of its simple passive construction and temperature capability.

Complex Custom Pattern

Hall normally provides the easiest and clearest signal implementation.

Back to Top

Sensor Identification

A simple first indication is the number of wires.

Typical VR Sensor

Usually:

2 wires

and no external power supply.

Typical Hall Sensor

Usually:

3 wires

for:

- Supply.
- Ground.
- Signal.

However, wire count alone is not absolute proof.

Some sensors use additional shielding, duplicated signals or integrated functions.

When uncertain, verify the sensor using testing procedures rather than relying only on wire count.

Back to Top

Detailed Sensor Testing

This guide explains the differences between Hall and VR technology.

Use the dedicated test guides for practical electrical testing:

Spitronics ECU - Testing Magnetic Crank Sensors - Guide

covers:

- Resistance.
- AC cranking voltage.
- VR polarity.
- Air gap.
- Oscilloscope testing.

Spitronics ECU - Hall and Optical Sensor Testing - Guide

covers:

- Sensor supply.
- Ground.
- Output switching.
- Pull-ups.
- Hall and optical waveform testing.

Back to Top

Quick Comparison

Hall

Powered → Digital signal → Strong at cranking → Easier custom installation

VR

Passive → AC signal → Amplitude increases with RPM → Excellent proven OEM technology

Back to Top

Selection Check

Before selecting or replacing a trigger sensor, verify:

[ ] Existing OEM sensor technology.

[ ] Firmware supports the trigger pattern.

[ ] Sensor supply requirements.

[ ] ECU input compatibility.

[ ] Required air gap.

[ ] Trigger-wheel material and geometry.

[ ] Wiring and screening requirements.

[ ] Sensor polarity where applicable.

[ ] Signal quality during cranking.

[ ] Signal quality at higher RPM.

[ ] Shared-signal requirements where another ECU remains connected.

Back to Top