Spitronics ECU - Testing Variable Reluctance (VR) Sensors - Guide

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This guide provides a practical procedure for diagnosing Variable Reluctance (VR), also commonly called magnetic, Crank and Cam Sensors.

A VR sensor generates an AC signal as trigger teeth pass the sensor.

Reliable ECU operation requires:

- A usable signal during cranking.
- Stable RPM detection.
- Correct sensor polarity.
- Correct sensor air gap.
- Good trigger-wheel geometry.
- Low electrical interference.

A weak or distorted signal can result in:

- No RPM.
- Erratic RPM.
- Difficult starting.

- Timing movement.
- Synchronisation errors.
- Misfire at higher RPM.

Before Testing

Before diagnosing the sensor itself, verify the basic ECU installation.

Check:

[ ] Startup procedure has been completed.

[ ] Correct firmware is loaded for the trigger pattern.

[ ] ECU has a stable power supply.

[ ] Ground connections are correct.

[ ] Trigger sensor wiring is connected correctly.

[ ] Trigger wiring is routed away from major interference sources.

[ ] Product-specific sensor input configuration is correct.

Product-specific jumper positions, connector pins and hardware settings are shown under the applicable Product information and are intentionally not repeated in this guide.

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How a VR Sensor Works

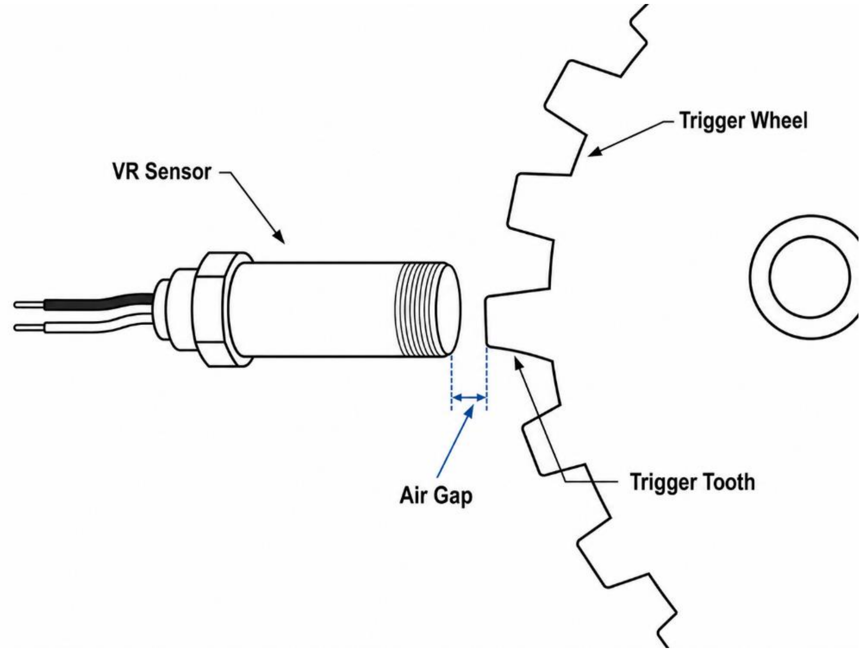
A VR sensor is a passive magnetic sensor.

It normally contains:

- Permanent magnet.
- Pole piece.
- Coil winding.

As a ferrous trigger tooth approaches and moves away from the sensor, the magnetic field through the coil changes.

This generates an alternating voltage.



Unlike a Hall sensor, the VR signal amplitude depends strongly on:

- Engine speed.
- Sensor air gap.
- Trigger-tooth shape.
- Sensor design.

At cranking speed the signal is relatively small.

At higher RPM the signal becomes much larger.

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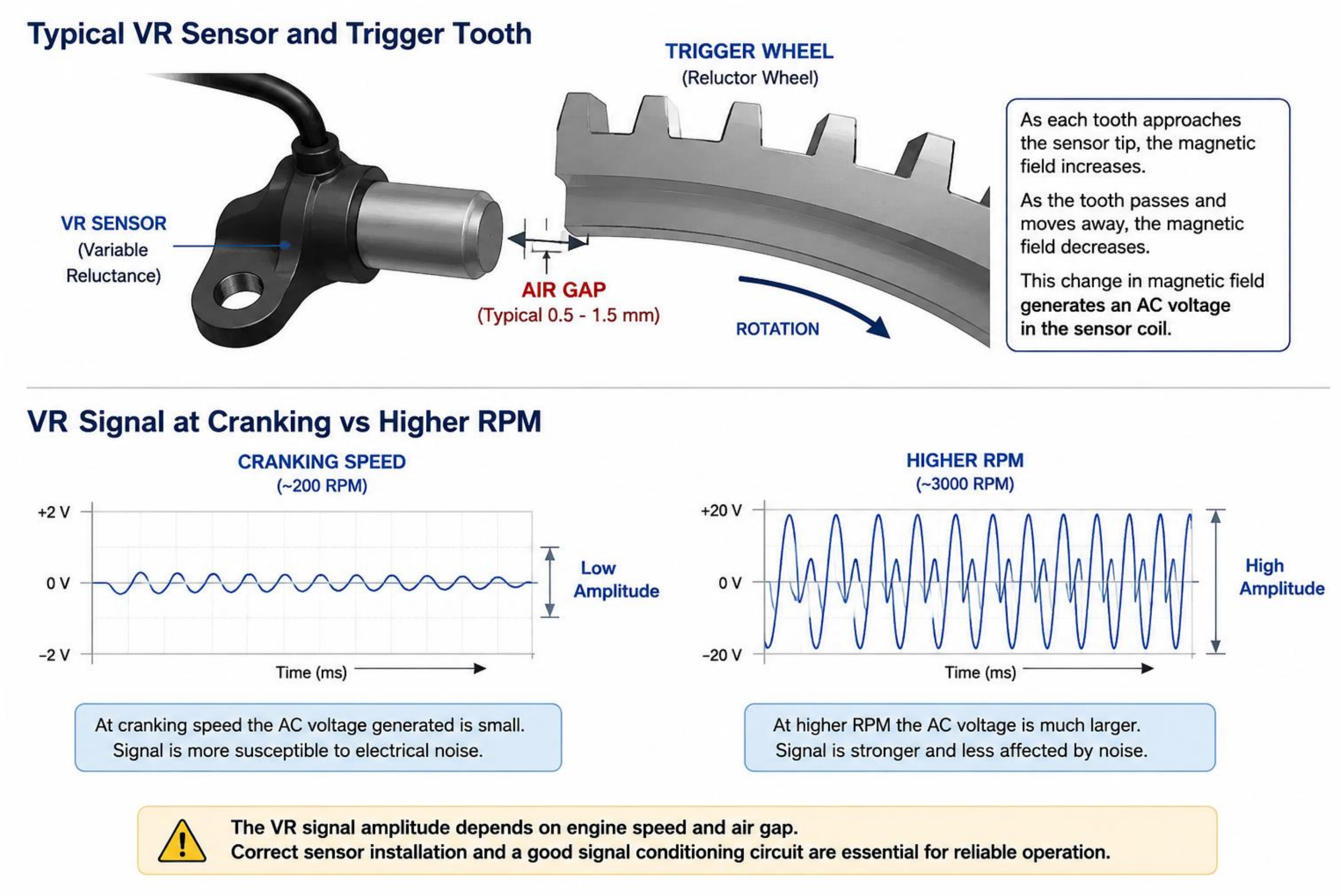

First Check - Realtime RPM

One of the quickest trigger checks is the Realtime RPM display.

Crank the engine and observe RPM.

A typical starter-speed reading may be approximately:

100-300 RPM

The exact value depends on the engine and starter system.

Stable RPM

A reasonably constant cranking RPM indicates that the ECU is receiving trigger events.

This does not prove that:

- Polarity is correct.
- Timing is correct.
- Signal remains reliable at higher RPM.

But it is a useful first check.

No RPM

If cranking speed is physically normal but the ECU shows no RPM, the ECU is not recognising a usable Crank signal.

Proceed with sensor and wiring tests.

Erratic RPM

If RPM jumps unpredictably while cranking:

Do not attempt to start the engine until the trigger problem is understood.

Possible causes include:

- Weak VR signal.
- Incorrect polarity.
- Excessive air gap.
- Electrical interference.
- Incorrect trigger configuration.
- Incorrect firmware.
- Mechanical trigger-wheel problems.

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Battery Voltage During Cranking

Cranking voltage affects the complete engine-management system.

Low battery voltage may reduce:

- Starter speed.
- Crankshaft speed.
- VR sensor output amplitude.
- ECU supply stability.

Useful practical cranking-voltage indicators are approximately:

- 11 V or above as a strong cranking supply.
- Below 10 V as weak.
- Below 9 V as a serious concern.

These should be treated as practical indicators rather than universal limits.

The important diagnostic principle is:

A slow-cranking engine produces a weaker VR signal.

If Battery Voltage is unusually low, correct the power or starting-system problem before changing trigger settings.

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Sensor Resistance Test

Most conventional two-wire VR sensors contain a coil winding that can be checked with a multimeter.

Disconnect the sensor from the ECU before performing the resistance test.

1. Set the multimeter to a suitable resistance range.
2. Measure across the two VR sensor wires.
3. Reverse the meter probes and repeat.

A healthy passive sensor should normally show a similar resistance in either probe direction.

A practical resistance range for many conventional VR sensors is approximately:

300-2000 Ω

This is not a universal VR sensor specification.

Always use known sensor information where available.

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Resistance Test Results

Normal Resistance

A stable resistance reading indicates that the sensor winding and wiring are continuous.

It does not prove that the sensor produces a sufficiently strong or correctly phased trigger signal.

Open Circuit

Possible causes:

- Broken sensor winding.
- Broken wire.
- Poor connector.
- Sensor not connected.

Very Low Resistance

Possible causes:

- Shorted sensor winding.
- Wiring short.
- Incorrect component being tested.

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AC Voltage Test

A VR sensor generates AC voltage while the engine rotates.

This can be checked with a multimeter.

1. Connect the meter across the VR sensor signal wires.
2. Select AC Voltage.
3. Crank the engine.
4. Observe the generated voltage.

Approximately 1 V AC during cranking is a useful practical indication of a healthy VR signal. Mercury-range products typically require approximately 0.5 V AC.

Important

A normal multimeter displays an averaged or RMS-type AC measurement, not the actual waveform peak-to-peak voltage.

Do not describe a multimeter reading as **1 V peak-to-peak**.

For actual signal amplitude, polarity and waveform shape, use an oscilloscope.

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Weak AC Signal

If the cranking signal is very low, investigate:

- Excessive sensor air gap.
- Low cranking speed.
- Weak or damaged sensor.
- Incorrect sensor for the trigger wheel.
- Poor trigger-tooth geometry.
- Contamination on the sensor.
- Mechanical misalignment.

Do not immediately change ECU filtering or trigger settings to compensate for a physically weak sensor installation.

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Sensor Air Gap

Air gap has a strong influence on VR signal amplitude.

A smaller gap normally produces a stronger signal.

A larger gap normally produces a weaker signal.

Many automotive trigger systems operate with a gap below approximately:

1 mm

but the correct value depends on the sensor and trigger design.

Use the OEM or sensor specification where available.

Too Large a Gap

Possible symptoms:

- No RPM during cranking.
- Starts only with a strong battery.
- Erratic low-RPM signal.
- Synchronisation loss.

Too Small a Gap

Possible problems:

- Physical contact if trigger wheel runs out.
- Sensor damage.
- Abnormal signal shape in some installations.

Always consider trigger-wheel run-out when setting a very small gap.

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Sensor Size and Trigger-Tooth Geometry

The sensing area should suit the size and spacing of the trigger teeth.

Consider:

- Tooth width.
- Tooth gap.
- Sensor pole-piece diameter.
- Wheel diameter.
- Air gap.
- Trigger-wheel speed.

A sensor that works well on a large coarse trigger wheel may not work equally well on a small wheel with closely spaced teeth.

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Trigger Wheel Condition

Inspect the trigger wheel mechanically.

Check for:

- Bent or buckled wheel.
- Excessive run-out.
- Loose wheel.
- Damaged teeth.
- Inconsistent tooth height.
- Poorly manufactured tooth spacing.
- Excessive vibration.

Mechanical trigger errors can appear as electrical trigger problems.

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Welded Trigger Wheels

A trigger wheel manufactured by welding separate teeth or components may sometimes produce inconsistent magnetic behaviour.

For best results:

- Use consistent ferrous material.
- Maintain uniform tooth geometry.
- Avoid unnecessary magnetic discontinuities.
- Verify the finished wheel with an oscilloscope if trigger quality is uncertain.

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VR Sensor Polarity

Although a VR sensor has only two signal wires and produces AC voltage, the wire polarity matters.

Reversing the two wires reverses the waveform.

This changes which part of the waveform the ECU sees at the trigger point.

Incorrect VR polarity can cause:

- Incorrect ignition timing.
- Timing movement as RPM changes.
- Difficult starting.

- Intermittent triggering.
- High-RPM trigger errors.

A resistance test cannot determine correct polarity.

Use:

- Known OEM wiring information.
- Oscilloscope waveform.
- Timing-light verification.

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Timing Movement with RPM

One of the most useful practical checks for VR polarity and trigger quality is ignition timing.

1. Lock the ECU ignition timing.
2. Verify timing with a timing light at low RPM.
3. Increase RPM.
4. Verify that the mechanical timing remains aligned with the ECU command.

If timing moves significantly while ECU timing remains locked, investigate:

- VR polarity.
- Trigger edge.
- Signal conditioning.
- Mechanical trigger movement.

Do not correct this by reshaping the ignition Tune.

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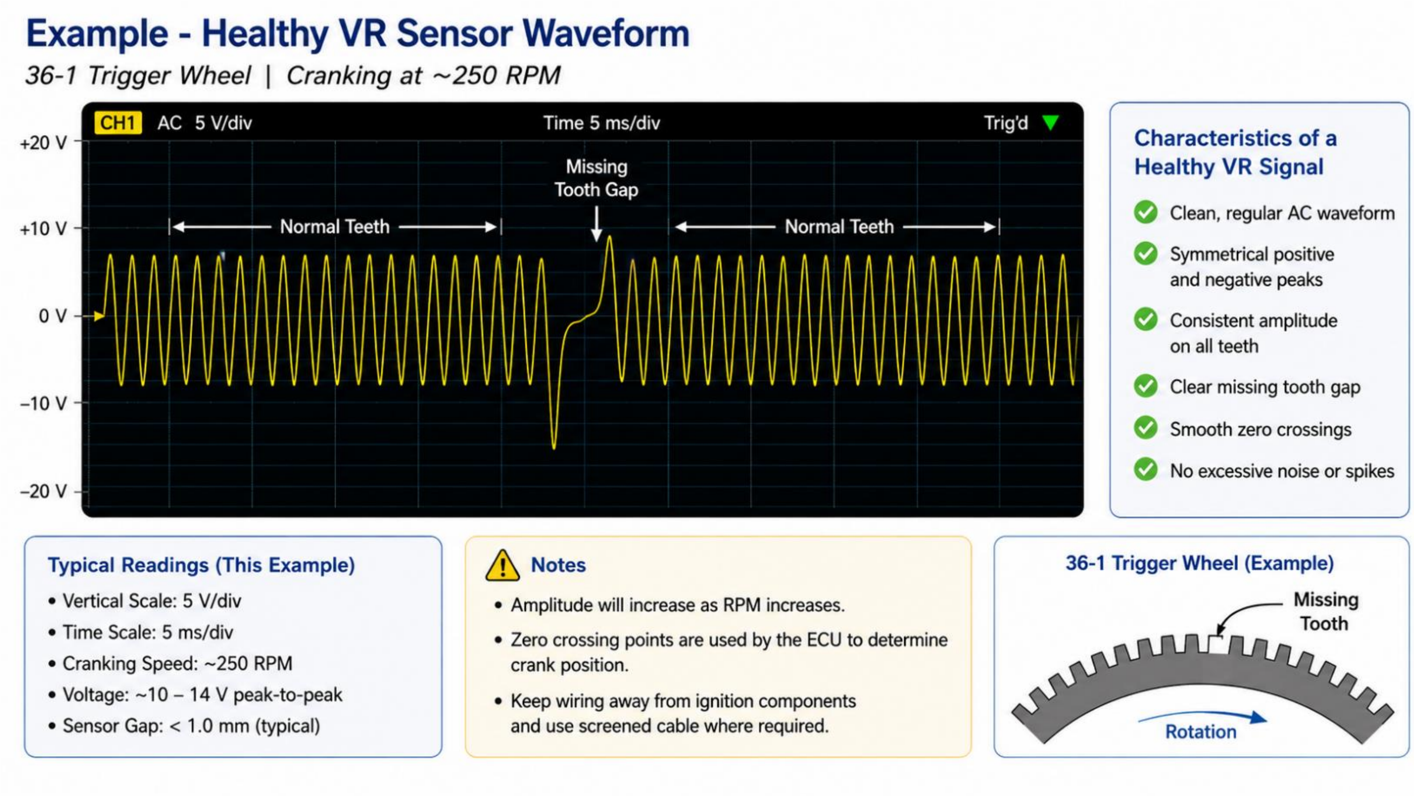
Oscilloscope Testing

An oscilloscope is the preferred tool for detailed VR diagnosis.

A healthy waveform should normally be:

- Clean.
- Repeatable.
- Symmetrical enough for the trigger arrangement.
- Free from large unwanted spikes.
- Increasing in amplitude with RPM.



Scope testing can reveal problems that a multimeter cannot, including:

- Incorrect polarity.
- Electrical interference.
- Missing tooth signature.
- Double triggering.
- Uneven tooth amplitude.
- Signal clipping.
- Trigger-wheel run-out.

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Electrical Interference

Ignition systems generate large electrical transients.

The trigger circuit may also be exposed to interference from:

- Coils.
- Spark plug leads.
- Injectors.
- Alternator.
- Starter wiring.
- High-current Ground wiring.

Use appropriate screened cable where required.

Route Crank and Cam wiring away from ignition and high-current wiring.

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Screened Cable

Where screened cable is used, the shield should normally be connected according to the applicable ECU wiring design.

Where applicable, connect the cable screen to Ground at the ECU end only.

Avoid creating unintended Ground loops through the cable screen.

Product-specific harness details belong under the applicable Product information.

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Ignition Interference Test

If RPM is stable while cranking but becomes erratic once ignition starts operating, suspect ignition interference.

This is an important diagnostic distinction:

Stable RPM while cranking + unstable RPM once coils fire

often points toward interference rather than a fundamentally weak Crank Sensor.

Check:

- Trigger cable routing.
- Screening.
- Coil Grounds.
- Spark plugs.
- HT leads where fitted.
- Ignition driver wiring.
- ECU Grounding.

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Spark Plug and HT Interference

Use ignition components with appropriate suppression for the ignition system.

Where interference is suspected, inspect:

- Resistor-type spark plugs where specified.

- Suppressed HT leads.
- Coil boots.
- Plug gaps.
- Damaged insulation.
- Arcing.

Avoid unsuppressed copper-core HT wiring unless the ignition system specifically requires it.

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Check for Ignition Arcing

In a dark workshop, visible arcing can sometimes reveal:

- Damaged HT leads.
- Cracked coil boots.
- Poor terminals.
- Insulation breakdown.

Keep Crank and Cam wiring away from any known ignition discharge path.

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High-RPM Trigger Errors

A sensor may work correctly during cranking and idle but fail at higher RPM.

Possible causes include:

- Trigger-wheel run-out.
- Excessive vibration.
- Poor tooth geometry.
- Sensor pole too large for the tooth pitch.
- Incorrect VR polarity.
- Input configuration.
- Electrical interference.
- Signal amplitude exceeding or distorting the input-conditioning range.

An oscilloscope is particularly valuable for this type of fault.

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Signal Fade or Drop-Out

If RPM drops suddenly or disappears at a repeatable RPM, investigate the trigger signal rather than immediately changing the Tune.

Check:

- Sensor air gap.
- Trigger-wheel run-out.
- Sensor mounting.
- Wiring.
- Polarity.
- Scope waveform at the failure RPM.

A repeatable RPM failure often provides a useful clue that signal conditioning or mechanical trigger geometry is involved.

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ECU Reset Is Not a Trigger Failure

If:

- Software disconnects.
- ECU restarts.
- Realtime Data disappears.
- Connection re-establishes after a moment,

the problem may be ECU power supply rather than the Crank Sensor.

Check:

- ECU power.
- Ignition relay.
- Ground.
- Battery voltage.
- Cranking voltage drop.

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Diagnostic Sequence

For a suspected VR Crank Sensor problem, work through the following order:

1. Check battery and cranking speed.
2. Confirm correct firmware and trigger configuration.
3. Observe Realtime RPM while cranking.
4. Inspect sensor and trigger wheel.
5. Measure sensor resistance.
6. Measure AC voltage while cranking.
7. Check sensor air gap.
8. Verify wiring and screening.
9. Confirm VR polarity.

10. Verify timing with a timing light.
11. Check waveform with an oscilloscope where required.
12. Repeat testing at the RPM where the fault occurs.

Fault Finding

Symptom	Likely Cause	Check
No RPM while cranking	No usable Crank signal	Resistance, AC voltage, wiring
Erratic cranking RPM	Weak/noisy signal	Gap, polarity, interference
Starts only with strong battery	Weak cranking VR signal	Battery, starter speed, air gap
Timing moves with RPM	VR polarity or trigger edge	Scope and timing light
Works at idle but fails at high RPM	Trigger geometry or signal-conditioning problem	Scope at failure RPM
RPM becomes unstable when coils fire	Ignition interference	Screening, routing, ignition system
ECU disconnects while cranking	Power supply problem	Battery, relay and Ground
One tooth has different amplitude	Wheel geometry/run-out	Inspect trigger wheel
Signal becomes weak when hot	Sensor or wiring fault	Repeat resistance/scope test hot

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Safety

During trigger testing:

- Do not attempt to start an engine with obviously erratic RPM.
- Avoid prolonged cranking.
- Allow the starter to cool between repeated tests.
- Keep hands and test equipment clear of rotating components.
- Secure oscilloscope and multimeter leads before cranking.
- Correct trigger faults before performing fuel or ignition tuning.

Setup Check

Before considering the VR Crank Sensor setup complete, verify:

[ ] Cranking Battery Voltage is healthy.

[ ] Realtime RPM is stable.

[ ] Sensor resistance is reasonable.

[ ] VR signal is strong enough during cranking.

[ ] Sensor air gap is correct.

[ ] Trigger wheel runs true.

[ ] Sensor size suits the tooth geometry.

[ ] Wiring is routed correctly.

[ ] Screening is correctly connected where used.

[ ] VR polarity is correct.

[ ] Timing light agrees with ECU timing.

[ ] Timing remains stable as RPM changes.

[ ] No trigger errors occur at high RPM.

[ ] No ignition interference is present.

[ ] ECU power remains stable during starting.

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