Spitronics ECU - Hall and Optical Sensor Testing - Guide

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Hall Effect and Optical sensors provide the ECU with a digital switching signal for Crank and Cam position sensing.

Both types normally produce a square-wave signal that switches between a LOW and HIGH voltage.

Unlike a Variable Reluctance (VR) sensor, a Hall sensor requires a power supply to operate. A typical Hall sensor therefore has:

- Power Supply.
- Ground.
- Signal Output.

The ECU does not need to know whether the digital signal was created by a Hall element or an optical sensor. It requires a clean switching signal that is electrically compatible with the trigger input.

Hall and Optical Signals

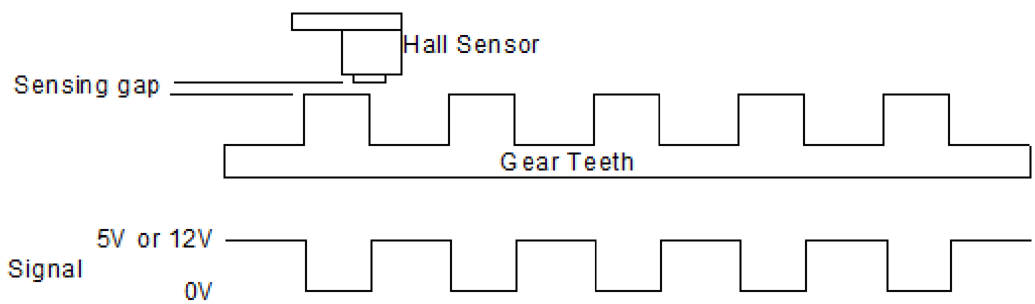
A typical digital trigger signal switches between two voltage levels.

Examples may include:

- 0 V ↔ 5 V.
- 0 V ↔ 12 V.

The actual voltage required depends on:

- Sensor design.
- Sensor supply voltage.
- Sensor output type.
- ECU hardware generation.
- Trigger-input circuit.



The important requirement is a clean and repeatable transition between LOW and HIGH.

The ECU then uses the applicable Rising or Falling edge as the timing reference.
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Active High and Active Low

Hall Sensor polarity depends on the sensor design.

Active Low

When the trigger tooth or target is detected:

Signal changes HIGH → LOW

Example:

12 V → 0 V

This arrangement is common in automotive applications.

Active High

When the trigger is detected:

Signal changes LOW → HIGH

Example:

0 V → 12 V

Both signal directions can be used provided the ECU is configured for the correct trigger edge.

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Before Testing

Do not assume that every Hall Sensor operates from 12 V.

Common sensor types include:

- 5 V Hall Sensors.
- 12 V Hall Sensors.
- Wide-supply Hall Sensors.
- Open Collector Hall Sensors.
- Push-Pull Hall Sensors.

Applying 12 V directly to a sensor designed only for 5 V may permanently damage it.

If the sensor specification is unknown, identify the sensor before applying an unknown supply voltage.

For unknown sensors, begin testing with the safer lower supply voltage.

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Hall Sensor vs VR Sensor

Before performing powered testing, confirm whether the sensor is actually a Hall / Optical sensor or a VR sensor.

Typical VR Sensor

A conventional VR sensor normally has:

- Two signal wires.
- Measurable coil resistance.
- No external power supply.
- AC output.
- Signal amplitude that increases with RPM.

Some three-wire VR sensors use the third wire only as a screen connection.

Typical Hall Sensor

A conventional Hall Sensor normally has:

- Power Supply.
- Ground.
- Signal.
- No normal coil-resistance characteristic.
- Electronic or diode-type readings between some terminals.
- Digital switching output.

Wire count alone is not sufficient to identify the sensor.

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Diode Test

A Hall Sensor contains electronic circuitry and may show diode-type readings when tested with a multimeter.

With the sensor disconnected:

1. Set the multimeter to Diode Test.
2. Test between the sensor terminals.
3. Reverse the probes and repeat.
4. Compare the readings.

Readings of approximately:

0.5 V to 1.9 V

may indicate semiconductor circuitry consistent with a Hall Sensor.

This is an identification aid only.

It does not identify:

- Correct pinout.
- Supply voltage.
- Output type.

Further testing is still required.

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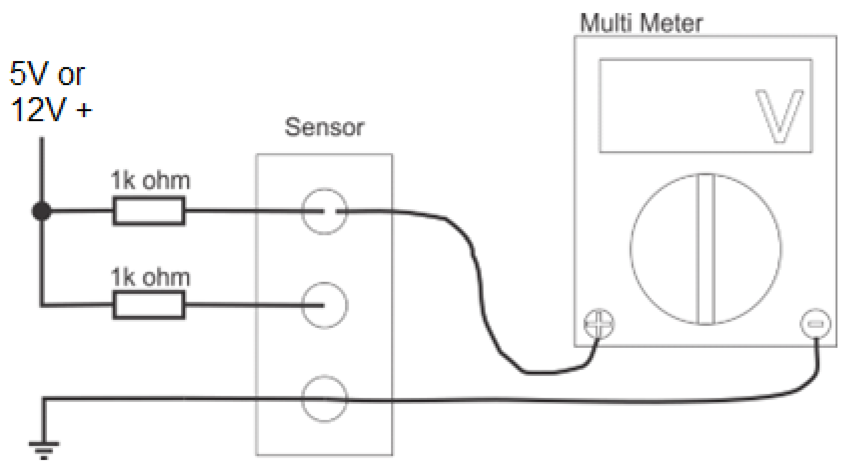
Safe Test for an Unknown Hall Sensor

When the sensor pinout is unknown, the resistor test method can reduce the risk of damage.

A safe Spitronics test uses two current-limiting resistors.



Typical test arrangement:

- Connect two resistors to the positive test supply.
- Connect the free ends of the resistors to two sensor pins.
- Connect the remaining sensor pin to Ground.
- Measure the possible Signal pins relative to Ground.

Start with:

5 V supply

when the sensor operating voltage is unknown.

The test normally uses:

1 kΩ resistors

although larger values may also be used for initial testing.

The resistors limit current if the assumed pinout is incorrect.

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Identify the Signal Pin

Connect a multimeter:

- Black lead → Ground.
- Red lead → possible Signal pin.

Move a suitable ferrous object or trigger tooth past the sensor.

The Signal pin should switch between LOW and HIGH.

Depending on the test arrangement and sensor type, this may be approximately:

0 V ↔ 5 V

or:

0 V ↔ 12 V

The important observation is that the voltage changes cleanly when the target passes the sensor.
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Identify the Supply Pin

The Supply pin should remain at a stable voltage while the target is moved.

The Signal pin changes state.

This allows the three basic connections to be identified:

- Supply.
- Ground.
- Signal.

If no switching is detected:

1. Recheck the possible Ground pin.
2. Try the other pin combinations.
3. Verify the test target is suitable.
4. Verify the sensor gap.
5. Only then consider whether a different supply voltage is required.

Do not immediately apply 12 V to an unknown sensor.
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Determine Sensor Supply Voltage

If the sensor operates correctly from 5 V, treat it as a 5 V sensor unless reliable specifications confirm that it can accept a higher supply voltage.

Some sensors can operate over a wide supply range, but this must not be assumed.

If the sensor only operates correctly from 12 V and its specification supports this, it can be treated as a 12 V Hall Sensor.
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Hall Sensor Output Types

The sensor supply voltage and the Signal output voltage are not necessarily the same.

This is especially important with Hall Sensors.

Two common output types are:

- Open Collector.
- Push-Pull.

Understanding the difference is essential before adding pull-up resistors or connecting the sensor to the ECU.
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Open Collector Output

An Open Collector Hall Sensor does not actively drive the Signal HIGH.

It can normally only pull the Signal LOW.

A pull-up resistor is therefore required to create the HIGH voltage.

Typical arrangement:

Pull-Up Supply → Resistor → Signal

The Hall Sensor then switches the Signal toward Ground.

[Insert Diagram - Open Collector Hall Output]

This means a sensor can, for example:

- Operate from a 5 V supply.
- Use an Open Collector output.

- Have its Signal pulled up to another compatible voltage required by the ECU input.

The sensor supply voltage and signal pull-up voltage must therefore be considered separately.
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Testing for Open Collector Output

A missing pull-up may cause:

- Signal stuck near 0 V.
- No visible HIGH state.
- Apparently dead sensor.

Fit a suitable pull-up resistor to a safe voltage and test again.

If the signal then switches correctly, the sensor is likely an Open Collector type.

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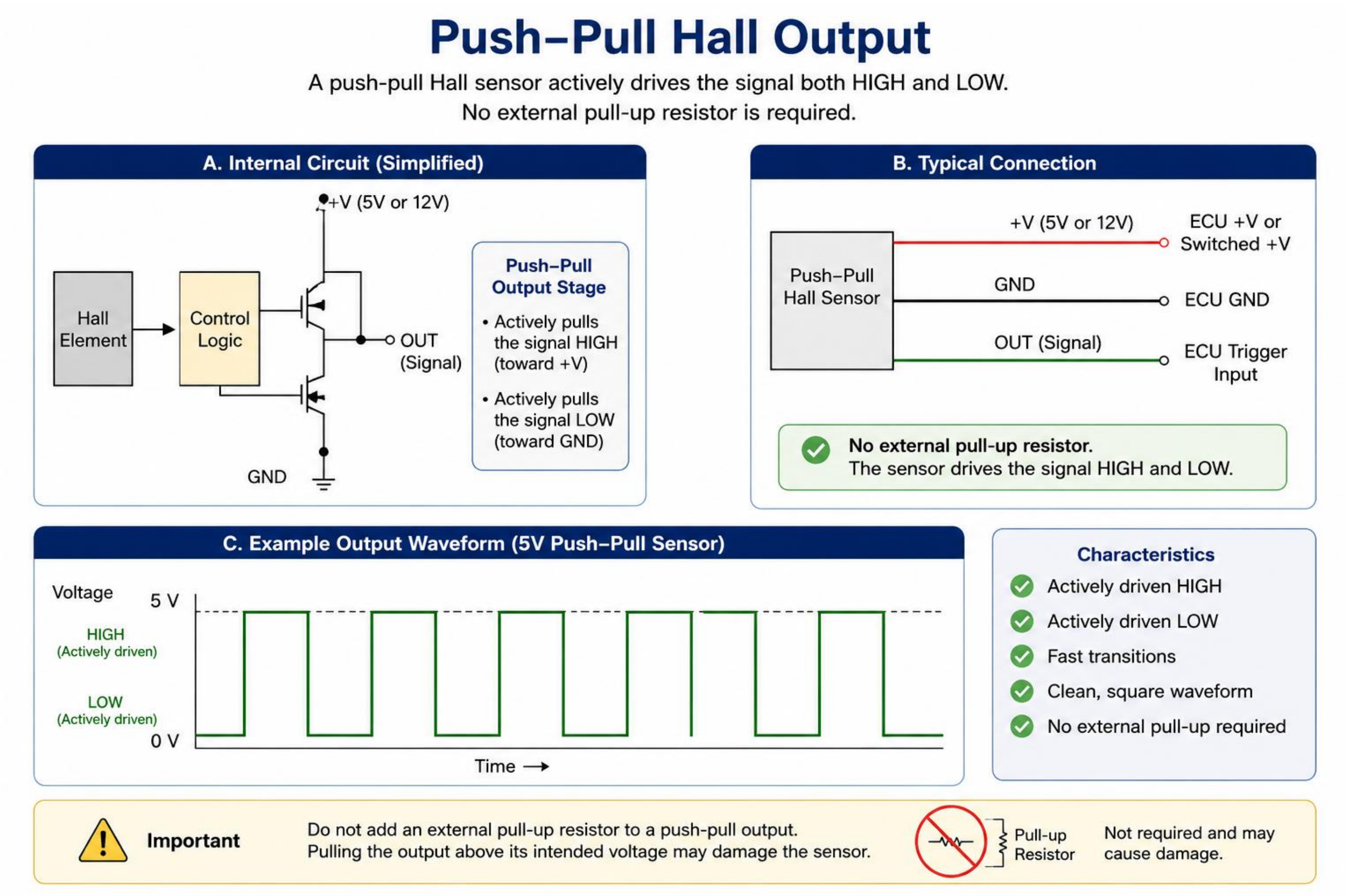
Push-Pull Output

A Push-Pull Hall Sensor actively drives the Signal both:

- HIGH.
- LOW.

It therefore does not normally require a pull-up resistor.



For example, a 5 V Push-Pull Sensor may produce:

0 V ↔ 5 V

directly from its internal electronics.

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Open Collector vs Push-Pull Test

A simple practical check can be made by removing the external pull-up.

Open Collector Sensor

Without the pull-up:

- HIGH state disappears.
- Signal no longer switches correctly.

Push-Pull Sensor

Without the pull-up:

- Sensor continues to produce both HIGH and LOW states.

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Pull-Up Voltage Safety

Do not connect an external pull-up resistor to a voltage that is unsafe for the sensor output stage.

This is especially important with Push-Pull outputs.

For example, a 5 V Push-Pull Hall Sensor actively drives its Signal HIGH to approximately 5 V.

If that Signal is then pulled toward 12 V externally, the sensor output stage may be damaged.

Before adding a pull-up resistor, determine:

[ ] Sensor supply voltage.

[ ] Output type.

[ ] Safe Signal voltage.

[ ] ECU input requirements.

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Spitronics Trigger Input Compatibility

Some Hall Sensors can connect directly to a Spitronics ECU.

Others require a hardware or wiring modification.

This depends on:

- Sensor supply voltage.
- Sensor output type.
- Signal HIGH voltage.
- ECU trigger-input design.

Do not assume that a sensor is directly compatible merely because it produces a square-wave signal.

The correct interface must be used.

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Sensor Supply Jumper

Some Spitronics ECUs provide a jumper that selects the sensor supply voltage.

Typical selections include:

- 5 V.
- 12 V.

The jumper supplies the correct **operating voltage to the sensor**.

It does not automatically convert the Hall Sensor Signal.

The physical jumper location is shown under the applicable Product information.
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Callisto Hall Input

Callisto uses a comparator / signal-shaper circuit on its Crank and Cam inputs.

The Hall comparator uses approximately a **5 V reference**.

This means a direct:

0 V ↔ 5 V Push-Pull Hall Signal

does not rise sufficiently above the comparator reference to provide a normal reliable Hall input.

For this reason, some 5 V Hall Sensors require an interface modification before they can be used with Callisto.
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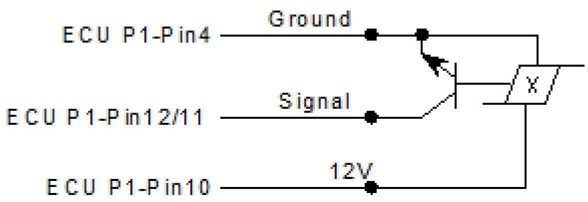
Callisto with a 12 V Hall Sensor

A compatible 12 V Hall Sensor can normally be connected directly.

Typical connection:

- Sensor Supply → 12 V.
- Sensor Ground → ECU Ground.
- Sensor Signal → applicable Crank or Cam Input.
- Sensor Supply jumper → 12 V position.
- Sensor Pullup jumper → 12 V on.



This produces a Signal voltage range suitable for the Callisto Hall comparator input.

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Callisto with a 5 V Open Collector Hall Sensor

A 5 V Open Collector Hall Sensor can be used with Callisto, but a modification is required.

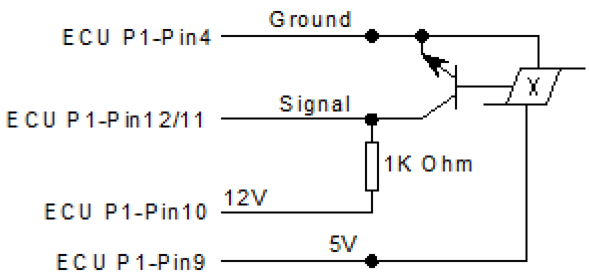
The sensor itself is powered from:

5 V

while its Open Collector Signal is pulled up to a higher voltage for the Callisto trigger input.

Typical modification:

- Sensor Supply → 5 V.
- Sensor Ground → ECU Ground.
- Sensor Signal → Crank or Cam Input.
- Sensor Supply jumper → 5 V position.
- Sensor Pullup jumper → off.
- External pull-up resistor from Signal to 12 V Ignition.



Use a **1 kΩ external pull-up to 12 V** for this arrangement.

Important

This is not a normal direct connection.

A wiring modification is required.

The modification works because an Open Collector output only pulls the Signal LOW. It does not actively drive the HIGH state.

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Callisto with a 5 V Push-Pull Hall Sensor

A 5 V Push-Pull Sensor actively produces:

0 V ↔ 5 V

This is not directly compatible with the normal Callisto Hall comparator input.

A simple pull-up modification cannot be used because the Push-Pull output is already actively driving the Signal HIGH and LOW.

Therefore:

5 V Open Collector → compatible with modification

5 V Push-Pull → requires additional signal-conditioning hardware

Do not attempt to solve a 5 V Push-Pull compatibility problem by fitting a 12 V pull-up resistor.

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Mercury3 Hall Input

Mercury3 can operate with suitable 5 V and 12 V Hall signals when configured correctly.

Some sensor arrangements can be connected directly.

Others require a pull-up modification depending on the sensor output type.

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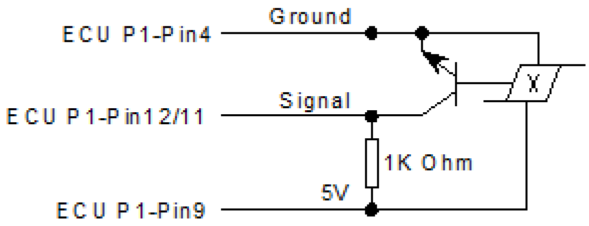
Mercury3 with a 5 V Hall Sensor

The Mercury3 harness includes a 12 V sensor supply on P1 Pin 10.

For a compatible 5 V Hall Sensor:

- Move the supply wire from Pin 10 (12 V) to Pin 9 (5 V)
- Connect Ground and Signal.
- Sensor Signal → Crank or Cam Input.
- Sensor Pullup jumper → off.
- Fit a **1 kΩ** pull-up resistor where the sensor uses an Open Collector output.



Use a **1 kΩ pull-up between 5 V and Signal** for the 5 V Open Collector arrangement. If the sensor is the Push-Pull kind then this resistor is not required.

This resistor is not present in the harness, it must be added.

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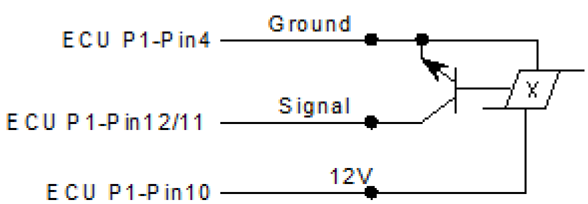
Mercury3 with a 12 V Hall Sensor

For a suitable 12 V Hall Sensor:

- Sensor Supply → 12 V.
- Sensor Ground → ECU Ground.
- Sensor Signal → Crank or Cam Input.
- Sensor Pullup jumper → 12 V on.



This is the normal connection for a compatible 12 V Hall Sensor.

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Mercury3 - Noisy 12 V Hall Signal

A practical Mercury3 problem can occur when the 12 V vehicle supply contains excessive electrical noise.

A typical symptom is:

Random RPM pulses while the engine is stationary.

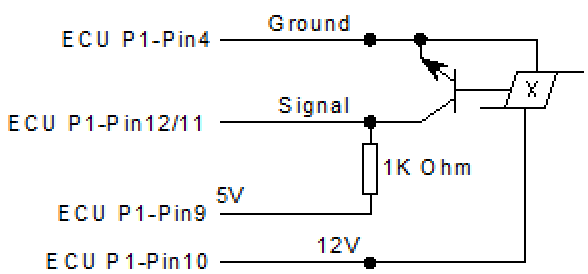
Where an Open Collector Hall Sensor is used, one solution is to modify the Signal pull-up.

The sensor can remain powered from 12 V while the Signal is pulled up to the ECU's regulated 5 V supply instead.

<u>Option1:</u> (Recommended)

Typical modification:

- Sensor Supply → 12 V.
- Sensor Ground → ECU Ground.
- Sensor Signal → Crank or Cam Input.
- Sensor Pullup jumper → off.
- Add external 1 kΩ pull-up from Signal to regulated 5 V.



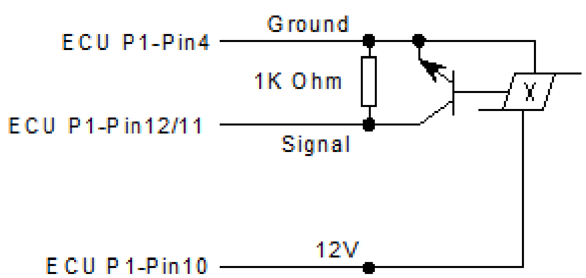
This modification is recommended where a noisy 12 V rail causes false Mercury3 triggering.

The regulated 5 V supply provides a cleaner pull-up reference.

<u>Option2:</u> (Easy method)

Typical modification:

- Sensor Supply → 12 V.
- Sensor Ground → ECU Ground.
- Sensor Signal → Crank or Cam Input.
- Sensor Pullup jumper → 12 V on.
- Add external 1 kΩ pull-up from Sensor Signal to Sensor ground.



This will attenuate the noise signal to safe levels. It is not always 100% effective.

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When a Modification Is Required

A modification may be required when:

- Sensor Supply and ECU Signal requirements are different.
- A 5 V Open Collector sensor is used on an input requiring a higher HIGH level.
- The vehicle 12 V supply is too noisy for reliable triggering.
- The required pull-up is not already provided by the sensor or ECU.
- Existing hardware configuration does not match the sensor output type.

Do not make pull-up or load-resistor changes without first identifying:

- Sensor voltage.
- Output type.
- ECU input requirement.

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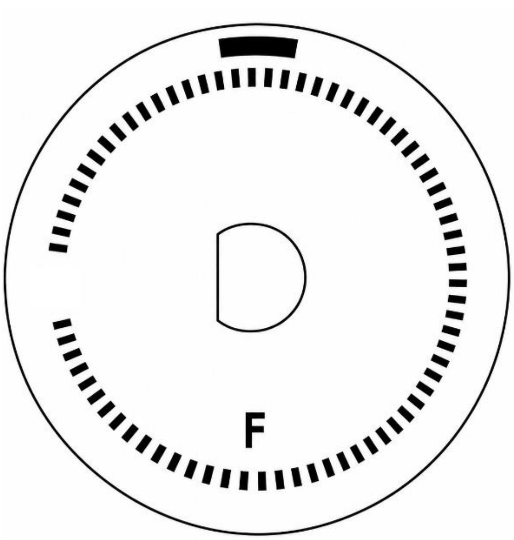
Optical Sensors

An Optical Sensor uses a light source and receiver together with a slotted or patterned trigger disc.

As the disc rotates:

- Light passes through a slot or is blocked.
- The receiver changes state.
- The output produces a digital signal.

From the ECU's point of view, this is treated similarly to a Hall Sensor.



Optical systems are commonly found in:

- Distributors.
- CAS units.
- Encoders.

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Testing an Optical Sensor

A practical test is similar to Hall Sensor testing.

1. Confirm the correct Supply voltage.
2. Confirm Ground.
3. Measure Signal relative to Ground.
4. Rotate the trigger disc.
5. Verify the Signal switches LOW and HIGH.

If there is no switching, inspect:

- Supply.
- Ground.
- Pull-up where required.
- Dirty optical slot.
- Oil contamination.
- Damaged encoder disc.
- Sensor alignment.

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Manual Vehicle Test

Once the sensor wiring is known:

1. Switch the ECU on.
2. Measure DC voltage between Signal and Ground.
3. Rotate the engine slowly by hand.
4. Move a trigger tooth, slot or window past the sensor.
5. Observe the voltage.

Expected behaviour:

A clean change between LOW and HIGH states.

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Cranking Test

After the manual switching test passes:

1. Crank the engine.
2. Observe Realtime RPM.
3. Verify RPM is stable.
4. Check for Crank or Cam errors.

A sensor may operate correctly when moved slowly but still fail during engine rotation because of:

- Excessive sensor gap.
- Trigger-wheel geometry.
- Electrical interference.
- Incorrect trigger edge.
- Incorrect input interface.
- Poor wiring.

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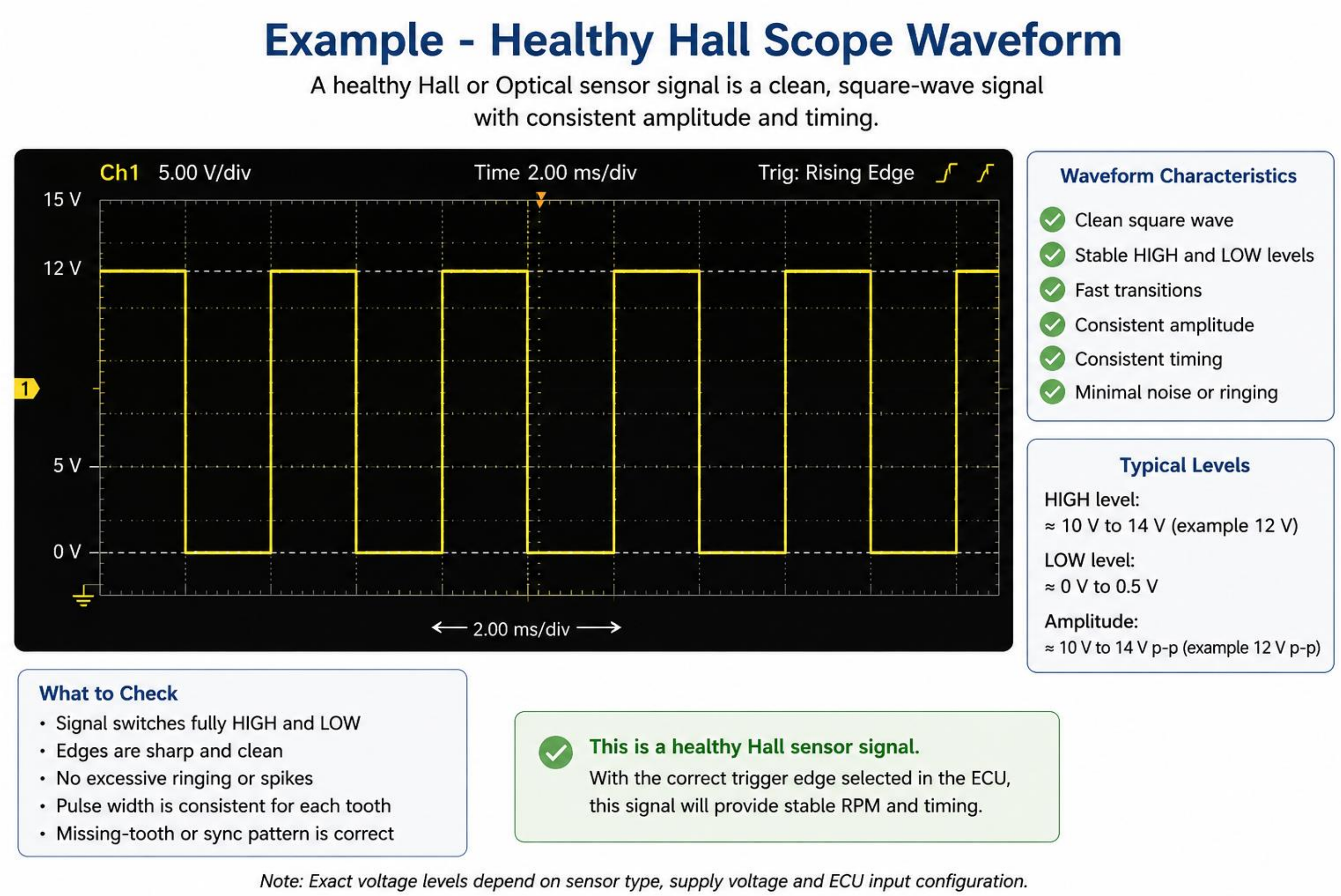
Oscilloscope Testing

An oscilloscope is the preferred tool for evaluating digital trigger quality.

A healthy Hall or Optical waveform should show:

- Clear LOW state.
- Clear HIGH state.
- Fast transitions.
- Consistent pulse width for identical trigger teeth.
- Correct missing-tooth or synchronisation pattern.
- Minimal noise or ringing.



Unlike the VR waveform, the Hall Signal amplitude should remain relatively constant as RPM changes.

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Sensor Air Gap

Hall Sensors are generally more tolerant of air-gap variation than VR sensors, but excessive gap can still result in missed trigger events.

Possible symptoms include:

- No RPM.
- Intermittent RPM.
- High-RPM errors.
- Synchronisation loss.

Use known sensor specifications where available.

Also check:

- Trigger-wheel run-out.
- Sensor mounting.

- Tooth width.
- Sensing-face alignment.

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Trigger Edge

The ECU normally uses either the Rising or Falling edge of the Hall Signal as the timing reference.

If the wrong edge is selected, possible symptoms include:

- Timing offset.
- Timing movement.
- Synchronisation errors.
- Erratic RPM.
- Incorrect relationship between Crank and Cam Signals.

Select the edge required by the firmware and verify actual ignition timing with a timing light.

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Electrical Interference

Digital Hall and Optical Signals are generally resistant to electrical interference, but a poor installation can still create false trigger events.

Keep Crank and Cam wiring away from:

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

Where screened cable is required, connect it according to the applicable ECU wiring design.

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Random RPM with Engine Stopped

If Realtime RPM appears while the engine is not rotating, a false trigger is entering the ECU.

Possible causes include:

- Noisy sensor supply.
- Floating Signal.

- Missing pull-up.
- Incorrect pull-up voltage.
- Poor Ground.
- Ignition or charging-system interference.
- Incorrect ECU input configuration.

On Mercury3, a noisy 12 V Hall pull-up is one known cause and may require the 5 V pull-up modification described earlier.

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Shared Hall Signals

When a Hall Signal is shared with another ECU or controller, the electrical circuit must be considered carefully.

Important factors include:

- Sensor output type.
- Existing pull-up resistor.
- Added ECU pull-up.
- Input impedance.
- Ground reference.
- Signal voltage.

Adding another controller can alter the trigger Signal even though the original sensor remains unchanged.

Detailed sharing and OEM Tap-In methods are covered separately in:

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

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Common Problems

Symptom	Possible Cause	Check
No RPM	Hall Sensor has no Supply	Check Supply voltage
No signal	Incorrect pinout	Identify Supply, Ground and Signal
Signal stuck LOW	Missing pull-up on Open Collector sensor	Check pull-up
Signal stuck HIGH	Sensor not switching	Check target and Ground
Erratic RPM	Incorrect trigger edge	Verify configuration
Erratic RPM	Electrical interference	Check wiring and screening
High-RPM errors	Excessive sensor gap	Check gap and trigger geometry

Symptom	Possible Cause	Check
Random RPM with engine stopped	Noise or floating Signal	Check Supply, pull-up and Ground
5 V sensor damaged	12 V applied incorrectly	Verify Sensor Supply before connection
Callisto does not detect 0-5 V Hall	5 V Push-Pull Signal incompatible with comparator reference	Use correct interface
Callisto 5 V Open Collector sensor not detected	Pull-up modification missing	Add correct higher-voltage pull-up
Mercury3 random stationary RPM	Noisy 12 V Signal pull-up	Use regulated 5 V pull-up modification where suitable
Signal disappears when pull-up removed	Open Collector output	Restore correct pull-up
Signal continues without pull-up	Push-Pull output	Do not add unnecessary pull-up

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Diagnostic Sequence

For an unknown or faulty Hall / Optical sensor:

1. Determine whether the sensor is Hall / Optical or VR.
2. Identify likely Supply, Ground and Signal pins.
3. Begin unknown powered testing at 5 V.
4. Verify sensor switching manually.
5. Determine whether the output is Open Collector or Push-Pull.
6. Determine the required Sensor Supply.
7. Determine the required ECU Signal voltage.
8. Decide whether direct connection or a modification is required.
9. Configure the applicable sensor-supply jumper.
10. Fit the required pull-up or load resistor where necessary.
11. Verify manual LOW/HIGH switching at the ECU.
12. Crank the engine and verify stable RPM.
13. Scope the Signal where required.
14. Verify the trigger edge.
15. Verify ignition timing with a timing light.

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Safety

When testing Hall and Optical Sensors:

- Never assume the Sensor Supply voltage.
- Do not apply 12 V to an unknown sensor without identifying it.
- Do not add a pull-up before understanding the output type.
- Do not pull a Push-Pull Signal above its safe voltage.

- Use current-limiting resistors when identifying unknown sensors.
- Do not assume every Hall Sensor is directly compatible with every Spitronics ECU.
- Apply required interface modifications before attempting engine operation.
- Avoid shorting Sensor Supply wiring.
- Keep test equipment away from moving engine components.
- Verify clean trigger operation before starting the engine.

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Setup Check

Before considering the Hall or Optical trigger setup complete, verify:

[ ] Sensor type is known.

[ ] Sensor Supply voltage is known.

[ ] Supply, Ground and Signal pins are identified.

[ ] Open Collector or Push-Pull output type is understood.

[ ] Correct Spitronics Sensor Supply jumper is selected.

[ ] Signal voltage is compatible with the ECU trigger input.

[ ] Required interface modification has been completed where applicable.

[ ] Pull-up voltage is correct where required.

[ ] Pull-up resistor is only fitted where appropriate.

[ ] Signal switches cleanly LOW and HIGH.

[ ] Callisto 5 V Open Collector installations use the required pull-up modification.

[ ] Callisto 5 V Push-Pull installations use suitable signal-conditioning hardware.

[ ] Mercury3 Hall input is configured correctly for the sensor used.

[ ] Sensor air gap is correct.

[ ] Realtime RPM is stable.

[ ] No false RPM appears with the engine stopped.

[ ] Trigger edge is correct.

[ ] Timing light agrees with ECU timing.

[ ] No Crank or Cam errors occur at higher RPM.

[ ] Shared OEM Signals use the correct Tap-In method.

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