Spitronics - Power and Grounding - Installation and Testing Guide

Correct power and grounding connections are essential for reliable operation of Spitronics electronic products.

Poor power or grounding can cause problems that appear unrelated to the electrical installation, including unstable sensor readings, communication problems, device resets, misfires, incorrect trigger signals and intermittent operation.

This guide covers general power and grounding principles used with Spitronics ECUs, TCUs, electronic throttle devices and other electronic devices.

Always use this guide together with the applicable product Pin Layout and power connection drawings.

Understanding Current Paths

A vehicle contains electrical systems operating at very different current levels.

The starter motor draws very high current during cranking. The alternator carries substantial current while charging the battery. Ignition coils, injectors, motors, solenoids and other switched loads can also produce large or pulsed currents.

Sensors, analogue inputs and communication between electronic devices operate at much smaller signal levels.

The installation should therefore keep high-current paths away from sensitive electronic reference paths wherever practical.

A good electrical installation is not simply about having low resistance to ground. It is also important to understand where current flows and which devices must share the same electrical reference.

Battery and Main Ground Connections

Use heavy cables of suitable size for the battery, starter and main ground connections.

On a conventional installation with the battery near the engine, a suitable arrangement is generally:

Battery Negative → Engine

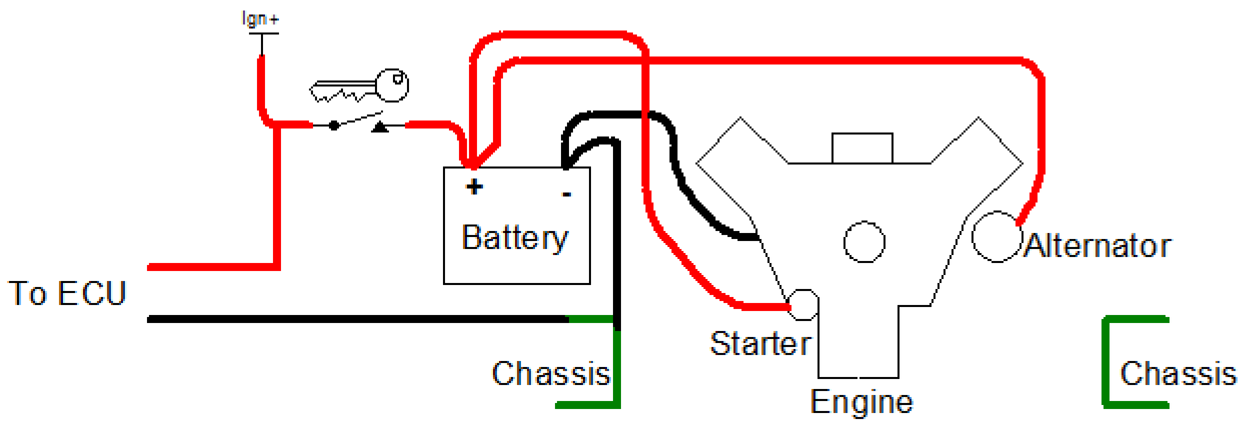
Battery Negative → Chassis

The engine connection provides the high-current return path for the starter and engine-mounted loads.

The chassis connection provides the reference and current return for vehicle electrical equipment connected to the body.

On vehicles with a remotely mounted battery, particularly racing vehicles, the grounding arrangement may be different. The chassis may form part of the main high-current return path with a heavy chassis-to-engine connection.

For this reason, one grounding arrangement cannot be prescribed for every vehicle. The important requirement is that high-current paths have sufficiently low resistance and do not create significant voltage differences between electronic devices that share signals. Below is an example of most common power and ground flows.



Starter Motor

The starter motor is normally the highest-current electrical load on the vehicle.

During cranking, even a small resistance in the battery, engine or chassis ground path can produce a significant voltage difference.

This becomes particularly important when one electronic device is referenced to the chassis while another device receiving its signal is referenced to the engine.

The main starter current must never use ECU, device, sensor or signal wiring as an alternative return path.

Alternator Connection

The alternator can carry substantial current and can also produce damaging voltage transients if the battery is disconnected while the alternator is charging.

The alternator charging connection must follow the applicable vehicle and alternator wiring requirements.

Where practical, keep alternator charging current out of sensitive device supply and ground paths.

Never Disconnect the Battery While the Engine Is Running

Never loosen or disconnect a battery terminal while the engine is running.

The battery is an important part of the vehicle charging system. If the battery becomes disconnected while the alternator is supplying charging current, a load-dump condition can occur.

The alternator field cannot reduce instantaneously when the battery is removed. This can cause the vehicle supply voltage to rise far above its normal operating voltage and damage ECUs and other electronic equipment. Automotive load-dump events are specifically recognised as potentially producing very large overvoltage transients.

Spitronics has experienced electronic equipment failures where battery connections were removed or became disconnected while the engine was running.

Always switch the engine off before loosening or disconnecting battery terminals.

Device Power Supply

Follow the applicable Spitronics connection drawing for the specific device.

High-current circuits should be supplied from the battery through correctly rated fuses and relays where required.

The ignition switch should normally be used as a control signal rather than carrying the complete operating current of the device and its connected loads.

Where excessive voltage drop exists through the ignition switch or existing vehicle wiring, use a suitable relay arrangement to provide the device with a clean supply.

Electronics Ground

Where a Spitronics product provides a dedicated electronics ground, connect it according to the applicable product connection drawing.

For products designed with separate electronics and driver grounds, these ground circuits are electrically isolated inside the device.

This allows the sensitive electronics and analogue circuits to use a clean electrical reference while high-current driver loads use a separate current path.

Where specified, the electronics ground may be connected directly to battery negative. This provides a stable reference relative to the device power supply.

Do not assume that the electronics ground and driver ground are internally connected. Refer to the applicable product documentation.

Note: Do not join separate Ground wires together and then use a single common wire to reach a remote Ground point. Instead, extend each Ground wire individually, using the same or a larger wire size, and join them only at the final Ground point.

Where Electronics Ground and high-current Ground must use the same electrical reference, use separate terminals or contact points where practical. Avoid stacking sensitive Electronics Ground and high-current Ground connections under the same terminal or bolt.

If a common Ground connection becomes loose or develops resistance, current from a high-current or inductive load may find an alternative return path through sensitive electronic wiring. This can create large voltage differences and may damage the Device or connected electronics.

Driver Ground

Some Spitronics products provide a separate high-current driver ground or ground pigtail.

This ground carries current from the output-driver section and may require a different connection point from the electronics ground.

Keeping driver current separate from the electronics ground helps prevent pulsed load current from producing voltage changes in sensitive analogue and shared signal references.

The correct connection point depends on the loads being controlled and the vehicle grounding arrangement.

Sensor Ground

Sensor Ground is a signal reference and must not be treated as a normal high-current ground.

Sensors requiring a Spitronics Sensor Ground must return to the Sensor Ground connection specified in the applicable connection drawing.

Do not independently connect Sensor Ground to:

- Engine block.
- Chassis.
- Battery negative.
- Ignition coil ground.
- High-current driver ground.

High-current voltage drop in the Sensor Ground path can directly change the sensor value measured by the device.

Smart Coil Grounding

Smart ignition coils require special consideration because the ECU supplies a low-current trigger signal while the coil itself switches considerably higher ignition current.

Many smart coils are grounded to the engine. This keeps the ignition current local to the engine and prevents it from unnecessarily flowing through other vehicle ground paths.

However, the coil trigger signal must also have a suitable reference to the ECU driver circuit.

During cranking, significant starter current can create a voltage difference between the engine, chassis and battery negative. If the ECU and smart coil use different electrical references, this voltage difference may be added to or subtracted from the trigger signal seen by the coil.

There is therefore no single grounding arrangement suitable for every smart-coil installation.

Where the ECU provides an isolated driver ground, the driver ground connection can be selected to provide a suitable reference for the connected coils while keeping driver current out of the electronics ground.

Where the coil design permits it, using a common suitable reference for the coil and ECU driver circuit may reduce the effect of voltage drop between the engine and chassis.

The correct arrangement depends on:

- Coil construction and grounding requirements.
- ECU driver design.
- Battery location.
- Starter current path.
- Engine-to-chassis ground path.
- Other devices sharing signals.

Separate Engine Ground Points

Where both the ECU driver ground and smart coil ground are connected to the engine, do not rely on one common terminal or bolt for both connections.

Use separate secure ground connections to the same general engine electrical reference where practical.

If the coil ground connection becomes loose, the installation must minimise the possibility of coil current or ignition energy finding an alternative return path through ECU wiring.

A failed or high-resistance coil ground can produce damaging voltage differences and should be treated as a serious electrical fault.

Multiple Devices and Shared Signals

Modern installations may contain several devices, including:

- Spitronics ECU.
- OEM ECU.
- TCU.
- Electronic throttle device.
- Dashboard or data logger.
- Other standalone devices.

Where devices share analogue signals, the signal voltage is meaningful only relative to the electrical reference used by both devices.

A voltage difference between device ground references therefore appears as an error in the shared signal.

This is particularly important for low-voltage analogue signals such as TPS, MAP, temperature and pressure signals.

Where a Spitronics device provides separate electronics and driver grounds, the electronics ground can maintain a clean reference with other devices while the driver ground handles the reference requirements of high-current loads.

Electrical Interference

Keep sensitive input and communication wiring away from:

- Starter cables.
- Alternator wiring.
- Ignition coils.
- High-tension leads.
- Injectors.
- Solenoids.
- Electric motors.
- High-current relay wiring.

Crank, cam, speed and other timing signals are particularly sensitive to interference.

Do not use device or Sensor Ground wiring as part of a high-current return path.

Racing Battery Isolators

Racing vehicles commonly use a master battery isolator for emergency shutdown.

A simple isolator that only disconnects the battery while the engine is running can create a dangerous electrical condition.

If the battery is disconnected while the alternator is still charging, the alternator may remain connected to the ECU and other vehicle electronics without the battery connected to the electrical system. This can create an alternator load-dump transient capable of damaging electronic equipment.

A racing isolation system should therefore perform two functions:

1. Stop the engine and electrical generation.
2. Safely isolate the battery from the vehicle.

These functions must occur in a controlled manner that does not expose the vehicle electronics to alternator load dump.

Modern electronic motorsport isolators commonly stop the engine by disabling the ECU or ignition system before completing battery isolation. Commercial systems with this sequencing and load-dump protection already exist.

Do not assume that a simple high-current battery switch provides safe isolation while the engine is running.

The exact isolator arrangement depends on the alternator, vehicle wiring and competition requirements.

Future Spitronics Electronic Isolation

A possible future Spitronics solution is an electronically controlled battery isolation system.

Such a system could use the ECU or dedicated device to initiate a controlled shutdown before operating a high-current solenoid or electronic battery isolator.

The required operating sequence, fail-safe behaviour, alternator control and competition requirements must be established before such a system is specified.

For now, this should be regarded as a development concept rather than an approved Spitronics wiring method.

Grounding Fault Symptoms

Power and grounding faults may cause:

- Unstable idle.
- Random misfires.

- Hard starting.
- Device resets.
- Communication problems.
- TPS readings that jump or drift.
- MAP or pressure readings that move unexpectedly.
- Incorrect temperature readings.
- Sensor values changing when electrical loads are switched.
- Timing instability.
- Weak or inconsistent ignition.
- Problems occurring only during cranking.

When several apparently unrelated electrical problems occur together, check power and grounding before changing software settings.

Visual Inspection

Before performing electrical measurements, check:

[ ] Battery terminals are clean and secure.

[ ] Main battery cables are correctly sized.

[ ] Battery-to-engine ground path is secure.

[ ] Battery-to-chassis ground path is secure where applicable.

[ ] Engine-to-chassis ground path is suitable where required.

[ ] Device electronics ground is correctly connected.

[ ] Driver ground is correctly connected.

[ ] Sensor Ground follows the applicable connection drawing.

[ ] Smart coil grounds are secure.

[ ] Alternator and starter connections are secure.

[ ] No high-current load is using sensitive device wiring as a return path.

Voltage Drop Testing

A connection can show very low resistance when tested with an ohmmeter but still develop a significant voltage drop when current flows.

For this reason, power and ground connections should be tested while the circuit is under load.

Cranking is particularly useful for testing the main battery, engine and chassis current paths because the starter creates a very high electrical load.

DC Voltage Drop

DC voltage measurement is useful for measuring the average voltage difference between two points while current is flowing.

Measure across the connection or current path being tested rather than simply measuring continuity.

Typical tests include:

- Battery negative to engine block.
- Battery negative to chassis.
- Engine block to chassis.
- Electronics ground to its required reference.
- Driver ground to the load ground reference.
- Battery positive to device supply.

The older Spitronics Power Connection procedure used less than approximately **0.2 V during cranking** as a practical target when checking ECU ground against battery negative.

AC Voltage Measurement

Some loads draw current in pulses rather than continuously.

Ignition coils, injectors, solenoids and other switched loads can therefore produce rapidly changing voltage differences that may not be obvious from the average DC measurement.

In these situations, measuring AC voltage across the same connection can help identify the varying component of the voltage drop.

If the cause of an electrical problem is uncertain, measure the connection using both DC and AC voltage ranges while the load is operating.

Do not use one universal AC voltage limit. Multimeters respond differently to pulsed DC signals, so the AC measurement should primarily be used as a diagnostic comparison.

For detailed investigation of fast transients, an oscilloscope is preferable.

Fault Finding Procedure

When a power or grounding problem is suspected:

1. Inspect the battery terminals and main power connections.
2. Check the main engine and chassis ground paths.
3. Inspect device electronics and driver ground connections.
4. Check Sensor Ground wiring.
5. Measure DC voltage drop during cranking.
6. Where pulsed loads are involved, repeat appropriate tests using AC measurement.
7. Measure device supply voltage drop.

8. Observe sensor readings while electrical loads are switched.
9. Check starter and alternator connections.
10. Check smart coil grounding where applicable.
11. Check the electrical reference between devices sharing signals.
12. Correct one problem at a time and retest.

Before Power-Up

Before applying power, check:

[ ] Battery connections are correct and secure.

[ ] Main engine and chassis ground paths are correct.

[ ] Alternator and starter connections are correct.

[ ] Device power supplies are correctly fused.

[ ] Electronics ground connections follow the applicable product drawing.

[ ] Driver ground connections are suitable for the connected loads.

[ ] Sensor Ground wiring is correct.

[ ] Smart coil grounding has been considered where applicable.

[ ] Devices sharing signals have a suitable common reference.

[ ] No sensitive electronic wiring forms part of a high-current return path.

[ ] All connections are clean and secure.

If power or grounding problems are suspected, perform voltage-drop testing before continuing with setup or fault finding.