Spitronics ECU - Fuel Pressure Control - Guide

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Overview

Fuel Pressure Control allows the ECU to control fuel-pump speed while monitoring actual Fuel Pressure. The ECU adjusts pump output to maintain the required pressure under changing engine load.

The system can also compensate the injector command for short-term Fuel Pressure changes that occur faster than the pump can respond.

Fuel Pressure Control is separate from the general fuel-system hardware arrangement. For pump selection, fuel lines, filters, regulators, return and returnless layouts, refer to:
Spitronics ECU - Fuel Supply Systems – Guide

This guide concentrates on the ECU Fuel Pressure Sensor, calibration, pressure-control settings, Setpoint Graph and Fuel Compensation Graph.

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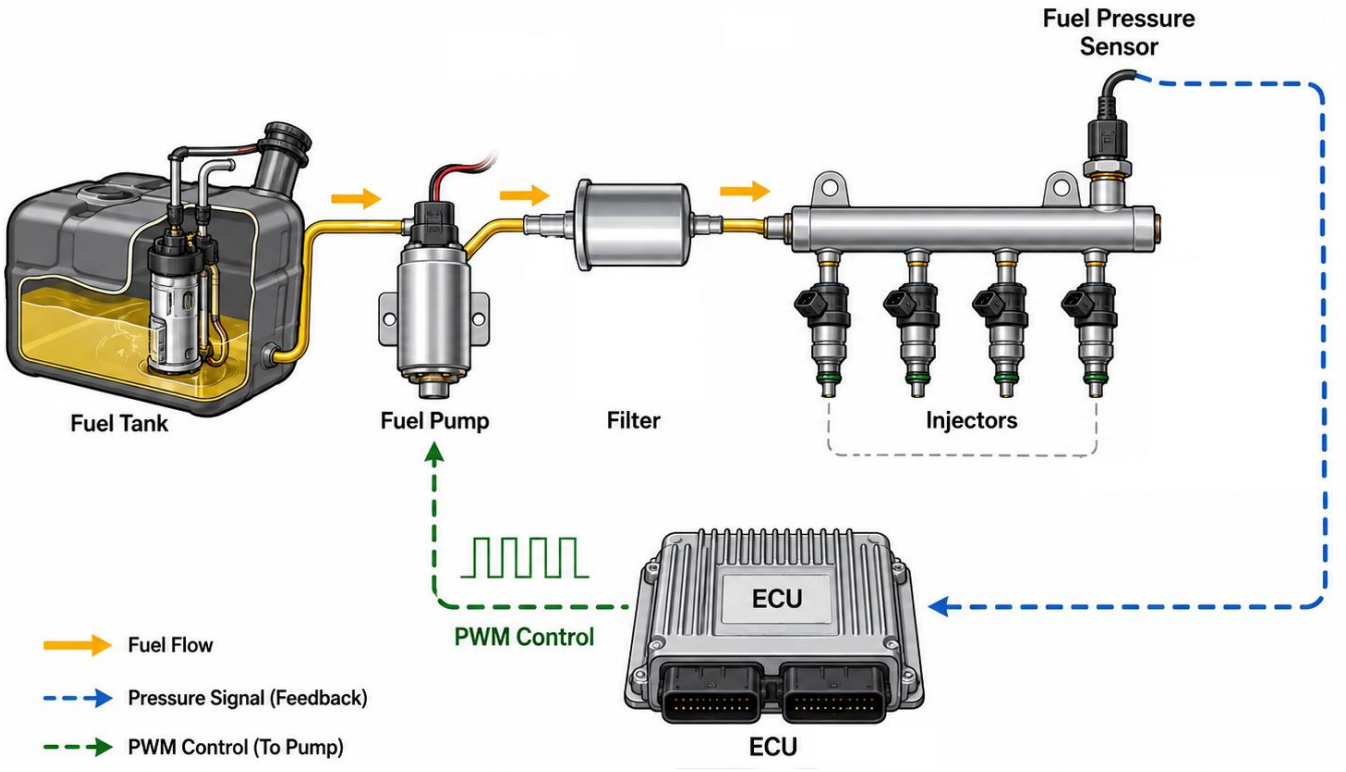

Software Versions and Terminology

Spitronics products and firmware have developed over many years. Older systems may not provide all the settings described in this guide, and some settings may use older terminology.

Current documentation uses the latest terminology while retaining older software names where this helps identify the equivalent function.
Always use the settings, Driver Output and Pin Layout shown by the firmware and software fitted to the vehicle.

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System Principle

The ECU controls the fuel pump using Pulse Width Modulation (PWM) and monitors the resulting Fuel Pressure with an electronic pressure sensor.

The control loop compares:
Required Fuel Pressure → Actual Fuel Pressure

and increases or decreases pump duty until the measured pressure follows the required pressure.

This provides electronic fuel-pressure regulation and can reduce the need for a conventional return-style pressure regulator where the complete fuel system is designed for electronic pressure control.
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Injector Differential Pressure

The injector does not respond only to Fuel Rail Pressure. The important value is the pressure difference across the injector.

Injector Differential Pressure = Fuel Rail Pressure - Manifold Pressure

To maintain predictable injector flow, the pressure difference across the injector should normally remain reasonably constant.

This means the required Fuel Rail Pressure changes as Manifold Pressure changes.

On a naturally aspirated engine, rail pressure can reduce during high manifold vacuum and increase again as Manifold Pressure approaches atmospheric pressure.

On a turbocharged engine, rail pressure must rise with boost to maintain the required Injector Differential Pressure.

Example:

- Required Injector Differential Pressure = 3.0 Bar.
- Manifold Pressure = 0 Bar gauge → Fuel Rail target ≈ 3.0 Bar gauge.
- Manifold Pressure = +1.0 Bar boost → Fuel Rail target ≈ 4.0 Bar gauge.
- Manifold Pressure = +2.0 Bar boost → Fuel Rail target ≈ 5.0 Bar gauge.

The exact displayed values depend on the pressure convention used by the software and sensor calibration.

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Increasing Injector Flow with Pressure

Increasing Injector Differential Pressure increases injector flow.

Where injectors are slightly undersized, Fuel Pressure Control can therefore be used to increase Injector Differential Pressure progressively with engine load and obtain some additional usable injector capacity.

This is a practical tuning option where only a modest increase is required, but it is not the preferred substitute for correct injector sizing.

Higher Fuel Pressure increases:
· Fuel-pump load.
· Electrical load.
· Injector mechanical load.
· Fuel-system pressure and hose stress.

Always verify Injector Duty, AFR / Lambda and actual Fuel Pressure under full load. The pump, injectors, hoses, rail and fittings must all be suitable for the increased pressure.
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Recommended Fuel Pressure Sensor

For new installations, use a dedicated automotive Fuel Pressure Sensor rated for direct petrol / fuel exposure and for the maximum expected system pressure.

Older Spitronics installations may use the earlier 4 Bar or 7 Bar MAP-type sensors, or the 5.5 Bar differential-pressure sensor. These installations can still be supported where correctly calibrated.

Do not assume that every Fuel Pressure Sensor is a true differential-pressure sensor. Confirm the sensor construction and pressure reference before configuring the control strategy.
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Rail Pressure Sensor vs Differential Pressure Sensor

Rail Pressure Sensor

A conventional Fuel Pressure Sensor measures Fuel Rail Pressure relative to its own pressure reference.

When this type of sensor is used, the Fuel Setpoint Graph must compensate for changes in Manifold Pressure so that Injector Differential Pressure remains approximately constant.

Differential Pressure Sensor

A true Differential Pressure Sensor measures the pressure difference between the fuel rail and a second pressure reference.

Where the low-pressure side is connected to the intake manifold, the sensor can directly measure Injector Differential Pressure.

In this arrangement, the required pressure target can remain substantially constant because manifold pressure is already included in the sensor measurement.
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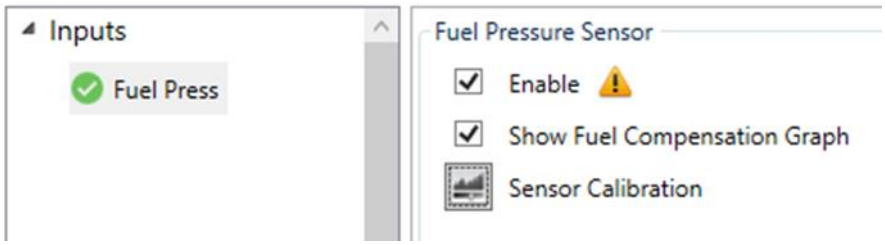
Fuel Pressure Sensor Input

Open:
Inputs → Fuel Press



This software version provides:

- Enable.
- Show Fuel Compensation Graph.
- Sensor Calibration.

Enable the Fuel Pressure Sensor before using Fuel Pressure Control or Fuel Pressure compensation.
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Realtime Fuel Pressure

Realtime Fuel Pressure shows the pressure calculated from the Fuel Pressure Sensor calibration.

Before enabling pressure control, verify that the displayed value agrees with a trusted mechanical gauge or known reference pressure.
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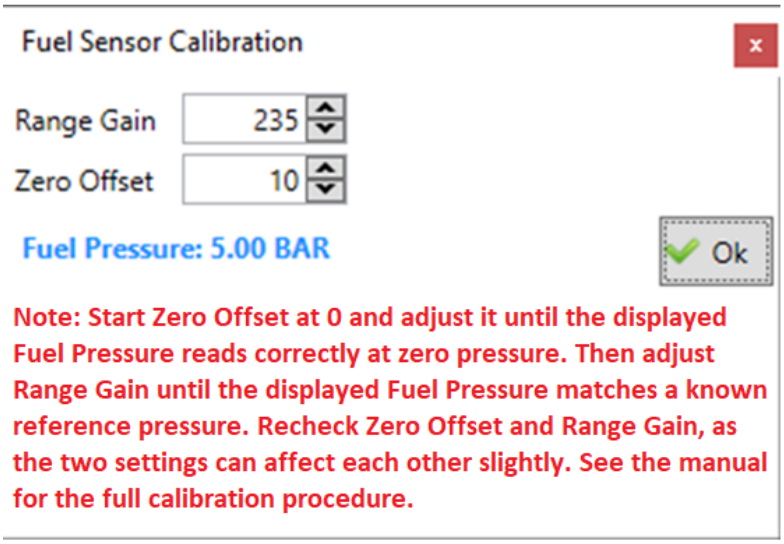
Fuel Sensor Calibration



The Fuel Sensor Calibration contains:
· Range Gain.
· Zero Offset.

These two values position and scale the sensor response so that the displayed pressure matches the actual Fuel Pressure.
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Zero Offset

Zero Offset positions the lower end of the sensor curve relative to the software pressure scale.
If the sensor already reads correctly at zero pressure, leave Zero Offset at 0.

Where the sensor has a non-zero electrical output at zero pressure, adjust Zero Offset so that the displayed Fuel Pressure agrees with the actual zero-pressure condition.

Zero Offset is not used to change the pressure-control target. It is part of sensor calibration.
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Range Gain

Range Gain adjusts the pressure span of the sensor calibration.

It is used to match the sensor voltage change to the actual pressure change.

After Zero Offset is reasonably correct, apply a known Fuel Pressure and adjust Range Gain until the displayed Fuel Pressure agrees with the trusted reference.
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Fuel Pressure Sensor Calibration Procedure

For Fuel Pressure Sensors, the preferred practical calibration sequence is:
1. Remove Fuel Pressure or establish a known zero-pressure condition suitable for the sensor.
2. Adjust Zero Offset until Realtime Fuel Pressure reads zero or the known low-pressure reference.
3. Apply a known working Fuel Pressure using a trusted mechanical gauge or calibrated reference.
4. Adjust Range Gain until the displayed Fuel Pressure agrees with the reference.
5. Return to the low-pressure condition and recheck Zero Offset.
6. Reapply the known working pressure and recheck Range Gain.
7. Repeat the Offset / Range check if necessary.

Zero Offset and Range Gain interact slightly. A second calibration pass is therefore normal and recommended.

The objective is not only to make one pressure point correct, but to obtain the best practical agreement across the useful pressure range.
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MAP Sensor Calibration Difference

Fuel Pressure Sensor calibration does not necessarily follow the same order used for MAP Sensor calibration.

With a MAP Sensor, local Barometric Pressure already provides a useful known pressure reference. A practical MAP calibration sequence is therefore usually Range Gain first, then Zero Offset, followed by another Range Gain check.

With a Fuel Pressure Sensor, a true zero-pressure condition can normally be established. It is therefore usually easier to set Zero Offset first and then Range Gain.

In both cases, a second check is recommended because the two adjustments interact slightly.
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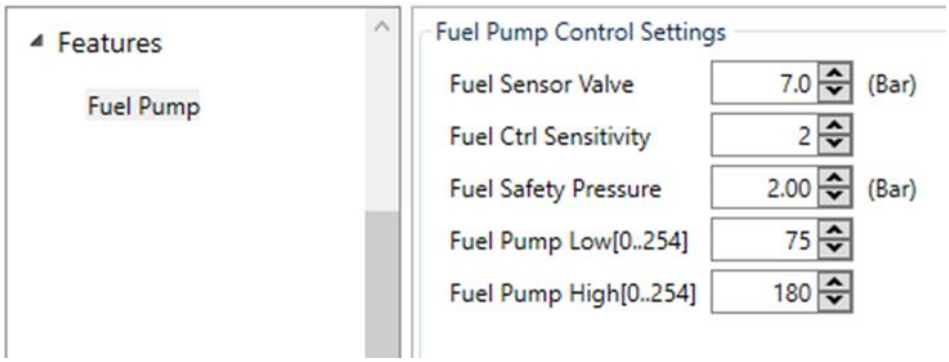
Fuel Pump Control

Open:
Features → Fuel Pump



This software version includes:
· Fuel Sensor Value / software label Fuel Sensor Valve.
· Fuel Ctrl Sensitivity.
· Fuel Safety Pressure.
· Fuel Pump Low [0..254].
· Fuel Pump High [0..254].

The exact available settings depend on Product and firmware.
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Fuel Sensor Value

Fuel Sensor Value defines the pressure range associated with the Fuel Pressure Sensor used by the control system.

Some software versions may display the label Fuel Sensor Valve.

The setting must agree with the sensor range and calibration used by the installation.

Do not use the printed sensor pressure range as a substitute for calibration. Always verify the Realtime Fuel Pressure against a trusted pressure reference.
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Fuel Control Sensitivity

Fuel Ctrl Sensitivity determines how quickly the pressure-control loop reacts to Fuel Pressure error. Lower values provide faster response.

A setting that is too fast can cause Fuel Pressure to hunt or oscillate as the ECU repeatedly over-corrects the pump duty.

Use the fastest setting that maintains stable Fuel Pressure without hunting.
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Fuel Safety Pressure

Fuel Safety Pressure is a protection setting for serious loss of Fuel Pressure.
If the measured pressure falls below the configured safety threshold during conditions where pressure should be present, the ECU can stop the fuel pump according to the firmware protection strategy.

This can reduce continued pumping after a major fuel-line or sensor-line failure, but it cannot prevent all fuel spillage because pressurised fuel may remain in the rail and lines.

Set the threshold low enough to avoid nuisance shutdown during normal operation but high enough to detect a meaningful pressure loss.
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Fuel Pump Low

Fuel Pump Low sets the minimum pump command available to the pressure controller.

The value is based on a 0-254 control scale:
127 ≈ 50%
254 ≈ 100%

If Fuel Pump Low is set too low, some pumps may slow excessively, stop, restart or operate unstably. Set the minimum value so that the pump continues to run smoothly at the lowest required Fuel Pressure.

If Fuel Pump Low is set too high, the controller may not be able to reduce Fuel Pressure sufficiently at low demand.
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Fuel Pump High

Fuel Pump High sets the maximum pump command available to the pressure controller.
This limits how hard the controller can drive the pump.

Use the lowest value that still allows the fuel system to maintain the required Fuel Pressure at full engine load and maximum fuel demand.

If Fuel Pump High is too low, Fuel Pressure may fall under load. If it is unnecessarily high, the system may create excessive pressure during a control fault or transient.
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Fuel Pump PWM Operation

Fuel Pressure Control varies pump speed using Pulse Width Modulation (PWM). During each PWM ON period, the pump receives essentially the full supply voltage. Pump speed and average power are controlled by changing the proportion of ON and OFF time.

The fuel-pump motor is inductive, so motor current does not rise and fall instantly with each PWM pulse. The winding inductance and freewheel-current path smooth the current between switching events.

The motor inductance stores energy; it does not remove copper loss. Motor heating still depends strongly on winding current, motor efficiency, hydraulic load and the amount of fuel available to cool the pump.

At very low pump speed, fuel circulation through the pump may be reduced substantially. Some pumps can therefore run hotter or less efficiently even though the average electrical power is lower.

For this reason, Fuel Pump Low should not be set lower than necessary. Use the lowest value that gives smooth pump operation, stable Fuel Pressure and acceptable pump temperature.
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Driver Output

The firmware allocates the physical Driver Output used for Fuel Pump Control.

Always verify:

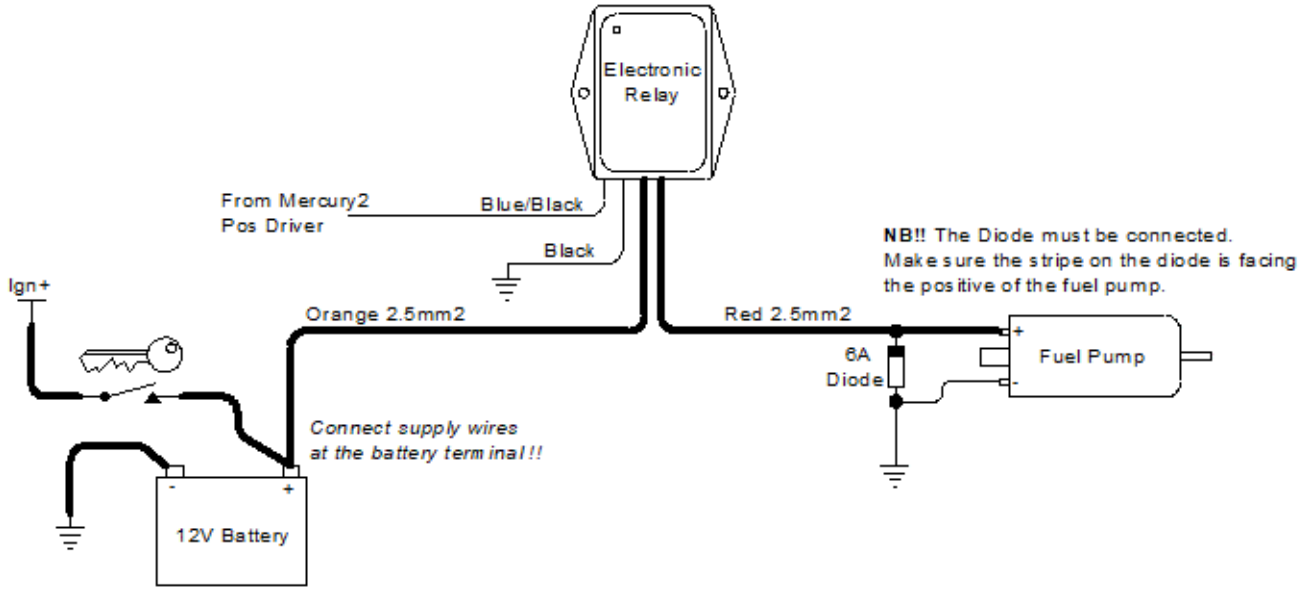
- Displayed Driver Output.
- Driver polarity.
- Driver current capability.
- Required electronic relay or power driver.
- Applicable Product Pin Layout.

Do not assume that Fuel Pump Control always uses the same physical ECU pin on every Product or firmware.

Fuel Pump Control requires a suitable positive ECU Driver Output. The ECU normally controls an external electronic relay or power driver, which then supplies the high-current PWM power to the fuel pump. Most fuel pumps draw more current than an ECU output should supply directly, so do not connect the pump directly to the ECU unless the applicable Product documentation specifically confirms that the driver is suitable.

Fit a suitable high-current freewheel diode across the fuel-pump power terminals where required. The diode cathode / stripe must face the positive side. This provides a path for inductive current when PWM switches OFF, reducing voltage spikes and electrical interference. A diode connected with the wrong polarity can act as a short circuit and cause damage.

Fit a suitable fuse in the fuel-pump power circuit as close to the power source as practical. Size the wiring, fuse and electronic power driver for the actual pump current.



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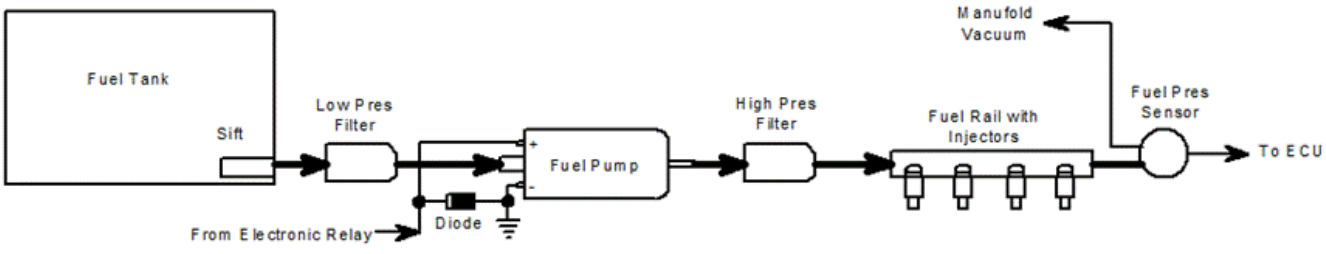
Pump Cooling and Return Flow

Fuel Pressure Control can operate with a returnless or single-feed fuel system. However, some installations benefit from a controlled return flow through a suitable restriction back to the tank.

Continuous circulation can help remove heat from the pump and return heated fuel to the tank. In a returnless system, verify that the fuel pump and fuel temperature remain stable during long periods of idle or low fuel demand, when very little fuel may flow through the pump.

Mount external fuel pumps in a safe, cool position away from exhaust and engine heat. For detailed pump mounting, return-line layout and fuel-system hardware, refer to Spitronics ECU - Fuel Supply Systems - Guide.
Excessive fuel temperature can promote vapour formation, particularly where pump inlet pressure is low. Vapour or air bubbles can make Fuel Pressure erratic, reduce the amount of liquid fuel delivered and disturb AFR / Lambda.

Do not rely on one fixed petrol boiling temperature because fuel composition and system pressure change the boiling behaviour. Prevent excessive pump heating, inlet restriction and air leaks.



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Pump Inlet Conditions and Cavitation

Fuel Pressure Control cannot correct a restricted fuel supply on the inlet side of the pump.

A supply line that is too small, a blocked pre-filter or an air leak can cause very low pressure at the pump inlet. As fuel temperature rises, this can promote vapour formation and cavitation.

Possible results include erratic Fuel Pressure, reduced fuel delivery, noisy pump operation, unstable AFR / Lambda and pump damage.

Use a correctly sized supply line and a suitable low-restriction pre-filter. If Fuel Pressure becomes unstable as the fuel warms, investigate pump temperature, inlet restriction, filter condition and air leaks before changing control settings.
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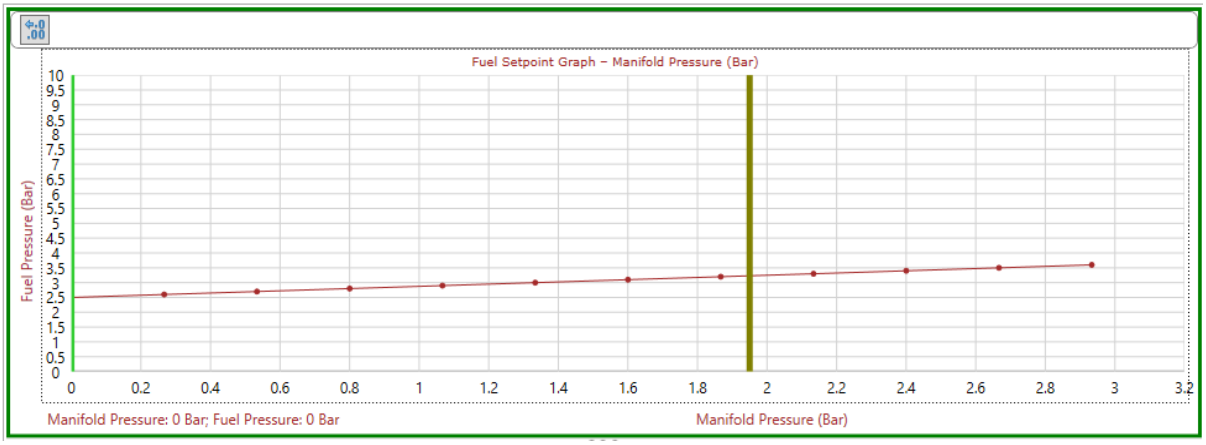
Fuel Setpoint Graph

The Fuel Setpoint Graph defines the required pressure over the engine operating range.

With a rail-pressure sensor, the graph should normally compensate for Manifold Pressure so that Injector Differential Pressure remains approximately constant.

With a true differential-pressure sensor referenced to the intake manifold, the Setpoint Graph can normally remain much flatter because the sensor already measures the pressure difference across the injector.



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Naturally Aspirated Fuel Pressure Strategy

A naturally aspirated engine still experiences changing Manifold Pressure.

At idle and light load, manifold vacuum increases Injector Differential Pressure if Fuel Rail Pressure remains fixed.

The Setpoint Graph can therefore reduce Fuel Rail Pressure during high vacuum and increase it again as Manifold Pressure approaches atmospheric pressure.

The objective is a consistent Injector Differential Pressure rather than a constant rail-pressure number.
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Turbocharged Fuel Pressure Strategy

On a turbocharged engine, Fuel Rail Pressure must rise with boost if Injector Differential Pressure is to remain constant.

For example, if the injector requires approximately 3 Bar differential pressure:

- 0 Bar gauge Manifold Pressure → approximately 3 Bar gauge Fuel Rail Pressure.
- 1 Bar boost → approximately 4 Bar gauge Fuel Rail Pressure.
- 2 Bar boost → approximately 5 Bar gauge Fuel Rail Pressure.

Always verify the actual pressure convention used by the software and sensor before entering final values.

The pump must also be capable of delivering the required fuel flow at the higher pressure.
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Fuel Compensation Graph

The Fuel Compensation Graph provides a second layer of fuel correction based on measured Fuel Pressure.

The fuel pump and pressure-control system have mechanical response delay. During a sudden throttle or fuel-demand change, actual Fuel Pressure may briefly rise or fall before pump speed catches up.

The Fuel Compensation Graph can temporarily alter Injector Time according to the measured Fuel Pressure so that AFR / Lambda remains more stable during these pressure transients.

This is not a substitute for correct pressure control. The pressure-control loop should first be made as stable as practical.

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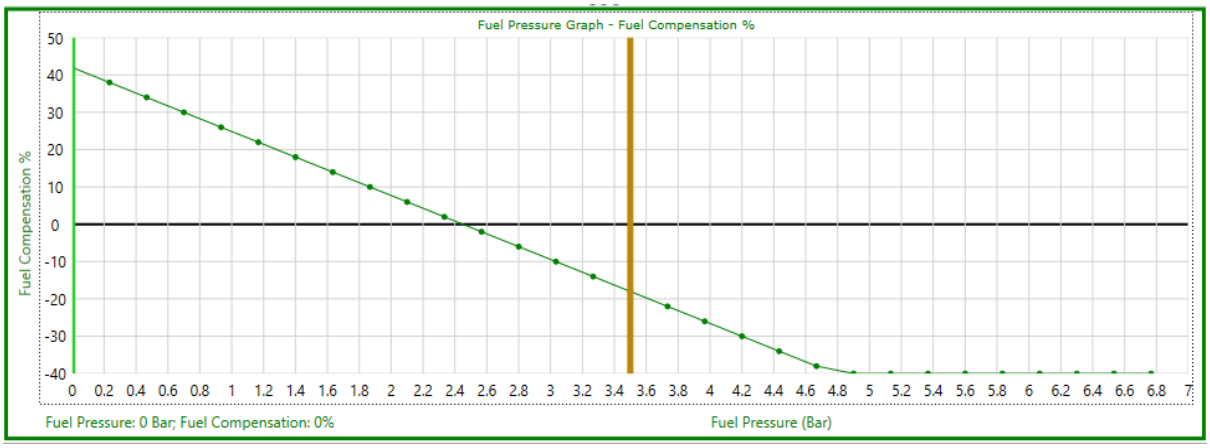
Tuning the Fuel Compensation Graph

A practical method is:
1. Begin with a flat Fuel Compensation Graph.
2. Warm the engine and establish a stable light-load operating point.
3. Tune the base Fuel Tune so AFR / Lambda is correct.
4. Change Fuel Pressure by a controlled amount while keeping engine load as stable as practical.
5. Adjust the Fuel Compensation Graph so AFR / Lambda returns to the original value.

6. Repeat at more than one pressure point where practical.
7. Restore the normal Fuel Pressure Setpoint.
8. Test throttle transitions and load changes.

Use small pressure changes during calibration and never exceed the safe pressure capability of the fuel system.



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Pump Stability and Hunting

A pressure-control loop that reacts too aggressively can cause Fuel Pressure to oscillate.

Typical symptoms include:

- Fuel Pressure repeatedly rising and falling around the target.
- Pump sound changing rapidly.
- AFR / Lambda moving with pressure oscillation.
- Unstable Fuel Pump command.

If pressure hunts:
1. Verify the sensor signal is stable.
2. Check fuel-system plumbing and pump supply.
3. Confirm Fuel Pump Low is not too low.
4. Reduce control aggressiveness by increasing Fuel Ctrl Sensitivity value.
5. Retest under several fuel-demand conditions.

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Fuel Pressure Sensor Installation

Mount the Fuel Pressure Sensor and plumbing according to the sensor manufacturer's requirements.

For new installations, do not deliberately create an air pocket or remote sensing hose unless the specific sensor and installation require that arrangement.

Older Spitronics systems sometimes used MAP-type sensors with a small sensing hose and an air pocket to isolate the sensor from direct fuel contact. This was an application-specific legacy arrangement and is not the recommended method for a modern dedicated fuel-compatible pressure sensor.

Use fuel-rated hose, fittings and seals suitable for the maximum expected pressure.
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Initial Setup Procedure

1. Complete the basic Fuel Supply installation.
2. Fit a dedicated fuel-compatible Fuel Pressure Sensor.
3. Enable the Fuel Pressure Sensor input.
4. Calibrate Zero Offset and Range Gain.
5. Verify Realtime Fuel Pressure against a trusted gauge.
6. Enable Fuel Pressure Control only after the sensor reading is correct.
7. Set the correct Fuel Sensor Value.
8. Set a conservative Fuel Ctrl Sensitivity.
9. Set Fuel Safety Pressure.
10. Set Fuel Pump Low so the pump runs smoothly at minimum demand.
11. Set Fuel Pump High so full-load pressure can be maintained.
12. Configure the Fuel Setpoint Graph.
13. Verify Injector Differential Pressure through the operating range.
14. Tune the Fuel Compensation Graph only after basic pressure control is stable.
15. Test progressively from idle to full load.

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Common Problems

Symptom	Possible Cause	Adjustment / Check
Fuel Pressure reads incorrectly at zero	Zero Offset incorrect	Recalibrate Zero Offset
Fuel Pressure correct at zero but wrong at working pressure	Range Gain incorrect	Recalibrate Range Gain
Calibration changes after adjustment	Offset and Range interaction	Repeat both calibration points
Fuel Pressure hunts	Control response too fast	Increase Sensitivity value
Pump stops or surges at low pressure	Fuel Pump Low too low	Increase Fuel Pump Low
Pressure falls at full load	Fuel Pump High too low or pump capacity insufficient	Increase High cautiously / check pump
Pressure too high at low load	Fuel Pump Low too high or Setpoint incorrect	Reduce Low / check graph
Turbo AFR changes with boost	Injector Differential Pressure not constant	Correct Setpoint Graph
Fuel Pressure drops during throttle transient	Pump response delay	Stabilise control, then tune compensation graph
Fuel Safety shutdown occurs	Pressure below safety threshold	Check leaks, pump supply and threshold
Pressure sensor reading unstable	Sensor, Ground or plumbing problem	Check wiring and installation
Fuel Pressure becomes erratic as fuel warms	Pump heating, inlet restriction or vapour formation	Check pump temperature, inlet line, pre-filter and air leaks
Fuel pump is noisy or sounds uneven	Air, dirt, water, cavitation or pump damage	Inspect pre-filter, inlet plumbing and pump condition
Pressure falls before the fuel rail	Supply line or filter restriction	Check line size, filter restriction and pressure drop
Pressure pulsates strongly with Batch Injection	Injectors opening together create rail pressure pulsation	Check rail volume, damping and pressure-control stability
Pump temperature rises at low PWM duty	Reduced fuel cooling or inefficient low-speed operation	Increase Fuel Pump Low and verify pump / fuel temperature

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Safety

Fuel systems contain flammable liquid under pressure.

- Do not loosen fuel fittings while the system is pressurised.
- Use only fuel-rated sensors, hose, fittings and seals.
- Keep fuel system components away from excessive exhaust heat.
- Do not exceed the pressure rating of the pump, injectors, rail, hoses or fittings.
- Do not increase Injector Differential Pressure without verifying pump capacity and injector suitability.
- Stop immediately if fuel leakage is detected.
- Do not rely on Fuel Safety Pressure as the only protection against a fuel leak.
- Test new pressure-control settings progressively and under controlled conditions.

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Setup Check

[ ] Dedicated fuel-compatible Fuel Pressure Sensor fitted.
[ ] Sensor range is suitable.
[ ] Zero Offset calibrated.
[ ] Range Gain calibrated.
[ ] Calibration rechecked at low and working pressure.
[ ] Realtime Fuel Pressure agrees with trusted gauge.
[ ] Fuel Sensor Value is correct.
[ ] Fuel Ctrl Sensitivity gives stable pressure.
[ ] Fuel Safety Pressure is suitable.
[ ] Fuel Pump Low keeps the pump running smoothly.
[ ] Fuel Pump High maintains full-load pressure.
[ ] Driver Output and Pin Layout are correct.
[ ] Fuel Setpoint Graph maintains the required Injector Differential Pressure.
[ ] Turbo boost compensation is correct where applicable.
[ ] Fuel Compensation Graph is tuned only after pressure control is stable.
[ ] Injector Duty and AFR / Lambda remain safe at full load.
[ ] Fuel system has been checked for leaks.
[ ] Electronic fuel-pump power driver is suitable for the pump current.
[ ] Freewheel diode is fitted with the stripe / cathode toward Positive where required.
[ ] Fuel-pump power circuit is correctly fused.
[ ] Fuel Pump Low does not cause unstable or excessively hot pump operation.
[ ] Pump inlet line and pre-filter do not create excessive restriction.
[ ] Pump and fuel temperature remain acceptable during prolonged idle / low demand.

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