

INSTALLATION · WIRING · TUNERSTUDIO

USER MANUAL

Everything you need to install, wire and tune your SpeedTech ECU: from the first wire to the first start, and from there to the advanced functions.

ST Mini

ST-02

ST-04

ST-100



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01 BEFORE YOU START

A programmable ECU controls how much fuel goes in and when the spark fires. Installed well, the engine runs better than stock; installed badly, it can be damaged. Read this whole chapter before you touch a wire.

IN THIS CHAPTER

1 Safety

2 What's in the box

3 Tools

4 How to read this manual

5 Glossary

6 Terms of use

1.1 SAFETY

DANGER Disconnect the battery negative before installing or moving any wire. Never plug or unplug the ECU connector with the key ON.

- **Don't start the engine without checking the base setup** (chapter 8): a mistake in the trigger or the ignition mode can burn coils or give dangerous timing.
- **Keep a fire extinguisher at hand** when you check injectors and fuel pressure.
- **Tune in a safe place:** on a dyno, on a track or with the car standing still. Don't tune while you drive: have someone else drive.
- **Don't weld on the car with the ECU connected** and don't jump-start it without disconnecting the ECU.
- **Fuse everything:** every circuit in this manual has its own fuse. Don't remove fuses or replace them with a higher rating.
- **Protections don't replace common sense:** the rev limiter, boost cut and the other protections (chapter 14) help, but they won't prevent damage if the tune is wrong.

1.2 WHAT'S IN THE BOX

MODEL	INCLUDES
ST Mini	ECU, harness with 20-pin Molex connector (1 m, 2 m optional), 1 m USB-C cable and 1.5 m hose for the MAP sensor
ST-02	ECU, 2 m harness with connector, 1 m USB-C cable and 1.5 m hose for the MAP sensor
ST-04	ECU, 2 m harness with connector, 1 m USB-C cable and 1.5 m hose for the MAP sensor
ST-100	ECU with 5" touch screen, 2 m harness with connector, 1 m USB type B cable and 1.5 m hose for the MAP sensor

1.3 TOOLS

- Multimeter (voltage, resistance and continuity)
- Timing light (strobe) to check ignition timing
- Crimper, terminals and heat shrink; soldering iron if you will solder splices
- Windows laptop with a USB port
- Wideband sensor with its controller (highly recommended for tuning)
- Fuel pressure gauge
- For turbo engines: a boost gauge separate from TunerStudio, to compare readings

1.4 HOW TO READ THIS MANUAL

The diagrams use the **real wire colors of the SpeedTech harness**. ST Mini diagrams show its pin numbers; ST-02, ST-04 and ST-100 diagrams name the signal as it appears on their pinout (for example *COIL 1* or *INJECTOR 1*). Below each diagram, the **On each ECU** table gives the pin of that signal on all four models. TunerStudio menu and field names are in English, as in the program, and are shown like this: `Settings > Engine Constants`. When a function only exists on some models, it is marked like this: `ST-02 · ST-04 · ST-100`.

Chapters 1 to 10 cover the installation and the first start, in the order you do them. Chapters 11 to 16 cover tuning and every function of the ECU; chapter 17 is for troubleshooting, and chapter 18 has complete installation examples on popular engines.

BOX	WHAT IT IS FOR
NOTE	Useful information to understand a step or do it better.
TIP	What we do at SpeedTech to save time.
CAUTION	A mistake here makes the engine run badly.
DANGER	A mistake here can damage the ECU or the engine, or hurt someone.

1.5 GLOSSARY

Most EFI terms are used in English everywhere. These are the ones you will see in TunerStudio and on the forums.

TERM	MEANING
AFR / Lambda	Air-fuel ratio. 14.7:1 (lambda 1.0) is the stoichiometric mixture for gasoline; lower is rich, higher is lean.
Burn	Write the changes made in TunerStudio to the ECU's permanent memory.
CKP / CMP	Crankshaft and camshaft position sensors.
CLT / IAT	Engine coolant temperature and intake air temperature.
COP	Coil on plug: one coil mounted directly on each spark plug.
Cranking	The engine turning on the starter motor, before it fires.
DFCO	Deceleration fuel cut-off: with the foot off the throttle and high RPM, the ECU stops injecting.
Duty cycle	Percentage of time an output is active. Used on injectors, idle valves, boost and VVT.
Dwell	Time the coil charges before each spark.

TERM	MEANING
Flat shift	Cutting the ignition for an instant to change gear without lifting off the throttle.
Igniter	Transistor that switches the coil current. "Smart" coils have one built in.
Launch control	RPM limiter for launching with the car stopped and the clutch pressed (2-step).
Closed / open loop	Closed loop: the ECU measures the result (AFR, RPM, boost) and corrects by itself. Open loop: it applies the table value without measuring.
MAP	Absolute pressure in the intake manifold: it is the engine load. 100 kPa $\approx$ atmospheric pressure at sea level.
PID	Closed-loop correction with three gains: P (reacts to the error), I (removes the error that remains over time) and D (slows the correction down so it doesn't overshoot).
TDC	Top dead center of the piston.
PWM	Output switched on and off very fast; the duty cycle sets how far a valve opens.
Req Fuel	Base injection time that TunerStudio calculates from displacement and injector size.
Trigger wheel	Toothed wheel read by the crank sensor. It is named by teeth and missing teeth: 36-1, 60-2...
Soft cut / Hard cut	Soft cut (the ECU retards timing to hold the RPM) and hard cut (it stops spark or fuel).
Speed Density / Alpha-N	Load calculated from MAP (the usual way) or from throttle position.
Sync	The ECU knows where the engine is in its rotation. Without sync there is no injection and no spark.
TPS / TPSdot	Throttle position sensor / how fast the throttle moves (%/s).
VE	Volumetric efficiency: how much air fills the cylinder. The VE table is the fuel map.
Wasted spark	One output fires two cylinders at once; one is on compression and the other on exhaust.
Warmup / ASE	Enrichment with a cold engine (warmup) and in the first seconds after starting (afterstart).

1.6 TERMS OF USE AND LIABILITY

- **Laws and vehicle inspection:** changing the engine management can change emissions and fuel consumption. Each owner is responsible for making sure the vehicle complies with the traffic, emissions and inspection laws that apply to it.
- **Installation and tuning:** the result depends on whoever installs and tunes. SpeedTech is not liable for damage to the engine, the transmission, the vehicle or third parties caused by incorrect installation, configuration or tuning, or by use outside what this manual describes.
- **Motorsport:** track or competition use is the responsibility of the driver and the team, with the safety measures each event requires.
- **Warranty:** covers manufacturing defects of the ECU for 1 year. It does not cover damage from reversed polarity, short circuits, water, impacts, loads connected beyond what section 3.3 allows, or ECUs that have been opened or modified (except for changing the sensor jumpers on the ST-02 and ST-04, section 4.1).
- **Base maps:** SpeedTech maps are a starting point to get the engine running, not a finished tune. Every engine is tuned with its own logs.
- **Manual version:** this manual may change. The current version can be downloaded from speedtechcr.com/manuales.

02 CHAPTER 2 **KNOW YOUR ECU**

All four ECUs run the same software and are set up the same way in TunerStudio. What changes is how many outputs they have and which extra functions they include. Check what yours has before you plan the installation.

IN THIS CHAPTER

1 The four models

2 Which functions each one can use

3 How to read the connectors

4 ST Mini

5 ST-02

6 ST-04

7 ST-100

8 What they don't drive

2.1 THE FOUR MODELS

	ST MINI	ST-02	ST-04	ST-100
Cylinders	1 to 6	1 to 4	1 to 8 (1 to 4 full sequential)	1 to 8 (1 to 4 full sequential)
Injection / ignition	3 + 3 outputs	2 + 2 outputs	4 + 4 outputs	4 + 4 outputs
Cam sensor (CMP)	No	Yes	Yes	Yes
Sequential	No: paired and wasted spark	No (2 outputs)	Yes, up to 4 cylinders	Yes, up to 4 cylinders
O2 / wideband sensor	No	Yes	Yes	Yes
Idle (3-wire IACV)	No	2 outputs	2 outputs	2 outputs
VVT · Boost	No	1 · Yes	2 · Yes	2 · Yes
Other	Fuel pump, fan, tachometer, clutch	Fuel pump, fan, tachometer, clutch	Fuel pump, fan, tachometer, clutch, flex, vehicle speed, external MAP, oil and fuel pressure, programmable output	Fuel pump, fan, tachometer, clutch, flex, vehicle speed, oil and fuel pressure, programmable output
Screen	—	—	—	5" touch screen
Built-in MAP sensor	4 bar	4 bar	4 bar	7 bar
Connector	Molex Micro-Fit 3.0 · 20 pins	Aptiv/FCI Sicma · 24 pins	Molex CMC · 48 pins	TE AMP Super Seal · 34 pins
PC connection	USB-C	USB-C	USB-C	USB type B

NOTE All four accept a VR or Hall crank sensor and analog TPS, coolant temperature (CLT) and air temperature (IAT) sensors. The warranty is 1 year against manufacturing defects.

2.2 WHICH FUNCTIONS EACH ONE CAN USE

TunerStudio shows every window of the software, whether or not your ECU has the input or output it needs. This table shows which functions can be used on each model and which chapter explains them.

FUNCTION	ST MINI	ST-02	ST-04	ST-100	CH.
Rev limiter, temperature cut and boost cut	Yes	Yes	Yes	Yes	14
Launch control and flat shift	Yes	Yes	Yes	Yes	15
Fuel pump, fan and tachometer	Yes	Yes	Yes	Yes	15
Idle control with timing (Idle Advance)	Yes	Yes	Yes	Yes	13
Sequential injection and ignition	—	—	Up to 4 cyl.	Up to 4 cyl.	5 and 6
Closed loop with O2 sensor and AFR protection	—	Yes	Yes	Yes	11 and 14
Idle valve	—	Yes	Yes	Yes	13
Boost control	—	Yes	Yes	Yes	16
VVT	—	1 output	2 outputs	2 outputs	16
Flex fuel (ethanol)	—	—	Yes	Yes	16
Vehicle speed and gear detection	—	—	Yes	Yes	15
Oil and fuel pressure	—	—	Yes	Yes	14 and 15
Programmable output	—	—	Yes	Yes	15
Staged injection	1 to 2 cyl.	1 to 2 cyl.	Up to 4 cyl.	Up to 4 cyl.	16

2.3 HOW TO READ THE CONNECTORS

Each ECU has its connector sheet: a drawing of the harness connector **seen from the back**, the side where the wires go in, which is how you hold it when inserting the terminals. Each cavity shows the **color of the wire** that goes in it and its **pin code**; on the right (or below) is the list grouped by function.

- **Pin codes:** the ST Mini and the ST-100 number their pins. The ST-02 and the ST-04 use a letter and a number, as molded on the connector: on the ST-02 the letter is the row (A, B, C) and the number the position (1 to 8); on the ST-04 the letter marks each group of 4 cavities (A to M, no I) and the number goes from 1 to 4.
- **Color code:** the same on every SpeedTech harness (section 3.5) and in the ST Premium Wiring Builder.
- **Shielded cable:** the crank and cam sensors use a two-wire shielded cable: **red** for the + input and **black** for the - input. On the sheet they have a dotted outline.
- **Empty cavities:** not used; on the ST-04 they are plugged.

2.4 ST MINI

SpeedTech's most compact ECU: 75 × 72 mm, everything on one 20-pin connector, with the pinout printed on the cover. It covers the essentials: injection, ignition, fuel pump, fan and tachometer. Since it has no cam sensor, it runs paired injection and wasted spark ignition.

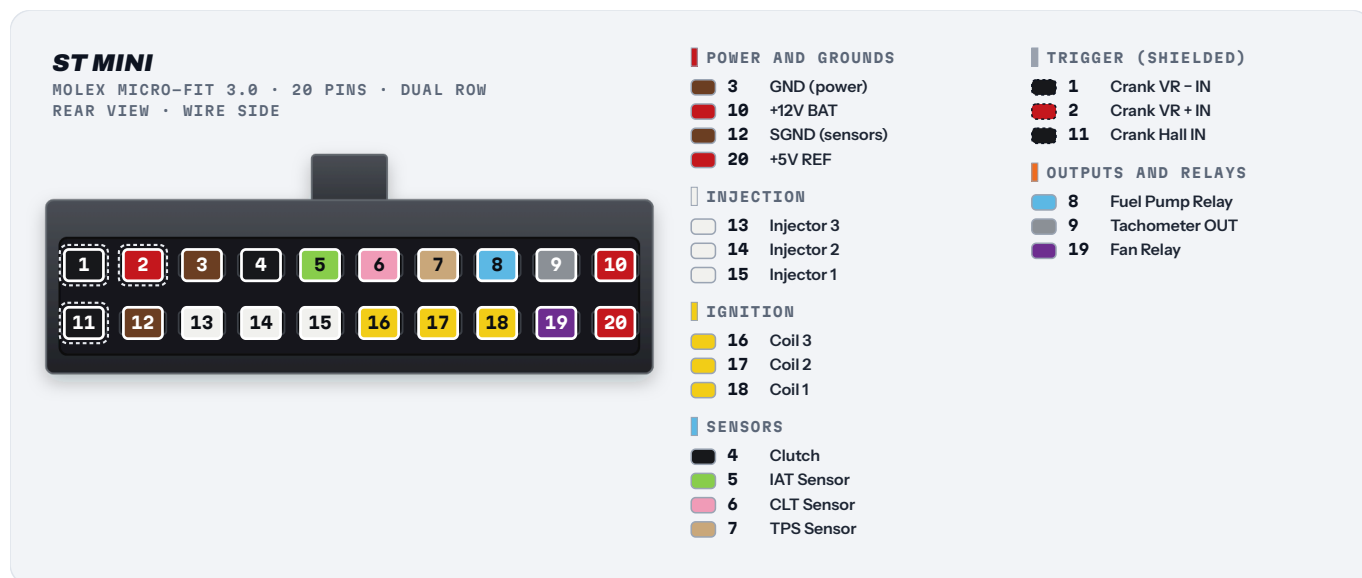


Figure 2.1 ST Mini connector (20-pin Molex Micro-Fit 3.0) seen from the back. The pinout is also printed on the ECU cover.

PIN	SIGNAL	FUNCTION	COLOR	GAUGE
1	VR-IN	VR crank sensor (-)	Black	22 AWG
2	VR+ IN	VR crank sensor (+)	Red	22 AWG
3	GND	Power ground	Brown	18 AWG
4	CLUTCH IN	Clutch switch	Black	22 AWG
5	IAT	Air temperature sensor	Light green	22 AWG
6	CLT	Coolant temperature sensor	Pink	22 AWG
7	TPS	Throttle position sensor	Tan	22 AWG
8	FUEL PUMP	Fuel pump relay	Light blue	22 AWG
9	TACH	Tachometer signal	Gray	22 AWG
10	+12V BAT	12 V supply (2 A fuse)	Red	18 AWG
11	HALL CKP	Hall crank sensor	Black	22 AWG
12	SGND	Sensor ground	Brown	18 AWG
13	INJ 3	Injector 3	White	18 AWG
14	INJ 2	Injector 2	White	18 AWG
15	INJ 1	Injector 1	White	18 AWG
16	IGN 3	Coil 3	Yellow	22 AWG
17	IGN 2	Coil 2	Yellow	22 AWG
18	IGN 1	Coil 1	Yellow	22 AWG

PIN	SIGNAL	FUNCTION	COLOR	GAUGE
19	FAN	Fan relay	Purple	22 AWG
20	VCC 5V REF	5 V reference for sensors (0.5 A resettable fuse)	Red	22 AWG

2.5 ST-02

1 to 4 cylinders with cam sensor, O2 sensor, idle control, VVT and boost.



Figure 2.2 ST-02 connector (24-way Aptiv/FCI Sicma) seen from the back: purple lock on the right, row A on top and column 1 on the lock side. Columns 1 and 8 take larger terminals.

PIN	FUNCTION	COLOR	GAUGE	NOTE
A1	+5V REF	Red	22 AWG	5 V reference for sensors.
A2	Idle Solenoid 2	Dark green	22 AWG	
A3	Fuel Pump Relay	Light blue	22 AWG	
A4	Coil 2	Yellow	22 AWG	
A5	IAT Sensor	Light green	22 AWG	
A6	CLT Sensor	Pink	22 AWG	
A7	O2 Sensor	Dark blue	22 AWG	
A8	Injector 2	White	18 AWG	
B1	GND (power)	Brown	18 AWG	Power ground to chassis or battery negative.
B2	Idle Solenoid 1	Dark green	22 AWG	
B3	Fan Relay	Purple	22 AWG	
B4	Coil 1	Yellow	22 AWG	
B5	TPS Sensor	Tan	22 AWG	
B6	Cam + IN	Red (shielded)	22 AWG	Shielded pair with Cam - (B7).
B7	Cam - IN	Black (shielded)	22 AWG	Shielded pair with Cam + (B6). Hall/optical: with the internal jumpers the signal is rerouted and enters on this negative line.
B8	Injector 1	White	18 AWG	
C1	+12V BAT	Red	18 AWG	Switched, fused 12 V supply.
C2	VVT Solenoid 1	Orange	22 AWG	

PIN	FUNCTION	COLOR	GAUGE	NOTE
C3	Boost Solenoid	Black	22 AWG	
C4	Tachometer OUT	Gray	22 AWG	
C5	Clutch	Black	22 AWG	Launch control input: switch to ground.
C6	Crank + IN	Red (shielded)	22 AWG	Shielded pair with Crank - (C7).
C7	Crank - IN	Black (shielded)	22 AWG	Shielded pair with Crank + (C6). Hall/optical: with the internal jumpers the signal is rerouted and enters on this negative line.
C8	SGND (sensors)	Brown	18 AWG	Signal ground for sensors.

2.6 ST-04

1 to 8 cylinders, with full sequential up to 4 cylinders, cam sensor, O2, external MAP, vehicle speed sensor, oil and fuel pressure sensors, two VVT outputs and a programmable output.



Figure 2.3 ST-04 connector (48-way Molex CMC) seen from the back, with the lever on the left. Columns L and M are the large cavities, for power and injectors.

PIN	FUNCTION	COLOR	GAUGE	NOTE
A1	Crank + IN	Red (shielded)	22 AWG	CKP signal positive (inductive sensor). Shielded cable recommended.
A2	Cam + IN	Red (shielded)	22 AWG	CMP signal positive (inductive sensor). Shielded cable recommended.
A3	Crank - IN	Black (shielded)	22 AWG	CKP signal negative (inductive and Hall). Shielded cable recommended. Hall/optical: with the internal jumpers the signal is rerouted and enters on this negative line.
A4	Cam - IN	Black (shielded)	22 AWG	CMP signal negative (inductive and Hall). Shielded cable recommended. Hall/optical: with the internal jumpers the signal is rerouted and enters on this negative line.
B2	Generic input	Black	22 AWG	Generic activation input. Possible use: A/C request or others.
B3	Fuel Press Sensor	Black	22 AWG	Fuel pressure sensor: use 3-wire 0–5 V / 12 V sensors.
B4	Coil 4	Yellow	22 AWG	Logic coil trigger. DO NOT use coils without igniter.
C2	VSS (vehicle speed)	Black	22 AWG	Vehicle speed sensor input. Hall-type sensors only.
C3	Oil Press Sensor	Black	22 AWG	Oil pressure sensor: use 3-wire 0–5 V / 12 V sensors.
C4	Coil 3	Yellow	22 AWG	Logic coil trigger. DO NOT use coils without igniter.
D1	Clutch	Black	22 AWG	Launch control activation input. Switch to GND recommended.
D2	TPS Sensor	Tan	22 AWG	TPS signal input.
D4	Coil 2	Yellow	22 AWG	Logic coil trigger. DO NOT use coils without igniter.
E1	Tachometer OUT	Gray	22 AWG	Tachometer output. Modern tachometers only.
E2	CLT Sensor	Pink	22 AWG	Coolant sensor signal input. 2-wire sensor recommended.
E4	Coil 1	Yellow	22 AWG	Logic coil trigger. DO NOT use coils without igniter.
F1	Fan Relay	Purple	22 AWG	Ground-switched output: fan activation.
F3	+5V REF	Red	22 AWG	5 V reference for sensors.
F4	+5V REF	Red	22 AWG	5 V reference for sensors.
G1	Fuel Pump Relay	Light blue	22 AWG	Ground-switched output: fuel pump activation.
G3	GND (optional)	Brown	18 AWG	Tied to ground on the board; normally left unwired.
G4	GND (optional)	Brown	18 AWG	Tied to ground on the board; normally left unwired.
H1	Boost Solenoid	Black	22 AWG	Electronic boost control output.
H2	IAT Sensor	Light green	22 AWG	Air temperature sensor signal input. 2-wire sensor recommended.
J1	Programmable output	Black	22 AWG	Generic programmable output. Internal mapping: TS pin no. 3.
J2	Flex Sensor	Black	22 AWG	Flex fuel control / signal.
J3	O2 Sensor	Dark blue	22 AWG	O2 sensor input. Preferably use a wideband.
K1	VVT Solenoid 2	Orange	22 AWG	Variable valve timing.
K2	Idle Solenoid 2	Dark green	22 AWG	Idle valve control no. 2. For 3-wire idle valves.
K3	GND (power)	Brown	18 AWG	Common ground: use it for the ECU ground.
K4	SGND (sensors)	Brown	18 AWG	Signal ground for sensors.
L1	VVT Solenoid 1	Orange	22 AWG	Variable valve timing.
L2	Idle Solenoid 1	Dark green	22 AWG	Idle valve control no. 1. For 2-wire idle valves.
L3	Injector 3	White	18 AWG	Use high-impedance injectors only.
L4	Injector 4	White	18 AWG	Use high-impedance injectors only.
M1	+5V REF	Red	22 AWG	5 V reference for sensors.

PIN	FUNCTION	COLOR	GAUGE	NOTE
M2	+12V BAT	Red	18 AWG	ECU 12 V supply. A relay dedicated to the ECU is recommended.
M3	Injector 1	White	18 AWG	Use high-impedance injectors only.
M4	Injector 2	White	18 AWG	Use high-impedance injectors only.

Pins not listed in the table are not used.

2.7 ST-100

ECU and display in one unit: 5" touch screen, 7 bar MAP sensor for turbo engines, sequential up to 4 cylinders and up to 8 in batch. It has the same inputs and outputs as the ST-04 and is set up the same way in TunerStudio; it connects to the computer with a USB type B cable.



Figure 2.4 ST-100 connector (34-way TE AMP Superseal) seen from the back. The shielded pairs are 10-11 (cam) and 18-19 (crank).

PIN	FUNCTION	COLOR	GAUGE	NOTE
1	GND (power)	Brown	18 AWG	Power ground to chassis/battery.
2	Oil Press Sensor	Black	22 AWG	
3	Fuel Press Sensor	Black	22 AWG	
4	O2 Sensor	Dark blue	22 AWG	
5	CLT Sensor	Pink	22 AWG	
6	Flex Sensor	Black	22 AWG	
7	Coil 3	Yellow	22 AWG	
8	Coil 4	Yellow	22 AWG	
9	+5V REF	Red	22 AWG	Reference for sensors (TPS, pressures).
10	Cam + IN	Red (shielded)	22 AWG	Shielded cable #1 with pin 11.
11	Cam - IN	Black (shielded)	22 AWG	Cam - of shielded pair #1 (with pin 10). Hall/optical: with the internal jumpers the signal is rerouted and enters on this negative line.

PIN	FUNCTION	COLOR	GAUGE	NOTE
12	SGND (sensors)	Brown	18 AWG	Sensor signal ground.
13	TPS Sensor	Tan	22 AWG	
14	IAT Sensor	Light green	22 AWG	
15	Coil 1	Yellow	22 AWG	
16	Coil 2	Yellow	22 AWG	
17	+12V BAT	Red	18 AWG	Switched ECU supply.
18	Crank + IN	Red (shielded)	22 AWG	Shielded cable #2 with pin 19.
19	Crank - IN	Black (shielded)	22 AWG	Crank - of shielded pair #2 (with pin 18). Hall/optical: with the internal jumpers the signal is rerouted and enters on this negative line.
20	VSS (vehicle speed)	Black	22 AWG	
21	Clutch	Black	22 AWG	
22	VVT Solenoid 2	Orange	22 AWG	
23	Idle Solenoid 2	Dark green	22 AWG	
24	Idle Solenoid 1	Dark green	22 AWG	
25	VVT Solenoid 1	Orange	22 AWG	
26	Programmable output	Black	22 AWG	
27	Boost Solenoid	Black	22 AWG	
28	Fuel Pump Relay	Light blue	22 AWG	Triggers the fuel pump relay (not the pump directly).
29	Fan Relay	Purple	22 AWG	Triggers the fan relay.
30	Tachometer OUT	Gray	22 AWG	
31	Injector 4	White	18 AWG	
32	Injector 3	White	18 AWG	
33	Injector 2	White	18 AWG	
34	Injector 1	White	18 AWG	

NOTE The ST-100 screen shows live engine data. It will get its own section in a future version of this manual.

2.8 WHAT SPEEDTECH ECUS DON'T DRIVE

Check this list before you buy or plan the installation, especially on modern cars: if your engine depends on any of these parts, it has to be replaced or handled separately.

PART OR FUNCTION	WHAT TO DO
Electronic throttle (drive-by-wire: the pedal has no cable and a motor moves the throttle plate)	No SpeedTech ECU drives it. Replace the throttle body with a cable one with its TPS, and fit a cable pedal.
Direct injection (injectors inside the cylinder, with a high-pressure pump)	Not compatible: the outputs are for port injectors in the intake manifold.
MAF sensor (mass air flow meter)	The ECU calculates load from MAP (Speed Density). The MAF is removed or left unplugged; if it has the air temperature sensor inside, fit a separate IAT.
Stepper motor idle valves (4 wires)	They need a driver these ECUs don't have. Use a 2- or 3-wire PWM valve (chapter 13).
Knock sensor	There is no knock input: these ECUs don't use the knock function. Tune the advance with a safety margin and check the spark plugs (chapter 12).
Automatic transmission controlled by the factory ECU	The ECU doesn't control gear changes. The transmission needs its own controller, or a swap to a manual.
Dashboard, immobilizer and modules that talked to the factory ECU (over CAN bus or their own signals)	They stop receiving data. The tachometer connects to the tachometer output (section 15.3); the factory immobilizer has to be removed or bypassed, depending on the car.
CAN bus, auxiliary inputs and secondary serial port	Not available on the connector. The TunerStudio windows <i>Canbus/Secondary Serial IO Interface</i> and <i>Local Auxillary Input Channel Configuration</i> are not used.
SD card logging	The ECUs have no SD card: logs are recorded on the computer with TunerStudio (section 7.7).

03 ELECTRICAL INSTALLATION

Most strange ECU faults come from power or ground. A clean installation, with relay, fuses and good grounds, is the foundation for everything else.

IN THIS CHAPTER

1 Power with main relay

2 Grounds

3 ECU outputs

4 Fuel pump and fan relays

5 ST color code

6 Good practice

7 Fuses and wires

8 Factory harness and sensors

3.1 POWER WITH MAIN RELAY

The ECU, coils and injectors are powered from a **main relay** switched by the key. This way all power is cut together when you switch off, and each circuit has its own fuse.

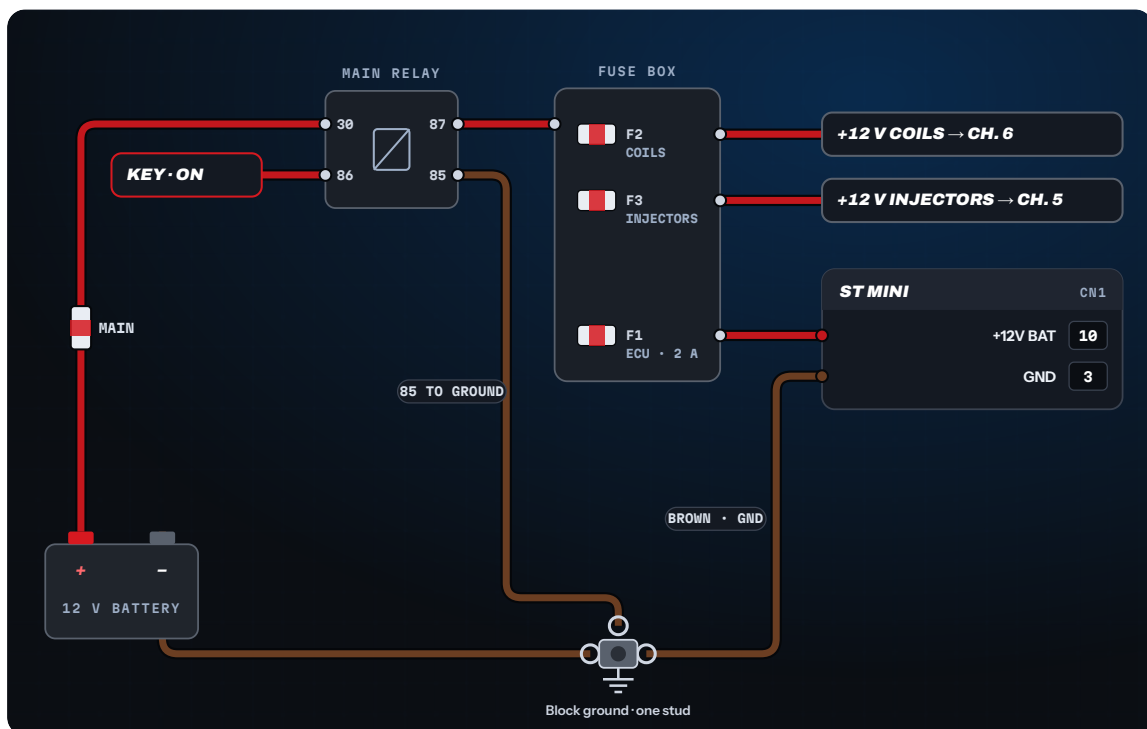


Figure 3.1 Power with main relay. The key switches the relay; the relay feeds the fuse box, which distributes +12 V to the ECU (F1, 2 A), the coils (F2) and the injectors (F3). All grounds go to the same stud on the block.

PIN / FUNCTION	WIRE	GOES TO
10 • +12V BAT	Red	F1 (2 A) in the fuse box
3 • GND	Brown	Ground stud on the block
Relay • 30	Red	Battery + with main fuse
Relay • 86 and 85	—	86: key +12 V • 85: ground
Relay • 87	Red	Fuse box input

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
+12V BAT	 10	 C1	 M2	 17
GND (power)	 3	 B1	 K3	 1

- 1 Run the battery positive, through a **main fuse**, to terminal 30 of the relay.
- 2 Connect the key +12 V (ON) to terminal 86 and terminal 85 to ground.
- 3 Terminal 87 feeds the fuse box: **F1, 2 A, for the ECU**, F2 for the coils and F3 for the injectors.
- 4 Connect pin 10 (+12V BAT, red) to F1 and pin 3 (GND, brown) to the ground stud on the engine block.

NOTE The 2 A ECU fuse is the one stated on the data sheet. The fuses for coils, injectors and other circuits depend on how many and which ones you use: section 3.7 gives guide values.

3.2 GROUNDS

- All power grounds (ECU, coils, relays, battery) go **to the same stud on the engine block**, with ring terminals on a clean, paint-free surface.
- The sensor ground (**SGND**: pin 12 on the ST Mini, C8 on the ST-02, K4 on the ST-04 and pin 12 on the ST-100) goes to the sensors only. **Never** connect it to the body.
- Check that there is a good ground between the block, the body and the battery negative: many bad readings come from there.

3.3 ECU OUTPUTS: WHAT YOU CAN CONNECT

Every ECU output that drives something (injectors, valves, relays) works **to ground**: one side of the load goes to switched, fused +12 V and the ECU connects the other side to ground to turn it on. No output supplies +12 V. Connect to each output only what this table says:

OUTPUT	WHAT TO CONNECT	MODELS
Injectors	High-impedance injectors only: 10 Ω or more measured across their pins, up to 2 per output. Below 10 Ω , with resistors (section 5.1)	All
Coils (IGN / COIL)	Coils with igniter only or an ignition module (section 6.1)	All
Idle and VVT	2- or 3-wire idle valves and VVT solenoids	ST-02, ST-04, ST-100
Boost	2-wire boost solenoid. If the solenoid measures less than 20 Ω , connect it through a relay	ST-02, ST-04, ST-100
Fuel pump and fan	Only the coil of a relay (figure 3.2)	All
Programmable output	A relay coil, a warning light or an LED	ST-04, ST-100
Tachometer	Only the signal input of a tachometer	All
+5V REF	Sensors only (TPS, pressure sensors and 5 V Hall sensors) and the B input of an HEI module (section 6.8)	All

DANGER Never connect a fuel pump, a fan, lights or a motor directly to an ECU output: they always go through a relay. An excess load damages the output even if it works for a few minutes.

- Feed each solenoid and valve with switched, fused +12 V, from the same main relay as the ECU (figure 3.1).
- Use standard 12 V automotive relays. They don't need a diode: the protection is inside the ECU.
- If a load makes the ECU hot or the output stops switching, disconnect it and use a relay.

3.4 FUEL PUMP AND FAN RELAYS

This is how the fuel pump and fan relays are wired. Any other power load you want to drive from an ECU output is wired the same way.

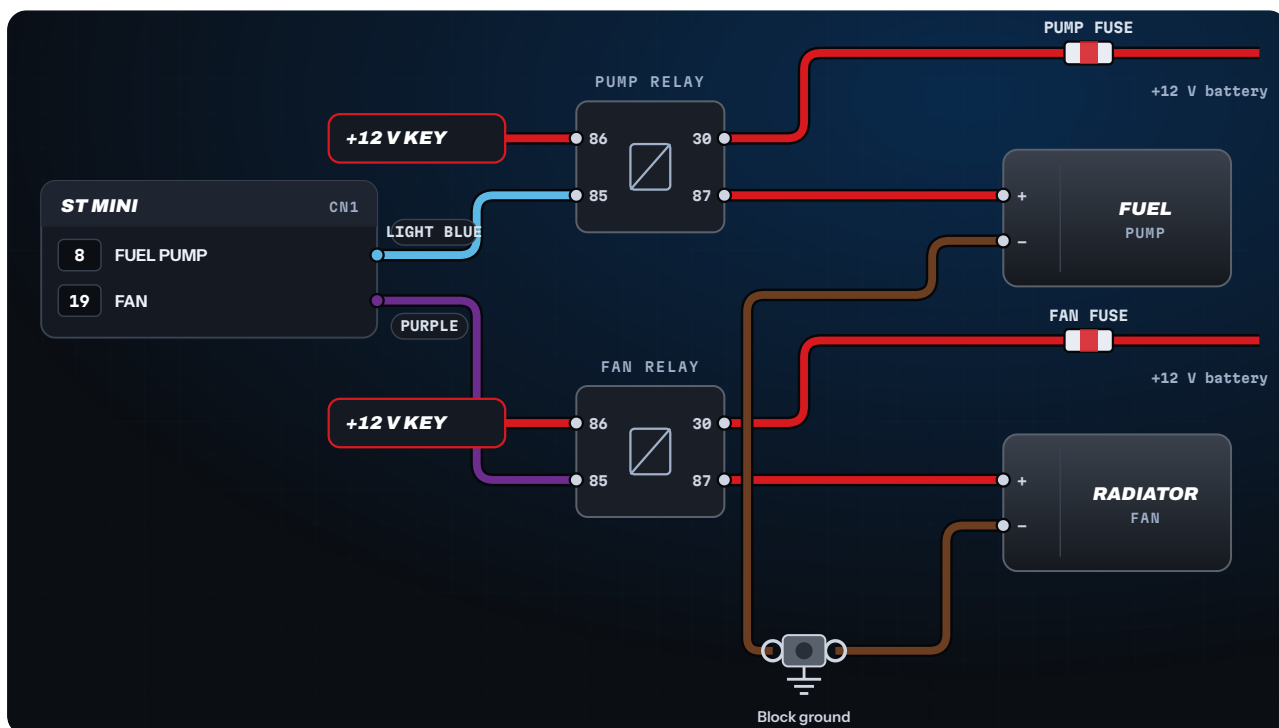


Figure 3.2 The ECU doesn't power the fuel pump or the fan: it grounds the coil of a relay (terminal 85) and the relay handles the current. Each load has its own fuse from the battery.

PIN / FUNCTION	WIRE	GOES TO
8 • FUEL PUMP	Light blue	Pump relay, terminal 85
19 • FAN	Purple	Fan relay, terminal 85
Relays • 86	Red	Switched +12 V
Relays • 30 and 87	Red	30: fused battery • 87: pump or fan

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Pump relay	8	A3	G1	28
Fan relay	19	B3	F1	29

3.5 ST COLOR CODE

Every SpeedTech harness uses the same code: one color per function, the same on all four ECUs. Models with more functions use more colors.

COLOR	FUNCTIONS
 Red	+12V BAT, +5V REF, crank and cam + inputs
 Black	Crank and cam – inputs, Hall, clutch, boost, programmable output, generic input, vehicle speed (VSS), flex and pressure sensors
 Brown	GND (power ground) and SGND (sensor ground)
 White	Injectors
 Yellow	Coils
 Light green	IAT
 Pink	CLT
 Tan	TPS
 Dark blue	O2 sensor (wideband)
 Light blue	Fuel pump relay
 Purple	Fan relay
 Gray	Tachometer
 Dark green	Idle valve
 Orange	VVT solenoids

3.6 GOOD PRACTICE

- Route the harness **away from spark plug leads, coils and the alternator**; cross them at right angles if there is no other option.
- Crank and cam sensor wires are **shielded**; the shield is grounded at the ECU end only.
- Crimped or soldered splices with heat shrink. No tape-only joints and no twisted splices.
- Mount the ECU inside the cabin or in a dry place, away from exhaust heat.
- Use resistor spark plugs and resistor leads: ignition noise is the number one cause of sync loss.

3.7 FUSES AND WIRES

The fuse protects **the wire**: it is chosen by the current of the circuit and can never be larger than what the wire it protects can carry. These values are a starting point; if the part maker gives another value, use theirs.

CIRCUIT	GUIDE FUSE	MINIMUM WIRE	NOTE
ECU (+12V BAT)	2 A	18 AWG	F1 in figure 3.1
High-impedance injectors, up to 4	10 A	18 AWG	F3. Each injector draws about 1 A
Injectors, 5 to 8	15 A	16 AWG	From the fuse to the first splice; each injector branch can be 18 AWG
Coils with igniter, up to 4	15 A	16 AWG	F2
Coils with igniter, 5 to 8	20 A	14 AWG	Or two 15 A fuses, one for each half of the coils
Boost and VVT solenoids and idle valve	5 to 10 A	18 AWG	One shared by the group
Wideband controller	As per its manual	18 AWG	The sensor heater draws more in the first seconds
Fuel pump	15 to 20 A	14 AWG	Depending on the pump current at your pressure; 30 A relay
Radiator fan	25 to 40 A	12 to 10 AWG	Depending on the fan; 40 A relay

WIRE GAUGE	MAXIMUM FUSE
22 AWG	Signals only: no load current
18 AWG	10 A
16 AWG	15 A
14 AWG	20 A
12 AWG	25 A
10 AWG	30 to 40 A

- Values for copper automotive wire in runs up to 3 m. For longer runs or near the exhaust, use a thicker gauge.
- **If a fuse blows, find the cause** (a short or a damaged part) before replacing it. Never fit a higher rating.
- Power circuits (fuel pump and fan) are fed straight from the battery with their fuse; the key only switches the relay (figure 3.2).

3.8 USING THE FACTORY HARNESS AND SENSORS

On many cars it makes sense to keep the factory harness and its sensors and connect the SpeedTech ECU to the wires that went to the factory ECU. It works well as long as every wire is identified with the **factory wiring diagram** for your model and year.

- 1** Get the wiring diagram (or the factory ECU pinout) for your exact engine. Versions of the same engine change colors and pins.
- 2** With the battery disconnected, find each signal from the table below on the factory ECU connector and mark it with tape.
- 3** Confirm them with the multimeter: continuity to the sensor, resistance of injectors and VR sensors, and no shorts to ground.
- 4** Splice each signal to the matching wire of the SpeedTech harness (chapter 2), crimped or soldered and with heat shrink. You can also build an adapter between both connectors so you can go back to the factory ECU.
- 5** Insulate and label the wires you won't use. Don't leave them loose or connect them to anything else.

SIGNAL	COMMON NAMES ON FACTORY DIAGRAMS	GOES TO THE SPEEDTECH ECU
Coolant temperature	THW (Toyota), ECT	CLT and SGND
Air temperature	THA (Toyota), IAT	IAT and SGND
Throttle	VTA, VC and E2 (Toyota), TPS	TPS, +5V REF and SGND
Manifold pressure	PIM (Toyota), MAP	Optional: external MAP input on the ST-04. Otherwise use the built-in MAP
Crank and cam	NE, G1, G2 (Toyota), CKP, TDC, CYP (Honda), CAS: POS and REF (Nissan)	Crank and cam inputs (chapter 9)
Injectors	#10, #20... (Toyota), INJ1, INJ2...	INJ outputs, paired or in firing order (chapter 5)
Coils	IGT, IGT1... (Toyota), IGN, ICM	IGN / COIL outputs (chapter 6)
Spark confirmation	IGF (Toyota)	Not used: leave it insulated
Factory oxygen sensor	OX, O2S, HO2S	Not used for tuning: the O2 input is for the wideband controller
Idle valve	ISC, IACV, EACV, AAC	IDLE outputs, if it is a 2- or 3-wire valve (chapter 13)
Power and sensor grounds	E01, E02, E1 (power) and E2 (sensors) on Toyota; PG and SG on Honda	Power to GND and the block; sensors to SGND

CAUTION Before connecting, check three things on the factory system: whether the injectors are **low impedance** (they need resistors, section 5.1), whether the coils have **no igniter** (they need a module, section 6.1) and whether the throttle is **electronic** (section 2.8). Factory temperature sensors work fine, but you have to choose their calibration in TunerStudio (section 8.7).

NOTE The factory main relay (for example Toyota's EFI MAIN or Honda's PGM-FI) can be used as the main relay in figure 3.1 if its contact feeds everything the SpeedTech ECU needs.

04 CHAPTER 4 SENSORS

Sensors tell the ECU how fast the engine turns, how much load it has, the throttle position and the temperatures. Without a clean crank signal, the engine won't start.

IN THIS CHAPTER

1 VR or Hall crank sensor

2 Cam sensor

3 TPS and temperatures

4 MAP sensor

5 Wideband sensor

6 Optional sensors

7 Aftermarket trigger wheel

4.1 CRANK SENSOR: VR OR HALL

	VR (INDUCTIVE)	HALL
Wires	2	3
Power	None: it generates its own signal	5 V or 12 V depending on the sensor
Signal	AC wave that grows with RPM	Square pulses
How to tell	It measures resistance across its two pins (usually hundreds of ohms)	It has power, ground and signal

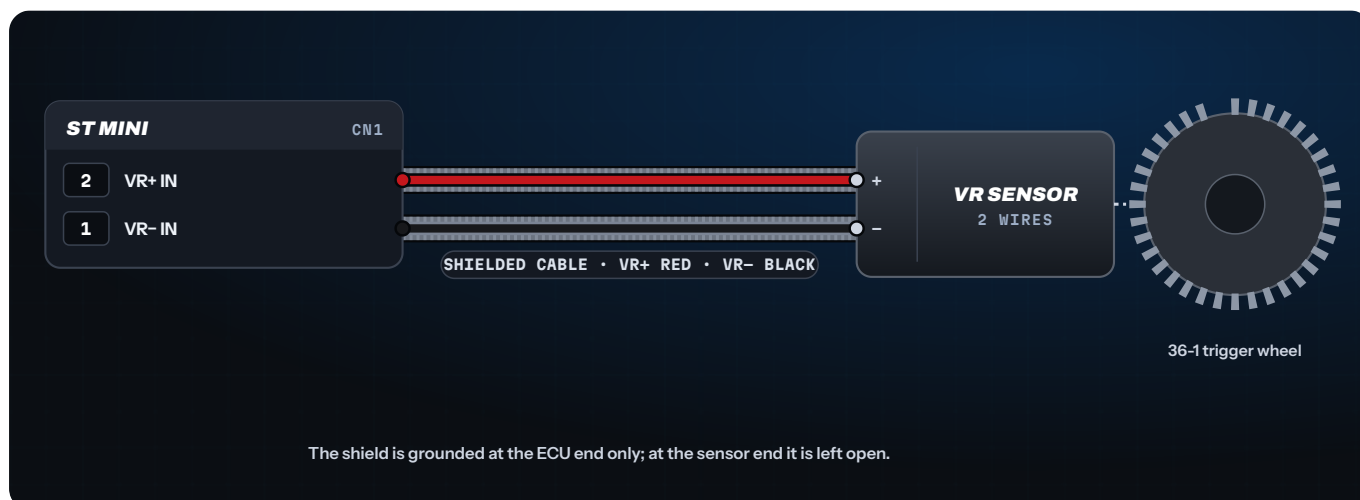


Figure 4.1 VR crank sensor (inductive, 2 wires) on the ST Mini. On the ST-02, ST-04 and ST-100 it connects the same way to CRANK + IN and CRANK - IN; the cam sensor, to CAM + IN and CAM - IN. If the engine doesn't sync, swap + and -.

PIN / FUNCTION	WIRE	GOES TO
2 • VR+ IN	Red, shielded	Sensor + terminal
1 • VR- IN	Black, shielded	Sensor - terminal

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Crank + (VR)	Red 2	Red C6	Red A1	Red 18
Crank -	Black 1	Black C7	Black A3	Black 19
Cam +	—	Red B6	Red A2	Red 10

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Cam -	-	 B7	 A4	 11

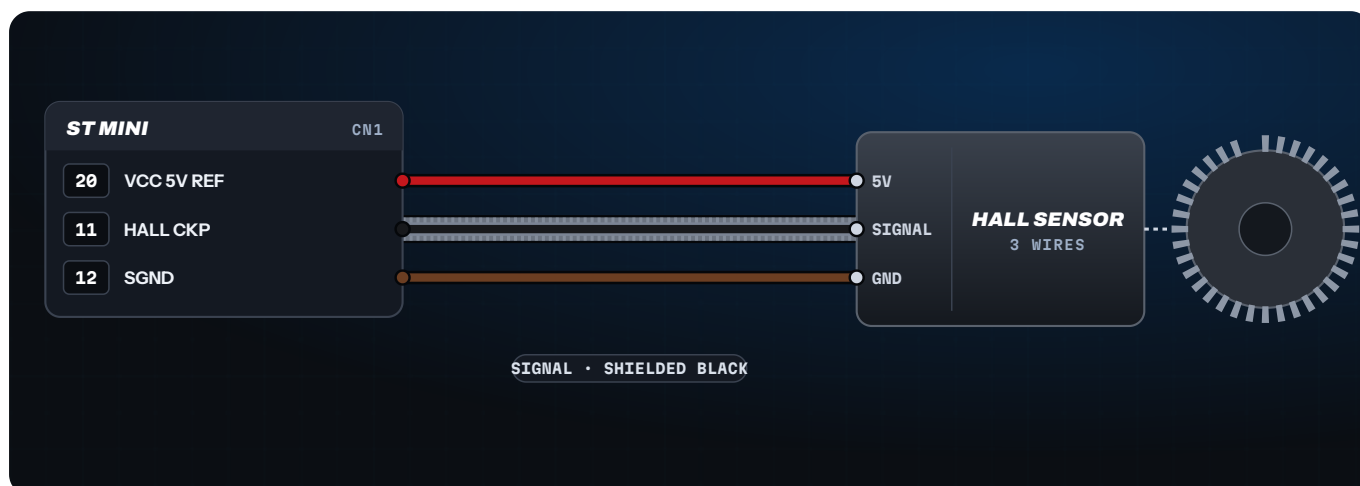


Figure 4.2 Hall crank sensor (3 wires) on the ST Mini: 5 V supply, signal and sensor ground. On the ST-02, ST-04 and ST-100 the Hall signal goes in on CRANK - IN (section 4.1). Some Hall sensors run on 12 V: check the sensor data sheet before connecting it.

PIN / FUNCTION	WIRE	GOES TO
20 • VCC 5V REF	 Red	Sensor supply
11 • HALL CKP	 Black, shielded	Sensor signal
12 • SGND	 Brown	Sensor ground

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
+5V REF	 20	 A1	 M1 • F3 • F4	 9
Hall signal	 11	 C7	 A3	 19
SGND	 12	 C8	 K4	 12

On the ST-02, ST-04 and ST-100 the crank and cam inputs have a VR sensor conditioner. To use a Hall or optical sensor, the ECU is set with **jumpers on the board**, one for the crank input (CRANK) and one for the cam input (CAM), and the Hall signal goes in on the negative line: *CRANK - IN* or *CAM - IN*.

	HALL OR OPTICAL SENSOR	VR (INDUCTIVE) SENSOR
Jumper position	HALL: the outer pins of the 3-pin jumper	VR: the inner pins
Where the signal goes in	<i>CRANK - IN</i> / <i>CAM - IN</i>	<i>CRANK + IN</i> and <i>CRANK - IN</i> (and the CAM ones)

- **The easiest way is to order it configured:** when you buy the ECU, tell us which sensor type your engine has on the crank and cam, and the ECU ships with the jumpers in that position.
- **ST-02 and ST-04:** if you have to change them, do it with the ECU disconnected and follow the **HALL** and **VR** marks printed on the board. Change only those jumpers.
- **ST-100:** it is sealed. To change the sensor type, send it to SpeedTech technical support.
- With a VR sensor, start with *Trigger edge: RISING*.

NOTE On the ST Mini, the crank Hall input (*HALL CKP*) has no jumpers and has a pull-up resistor: the sensor connects directly. Use **5 V** Hall sensors, powered from *VCC 5V REF*; don't connect 12 V Hall sensors.

4.2 CAM SENSOR

ST-02 • ST-04 • ST-100

The cam sensor tells the ECU which phase the engine is in (compression or exhaust). It is only needed for **sequential injection and ignition** and for some factory trigger patterns (chapter 9). It connects to the *CAM + IN* and *CAM - IN* inputs just like the crank sensor: VR with two shielded wires, or Hall with power, signal and ground.

4.3 TPS AND TEMPERATURES

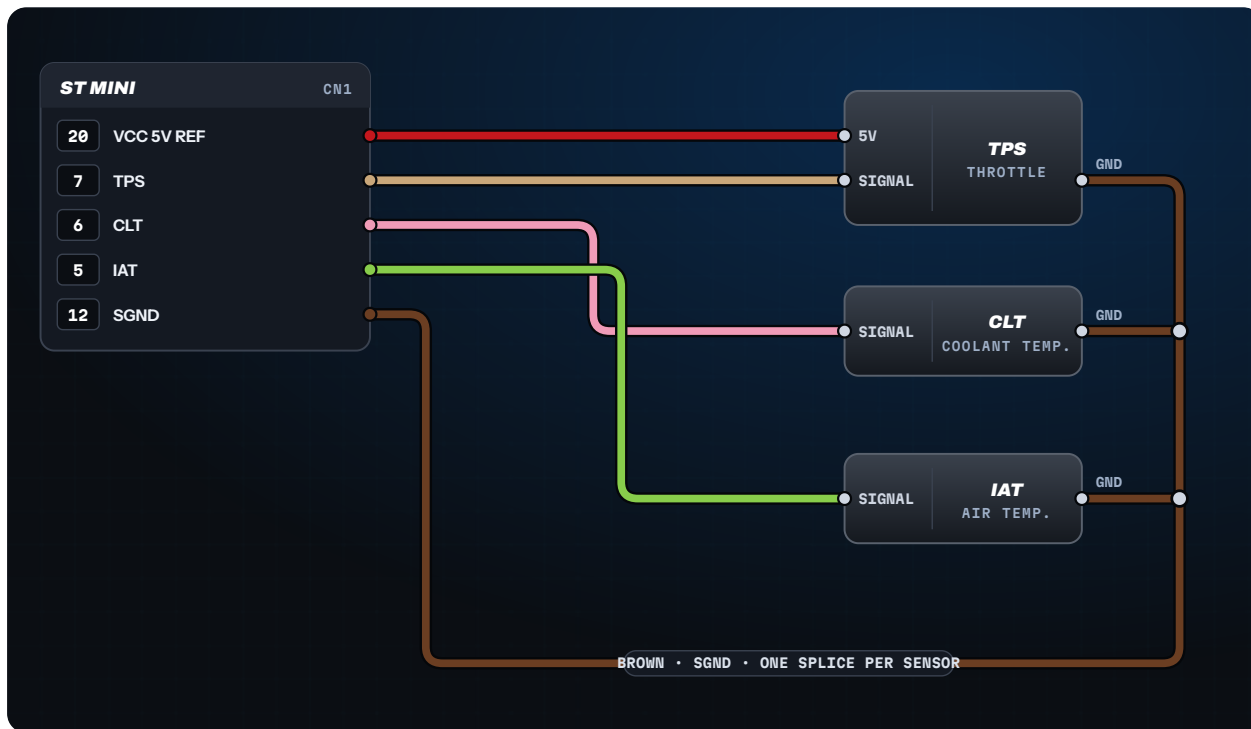


Figure 4.3 Analog sensors on the ST Mini: TPS (3 wires), coolant temperature and air temperature (2 wires each). All their grounds go to SGND (pin 12), never to the body.

PIN / FUNCTION	WIRE	GOES TO
20 • VCC 5V REF	Red	TPS • supply
7 • TPS	Tan	TPS • signal
6 • CLT	Pink	Coolant temperature sensor
5 • IAT	Light green	Air temperature sensor
12 • SGND	Brown	Ground of the three sensors (splice)

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
+5V REF	Red 20	Red A1	Red M1 • F3 • F4	Red 9
TPS	Tan 7	Tan B5	Tan D2	Tan 13
CLT	Pink 6	Pink A6	Pink E2	Pink 5
IAT	Light green 5	Light green A5	Light green H2	Light green 14
SGND	Brown 12	Brown C8	Brown K4	Brown 12

- **TPS:** 5 V, signal and sensor ground. It is then calibrated in [Tools > Calibrate TPS](#) (chapter 8).
- **CLT and IAT:** 2-wire thermistors, no polarity. They are calibrated in [Tools > Calibrate Temperature Sensors](#) by picking the sensor from the list or with three measured points.

- **IAT:** place it where it measures the air going into the engine, away from manifold heat. On turbo engines, after the intercooler.

4.4 MAP SENSOR

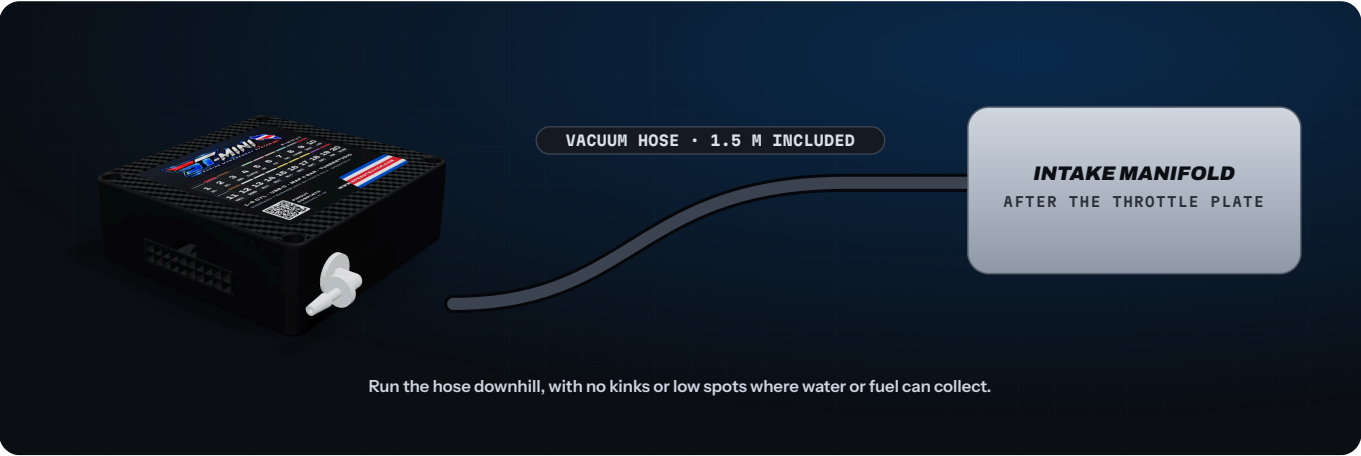


Figure 4.4 The 4 bar MAP sensor is inside the ST Mini: just run the hose from the ECU elbow to a manifold vacuum port, after the throttle plate.

TIP Take vacuum from a point all cylinders reach (a common plenum). If the engine has individual throttle bodies, join the ports of each cylinder in a small manifold before running the hose to the ECU.

4.5 WIDEBAND SENSOR

ST-02 · ST-04 · ST-100

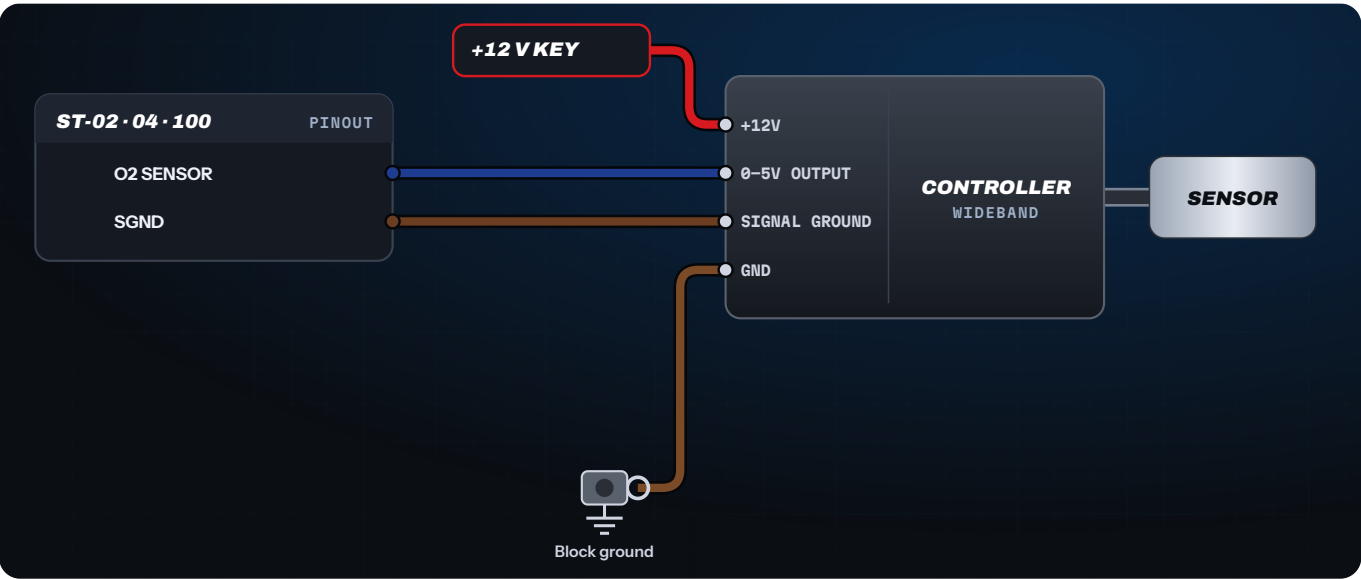


Figure 4.5 Wideband sensor with its controller on the ST-02, ST-04 and ST-100 (the ST Mini has no O2 input). The controller sends 0-5 V to the O2 SENSOR input and its signal ground goes to SGND; it is then calibrated in Tools > Calibrate AFR Sensor with the controller maker's table.

PIN / FUNCTION	WIRE	GOES TO			
O2 SENSOR	Dark blue	Controller 0-5 V analog output			
SGND	Brown	Controller signal ground			
Controller	—	Switched +12 V and ground to the block			
ON EACH ECU	ST MINI	ST-02	ST-04	ST-100	
O2 SENSOR	—	A7	J3	4	

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
SGND	 12	 C8	 K4	 12

A badly placed sensor gives false readings, and with them the whole tune goes wrong. When installing it:

- **Where:** in the exhaust pipe, where the gases of all cylinders have already merged, about 45 to 90 cm from the cylinder head and **before the catalytic converter**. On turbo engines, **after** the turbo: before the turbine, pressure distorts the reading.
- **Angle:** tip down and the body between 10 and 2 o'clock (at least 10° above horizontal). This way the water that condenses in the exhaust doesn't collect in the sensor. Never mount it under the pipe.
- **No leaks before the sensor:** a leak in the manifold, a gasket or a flex pipe lets air in and the reading shows lean even when the mixture is fine.
- **Thread:** weld an M18 × 1.5 bung on the pipe and tighten the sensor to its maker's torque (on Bosch LSU 4.9, 40 to 60 N·m).
- **Never run the engine with the sensor installed and the controller off:** without its heater, soot and water damage it quickly. If you remove the controller, also remove the sensor and fit a plug.
- **It is damaged by** leaded fuel, oil additives and silicone sealants that are not labeled oxygen-sensor safe.
- **Very short or open exhausts:** at idle, outside air can get in through the tailpipe and the reading shows lean. Mount the sensor far from the exhaust outlet.
- If the controller manual asks for a free-air calibration, do it before installing the sensor.

TIP Even though the ST Mini has no O2 input, use a wideband sensor with its own gauge while you tune: it is the only way to know how much fuel is really going in.

4.6 OPTIONAL SENSORS

ST-04 • ST-100

The ST-04 and ST-100 have inputs for sensors that enable extra functions. They are wired like this and set up in the chapter indicated:

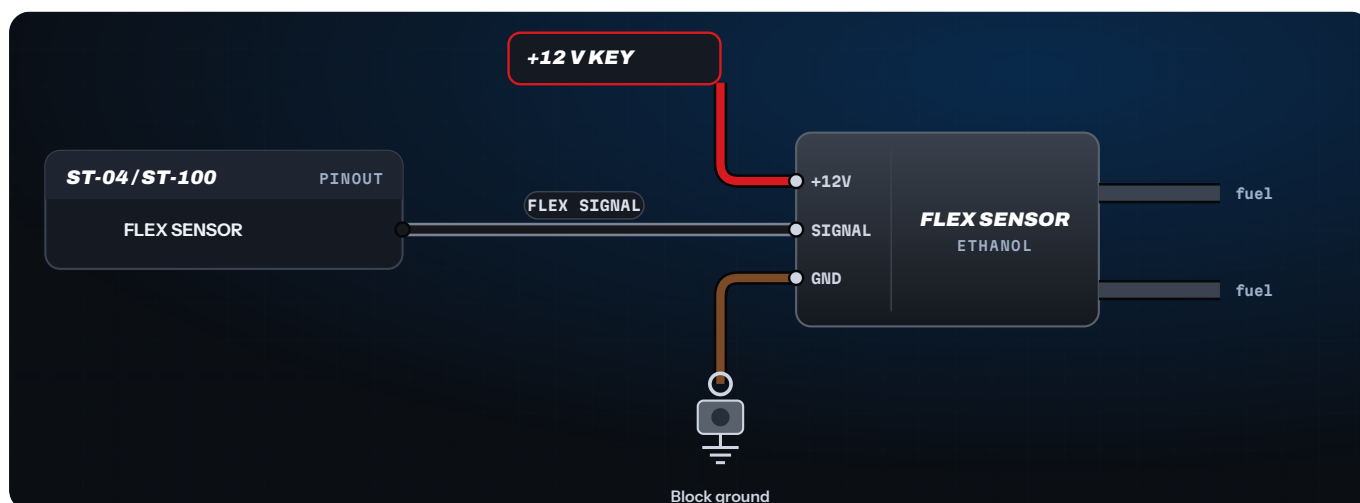


Figure 4.6 Ethanol (flex) sensor on the ST-04 and ST-100: switched +12 V, ground and signal to FLEX SENSOR. The sensor goes in the fuel line, feed or return; the pins are marked on its body.

PIN / FUNCTION	WIRE	GOES TO
FLEX SENSOR	 Black	Sensor signal pin
Sensor +12V	 Red	Switched, fused +12 V

PIN / FUNCTION	WIRE	GOES TO
Sensor • GND	 Brown	Block ground

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Flex sensor	—	—	 J2	 6

NOTE The FLEX SENSOR input has an internal pull-up resistor: the flex sensor connects directly, with no external resistor.

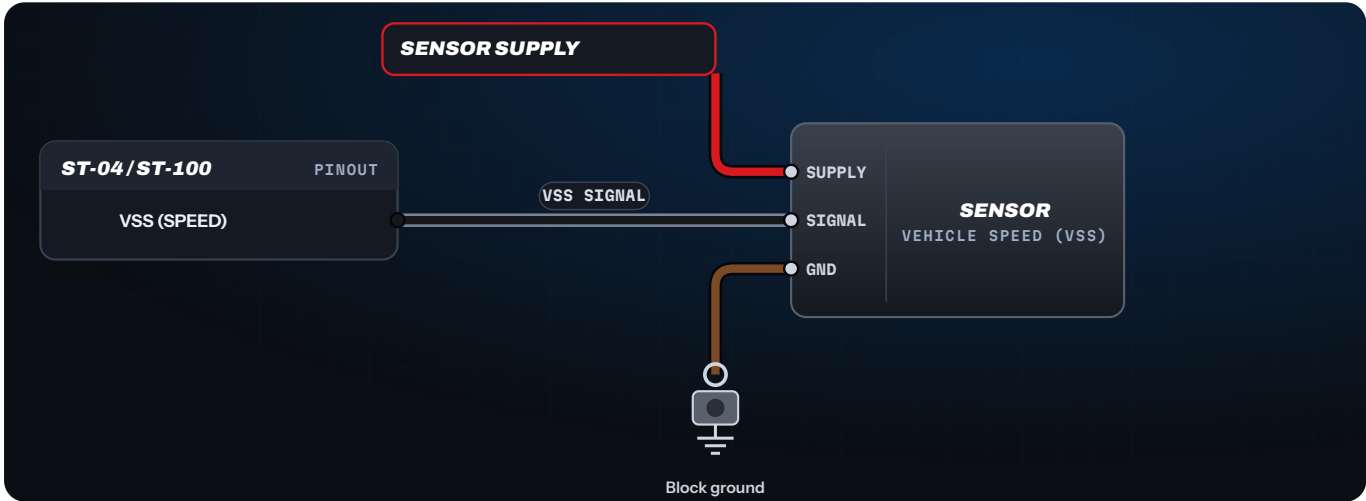


Figure 4.7 Vehicle speed sensor on the ST-04 and ST-100. On the ST-04 the input accepts Hall sensors only; its supply depends on the sensor (12 V or 5 V). Check the car's wiring diagram before connecting it.

PIN / FUNCTION	WIRE	GOES TO
VSS (SPEED)	 Black	Sensor signal
Sensor • supply	 Red	Depending on the sensor (12 V or 5 V)
Sensor • GND	 Brown	Block ground

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Vehicle speed (VSS)	—	—	 C2	 20



Figure 4.8 Oil pressure sensor on the ST-04 and ST-100 (3-wire, 0-5 V transducer). The fuel pressure sensor connects the same way, with its signal on FUEL PRESS SENSOR. They are enabled in Accessories > Fuel/Oil pressure.

PIN / FUNCTION	WIRE	GOES TO
+5V REF	 Red	Sensor supply
OIL PRESS SENSOR	 Black	Sensor signal
SGND	 Brown	Sensor ground

ON EACH ECU	ST-MINI	ST-02	ST-04	ST-100
+5V REF	 20	 A1	 M1 • F3 • F4	 9
Oil pressure	—	—	 C3	 2
Fuel pressure	—	—	 B3	 3
SGND	 12	 C8	 K4	 12

- **Flex (ethanol) sensor:** set up in [Tuning > Flex Fuel](#) (section 16.3).
- **Vehicle speed (VSS):** [Accessories > VSS and Gear detection](#) (section 15.5).
- **Oil and fuel pressure:** [Accessories > Fuel/Oil pressure](#) (section 15.7) and oil pressure protection (section 14.4).
- **External MAP (EXTERNAL MAP SENSOR):** a second pressure sensor; selected in [Tools > Calibrate Pressure Sensors](#).
- **Knock:** no SpeedTech ECU has a knock input or uses that function (section 2.8).

4.7 INSTALLING AN AFTERMARKET TRIGGER WHEEL

If your engine has a distributor or a factory wheel that isn't compatible, the most common solution is to fit a missing-tooth wheel (36-1 or 60-2) on the crankshaft with its sensor. It is the most important step of a carburetor-to-injection conversion: everything else depends on this wheel.

- 1 Choose the wheel:** steel (VR and almost all Hall sensors need magnetic metal: aluminum doesn't work) and the largest diameter that fits behind the pulley. A 36-1 suits almost every engine; a 60-2 gives a little more precision.
- 2 Mount it concentric:** bolted to the pulley or the crank hub, with no wobble. Turn the engine by hand and check that the gap to the sensor is the same all the way round; if it changes, the wheel is off-center or bent.
- 3 Fix the sensor on a rigid bracket** bolted to the block, not to parts that vibrate on their own (plastic covers, the alternator). The sensor sits square to the tooth face and centered on its width.
- 4 Set the gap** between sensor and teeth with feeler gauges, per the sensor maker: usually 0.5 to 1.5 mm. Too far and the signal is weak when cranking; too close and the sensor can touch the wheel.
- 5 The position of the gap isn't critical:** the ECU corrects it with the Trigger Angle (section 9.2). The only rule is that once the angle is measured, the wheel must not move relative to the crank: mark the pulley and the wheel.
- 6 Make a TDC mark** for cylinder 1 on the pulley and fit a fixed pointer on the block: you will need it to check timing with the timing light (section 10.7).
- 7 Wire it with shielded cable** (section 3.6), away from the alternator and the plug leads. Set the pattern in [Settings > Trigger Setup](#) (section 9.3) and check the signal in the Composite Logger before cranking.

CAUTION With a VR sensor, if the signal is inverted, timing drifts as RPM rises or the engine loses sync. Swap the two sensor wires to fix it (section 17.1).

05 CHAPTER 5 INJECTORS

Each INJ output of the ECU opens one or two injectors. How many go on each output and in what order depends on the number of cylinders and on whether your ECU can run sequential.

IN THIS CHAPTER

1 Which injectors you can use

2 How each injector is wired

3 Paired

4 Sequential

5 Table for 1 to 8 cylinders

6 Fuel system

5.1 WHICH INJECTORS YOU CAN USE

The injection outputs are **for high-impedance injectors only**: those that measure **10 Ω or more** across their two pins (most measure 12 to 16 Ω). Measure yours with the multimeter before connecting them.

INJECTOR	RESISTANCE	HOW IT IS CONNECTED
High impedance	10 Ω or more	Directly to the INJ output, up to 2 per output
Low impedance	Less than 10 Ω (usually 2 to 4 Ω)	With one series resistor per injector

CAUTION A low-impedance injector connected directly damages the ECU output. Fit a power resistor in series with each injector, between +12 V and the injector: it is the "resistor pack" that cars with these injectors had from the factory.

- **The rule:** injector + resistor must add up to **10 Ω or more**. For a 2.5 Ω injector, an 8 Ω resistor gives 10.5 Ω .
- **Resistor power rating:** 25 W, mounted on metal, away from the harness: it gets hot.
- **Adjust the Injector Open Time** (section 8.4): with the resistor the injector opens more slowly. Confirm it with the wideband.

5.2 HOW EACH INJECTOR IS WIRED

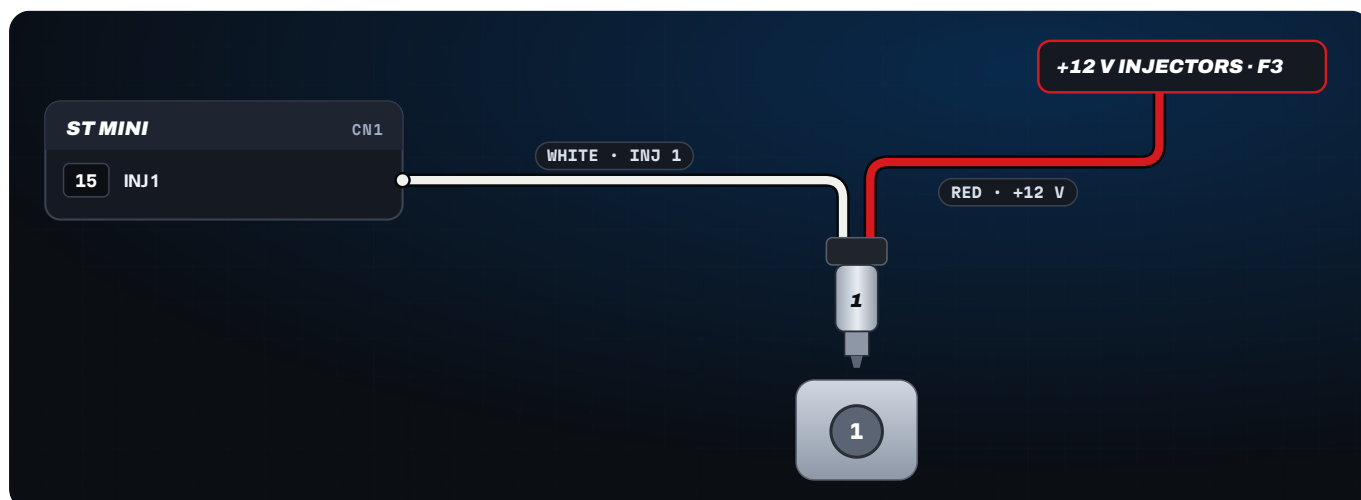


Figure 5.1 How each injector is wired: one side gets switched +12 V (fuse F3) and the other goes to the ECU INJ output, which grounds it to open it. High-impedance injectors have no polarity.

PIN / FUNCTION	WIRE	GOES TO
15·INJ1	 White	Injector signal terminal
F3	 Red	Other injector terminal (switched +12 V)

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Injector 1	 15	 B8	 M3	 34
Injector 2	 14	 A8	 M4	 33
Injector 3	 13	–	 L3	 32
Injector 4	–	–	 L4	 31

5.3 PAIRED INJECTION

Two injectors per output: the cylinders that reach TDC at the same time (360° of crank apart) are grouped. It doesn't need a cam sensor and it is what the ST Mini uses. In TunerStudio: *Injector Layout: Paired*.

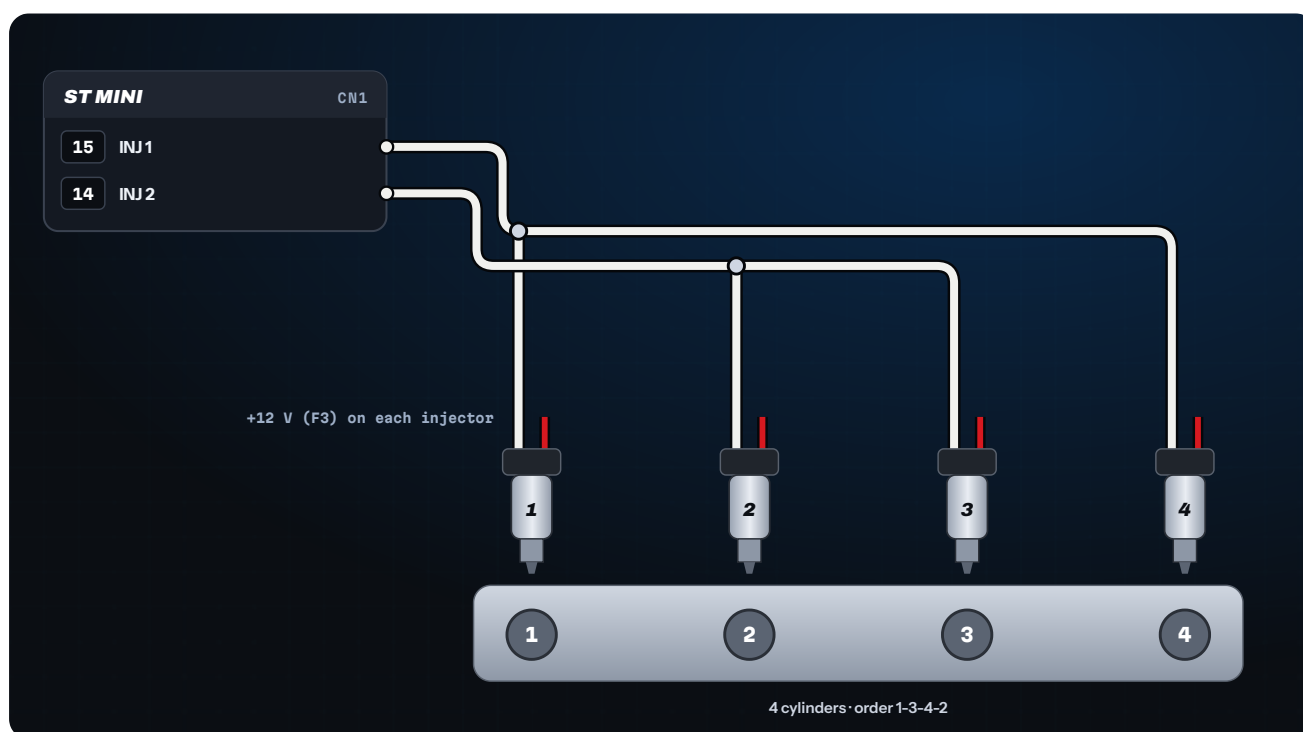


Figure 5.2 Paired injection with the ST Mini on a 4-cylinder: INJ 1 opens injectors 1 and 4 and INJ 2 injectors 2 and 3, which reach TDC together. The dots are splices.

PIN / FUNCTION	WIRE	GOES TO
15·INJ1	 White	Injectors 1 and 4 (splice)
14·INJ2	 White	Injectors 2 and 3 (splice)

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Injector 1 (cyl. 1 and 4)	 15	 B8	 M3	 34
Injector 2 (cyl. 2 and 3)	 14	 A8	 M4	 33

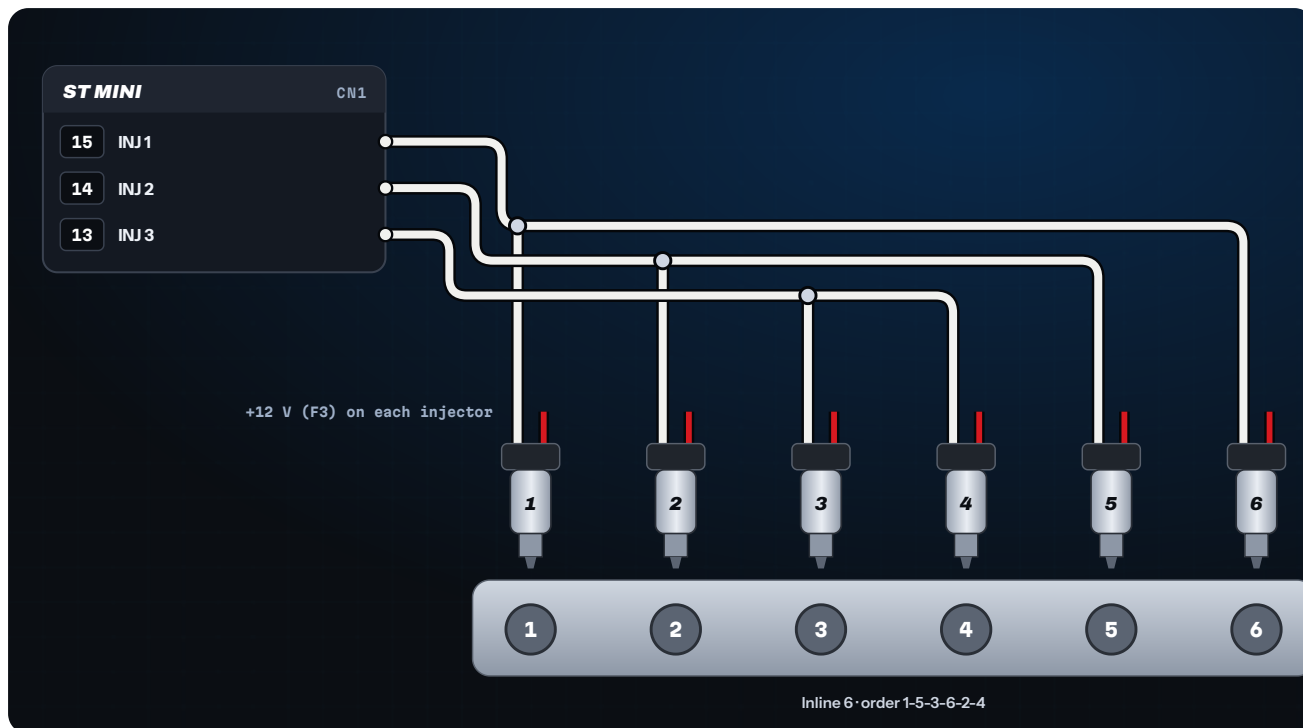


Figure 5.3 Inline 6-cylinder with the ST Mini in pairs: INJ 1 to cylinders 1 and 6, INJ 2 to 5 and 2, INJ 3 to 3 and 4. Each pair is the cylinders that reach TDC together.

PIN / FUNCTION	WIRE	GOES TO
15•INJ1	○ White	Cylinders 1 and 6
14•INJ2	○ White	Cylinders 5 and 2
13•INJ3	○ White	Cylinders 3 and 4

5.4

SEQUENTIAL INJECTION

ST-04 • ST-100

One injector per output, opened just before the intake valve of its cylinder opens. It needs a cam sensor and one output per cylinder: on the ST-04 and ST-100, up to 4 cylinders. In TunerStudio: *Injector Layout: Sequential*.

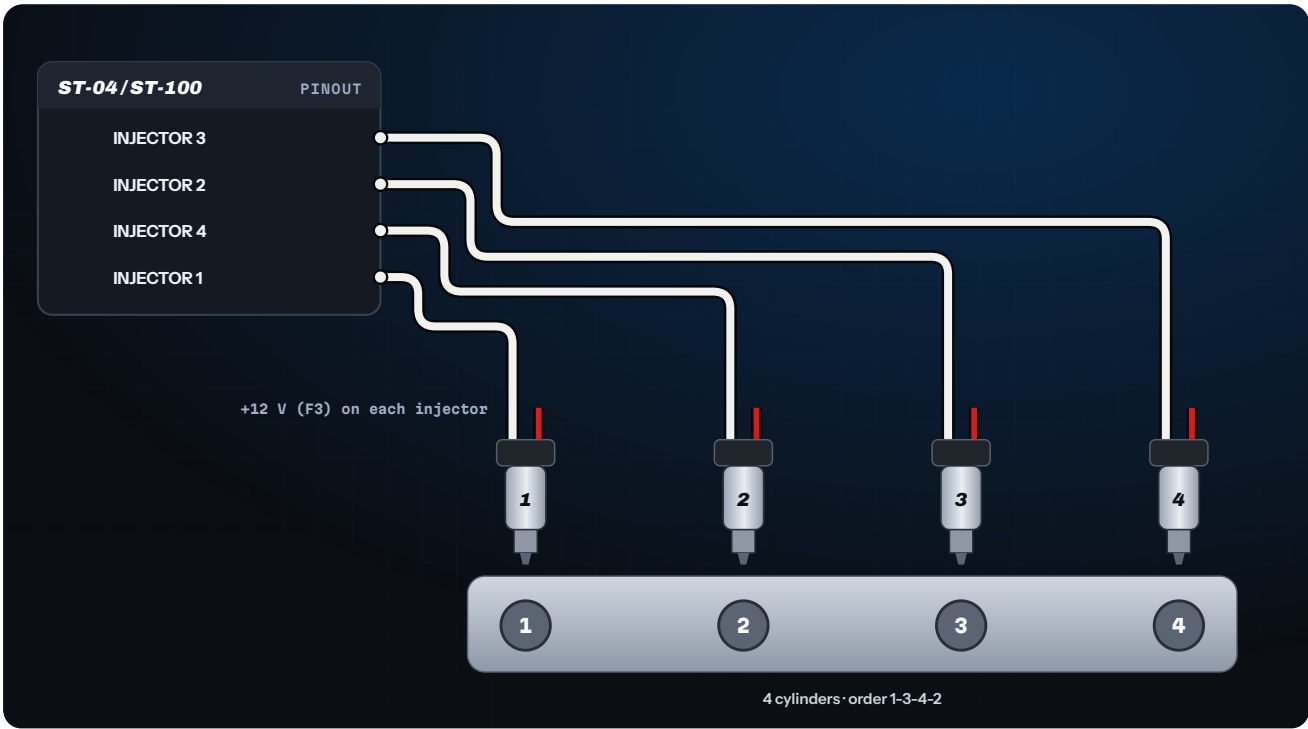


Figure 5.4 Sequential injection on the ST-04 or ST-100 (requires a cam sensor). The outputs fire in numerical order 1-2-3-4, so they are wired following the firing order: INJECTOR 1 to cylinder 1, INJECTOR 2 to 3, INJECTOR 3 to 4 and INJECTOR 4 to 2.

PIN / FUNCTION	WIRE		GOES TO	
INJECTOR 1		White	Cylinder 1	
INJECTOR 2		White	Cylinder 3	
INJECTOR 3		White	Cylinder 4	
INJECTOR 4		White	Cylinder 2	

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Injector 1	15	B8	M3	34
Injector 2	14	A8	M4	33
Injector 3	13	–	L3	32
Injector 4	–	–	L4	31

CAUTION

Sequential outputs always fire in numerical order (1, 2, 3, 4). That is why **they are wired following the firing order**, not the cylinder number.

Semi-sequential: on a 4-cylinder with one injector per output but no cam sensor, choose *Injector Layout: Semi-Sequential*. Each injector has its own output, but they fire in pairs as in paired mode; the *Injector Pairing* field sets which outputs go together (1+4 and 2+3, or 1+3 and 2+4).

5.5 TABLE FOR 1 TO 8 CYLINDERS

CYLINDERS	OUTPUTS	HOW THEY ARE SPLIT	INJECTOR LAYOUT	MODELS
1	1	INJ 1 to cylinder 1	Paired	All
2	1 or 2	One per output, or both on INJ 1	Paired	All
3	3	One per output	Paired	ST Mini, ST-04, ST-100
4	2	1 and 4 on INJ 1 · 2 and 3 on INJ 2 (order 1-3-4-2)	Paired	All
4	4	Following the firing order (figure 5.4)	Sequential	ST-04, ST-100
Inline 6	3	1 and 6 · 5 and 2 · 3 and 4 (order 1-5-3-6-2-4)	Paired	ST Mini, ST-04, ST-100
V6	3	1 and 5 · 4 and 3 · 2 and 6 (order 1-4-2-5-3-6)	Paired	ST Mini, ST-04, ST-100
V8	4	1 and 6 · 8 and 5 · 4 and 7 · 3 and 2 (order 1-8-4-3-6-5-7-2)	Paired	ST-04, ST-100

NOTE For another firing order: write the order down and pair each cylinder with the one halfway down the list. In 1-3-4-2, 1 goes with 4 and 3 with 2.

5.6 FUEL SYSTEM

The ECU decides how long each injector opens; how much fuel comes out depends on **pressure**, so it must be stable and known.

	RETURN	RETURNLESS
Layout	Regulator on the rail, excess fuel back to the tank, vacuum hose to the manifold.	Regulator in the tank or by the pump; a single line to the rail.
Pressure	Fixed above manifold pressure : rises with boost, drops with vacuum.	Fixed relative to outside air, regardless of vacuum or boost.
Use	Recommended for tuning and required with a turbo : the injector delivers the same at any load.	NA street engines. With boost, the injector delivers less just when it is needed most.

DANGER Work on the fuel system with the engine cold, the battery disconnected and a fire extinguisher at hand. Relieve the pressure before opening a line and check for leaks with the pump running before cranking.

- **Measure the base pressure** with a gauge on the rail, engine idling and the regulator vacuum hose disconnected and plugged. Many systems run 3 bar (43.5 psi).
- **Injector flow changes with pressure**: $\text{new flow} = \text{rated flow} \times \sqrt{(\text{new pressure} \div \text{rated pressure})}$. A 440 cc/min injector at 3 bar gives about 508 cc/min at 4 bar. The flow you enter in the Required Fuel calculator (section 8.3) is the one at **your** pressure.
- **The pump has to keep up**: at least the flow of all injectors open at 85 % at your working pressure (base + boost), with margin. Example: 4 injectors $\times$ 440 cc/min $\times$ 0.85 $\approx$ 1500 cc/min $\approx$ 90 L/h. Check the pump curve at that pressure.
- **Filter and lines**: a new filter, fuel-rated (and ethanol-rated for flex fuel) hoses and injection clamps.

06 CHAPTER 6 IGNITION

The ignition output tells the coil when to fire. Choosing the right coil type and output mode is what separates an engine that starts first time from one that misfires or burns coils.

IN THIS CHAPTER

1 Coils with and without igniter

2 Output modes

3 Wasted spark

4 COP coils

5 Sequential

6 Distributor

7 Dwell

8 GM HEI module

6.1 COILS WITH AND WITHOUT IGNITER

The ECU ignition outputs give a **5 V logic signal**: they are not strong enough to charge a coil directly. The coil must have its own **igniter**, or an ignition module has to sit between the ECU and the coil.

	"SMART" COIL (WITH IGNITER)	"DUMB" COIL (NO IGNITER)
How to tell	3 or 4 wires: +12 V, ground and one signal per channel	2 wires: +12 V and the coil negative
Primary resistance	Can't be measured: there are electronics inside	Low, usually under 1 Ω
With the SpeedTech ECU	Connects directly to the IGN output	Needs an ignition module

DANGER Never connect a coil without igniter directly to an IGN output. The primary current destroys the ECU output in seconds. If you don't know which coil you have, measure across its pins and ask us before powering it.

6.2 THE FOUR OUTPUT MODES

The mode is chosen in [Spark > Spark Settings > Spark output mode](#):

MODE	HOW IT WORKS	4 CYL.	6 CYL.	8 CYL.	CAM
Wasted Spark	One output fires two cylinders that reach TDC together; one on compression and the other on exhaust.	2	3	4	No
Wasted COP	Like wasted spark, but the ECU fires two outputs at once (1 with 3 and 2 with 4): one COP coil per output, no splices. 4 cylinders only, with 4 outputs.	4	—	—	No
Sequential	One output and one coil per cylinder, in firing order.	4	—	—	Yes
Single Channel	A single output drives a distributor's module.	1	1	1	No

NOTE The ST Mini (no cam sensor) runs Wasted Spark or Single Channel; with its three outputs (pins 18, 17 and 16) it covers up to 6 cylinders. With COP coils on the ST Mini or the ST-02, use *Wasted Spark* with two coils spliced per output (figure 6.3). *Wasted COP* needs 4 outputs: ST-04 and ST-100. The ST-04 and ST-100 run sequential up to 4 cylinders and wasted spark up to 8. As with the injectors, the ignition outputs always fire in numerical order: the firing order is handled in the wiring.

6.3 WASTED SPARK WITH A TWIN COIL PACK

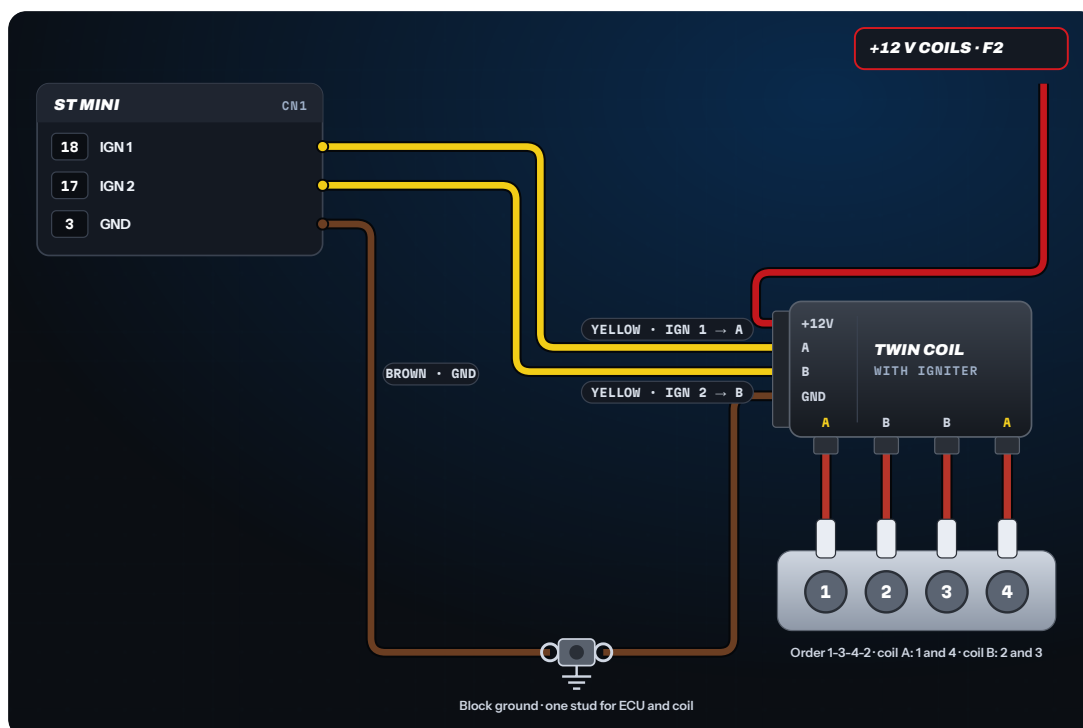


Figure 6.1 4-cylinder wasted spark with the ST Mini and a 4-tower twin coil with igniter. The coil has two inputs: A fires cylinders 1 and 4; B, cylinders 2 and 3.

PIN / FUNCTION	WIRE	GOES TO
18 · IGN 1	Yellow	Coil signal A (cylinders 1 and 4)
17 · IGN 2	Yellow	Coil signal B (cylinders 2 and 3)
3 · GND	Brown	Ground stud, together with the coil ground
F2	Red	Coil +12 V

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Coil 1 (signal A)	18	B4	E4	15
Coil 2 (signal B)	17	A4	D4	16
GND (power)	3	B1	K3	1

- 1 Feed the coil with +12 V from the main relay, through its fuse (F2).
- 2 Run the coil ground to the same stud as the ECU ground.
- 3 Connect pin 18 (IGN 1) to coil signal A (cylinders 1 and 4) and pin 17 (IGN 2) to signal B (cylinders 2 and 3).
- 4 In [Spark > Spark Settings](#) choose *Spark output mode: Wasted Spark* and check the dwell (section 6.7) before cranking.
- 5 Test without starting with [Hardware Testing > Test Output Hardware](#) : fire each output and confirm the spark on the right cylinder.

6.4 COP COILS

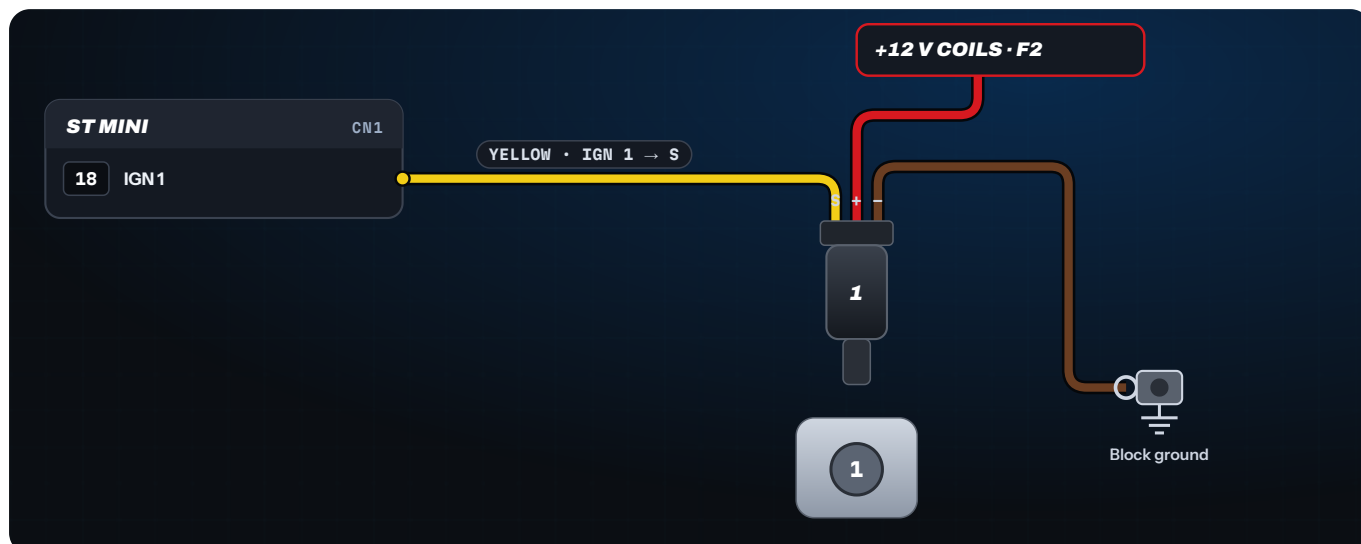


Figure 6.2 How a COP coil with igniter is wired: S (signal) to the ECU IGN output, + to switched +12 V (F2) and - to block ground. The pin order changes by brand: identify them with its diagram before connecting.

PIN / FUNCTION	WIRE	GOES TO
18 • IGN 1	Yellow	Coil signal pin (S)
F2	Red	Coil + pin
Ground	Brown	Coil - pin to the block

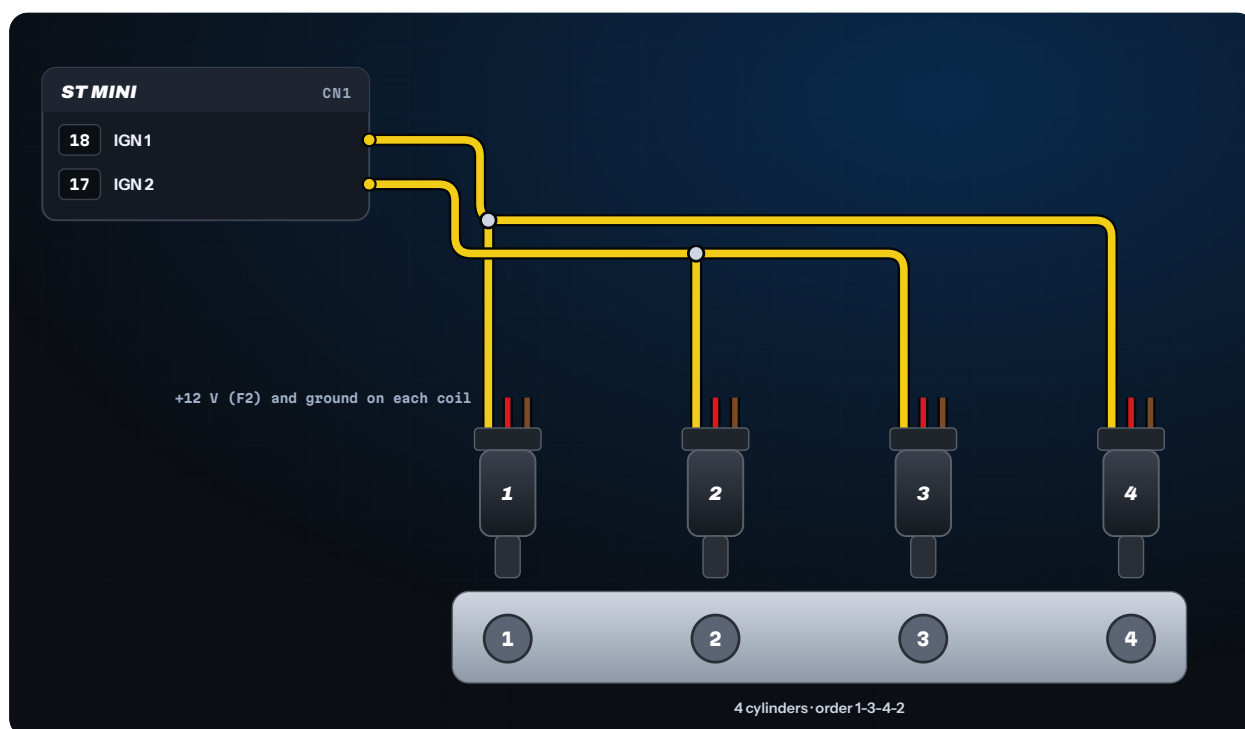


Figure 6.3 Four COP coils in wasted spark with the ST Mini (Spark output mode: Wasted Spark): IGN 1 goes to coils 1 and 4; IGN 2, to 2 and 3 (the dots are splices). Power and ground for each coil as in the previous figure. On the ST-04 and ST-100 Wasted COP can also be used, with one output per coil and no splices.

PIN / FUNCTION	WIRE	GOES TO
18 • IGN 1	Yellow	Coils 1 and 4 (splice)
17 • IGN 2	Yellow	Coils 2 and 3 (splice)

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Coil 1 (cyl. 1 and 4)	 18	 B4	 E4	 15
Coil 2 (cyl. 2 and 3)	 17	 A4	 D4	 16

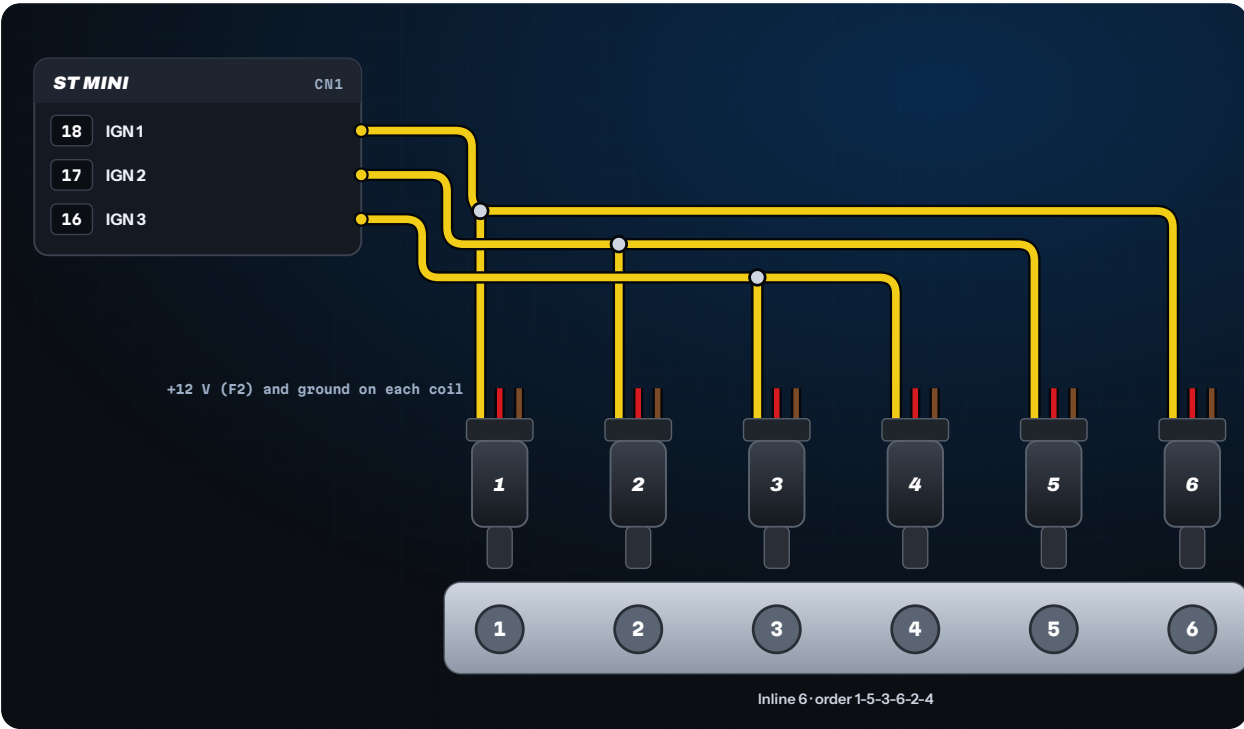


Figure 6.4 Inline 6-cylinder wasted spark with the ST Mini: IGN 1 to cylinders 1 and 6, IGN 2 to 5 and 2, IGN 3 to 3 and 4. With twin coils it is the same: each twin coil goes with one pair.

PIN / FUNCTION	WIRE	GOES TO
18 • IGN 1	 Yellow	Cylinders 1 and 6
17 • IGN 2	 Yellow	Cylinders 5 and 2
16 • IGN 3	 Yellow	Cylinders 3 and 4

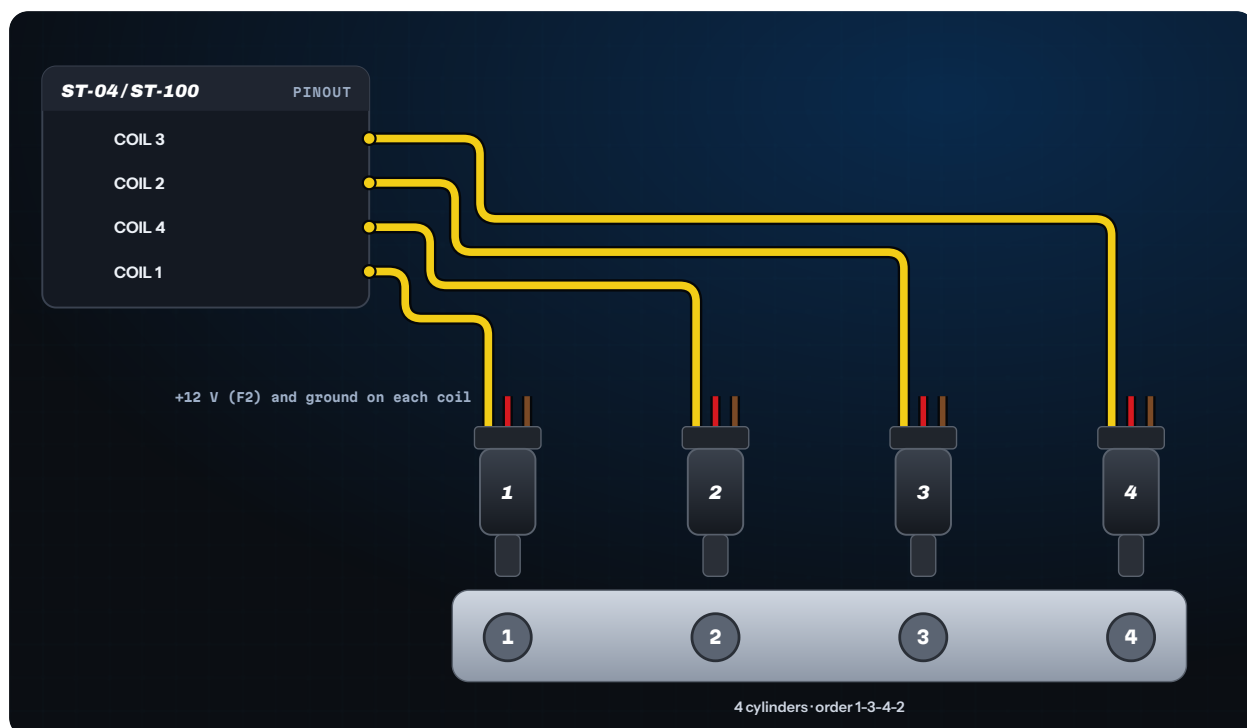


Figure 6.5 Sequential ignition with the ST-04 or ST-100 (requires a cam sensor): one coil per cylinder. The outputs fire in order 1-2-3-4, so COIL 1 goes to cylinder 1, COIL 2 to 3, COIL 3 to 4 and COIL 4 to 2.

PIN / FUNCTION	WIRE	GOES TO
COIL 1	Yellow	Cylinder 1 coil
COIL 2	Yellow	Cylinder 3 coil
COIL 3	Yellow	Cylinder 4 coil
COIL 4	Yellow	Cylinder 2 coil

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Coil 1	18	B4	E4	15
Coil 2	17	A4	D4	16
Coil 3	16	—	C4	7
Coil 4	—	—	B4	8

6.6 DISTRIBUTOR

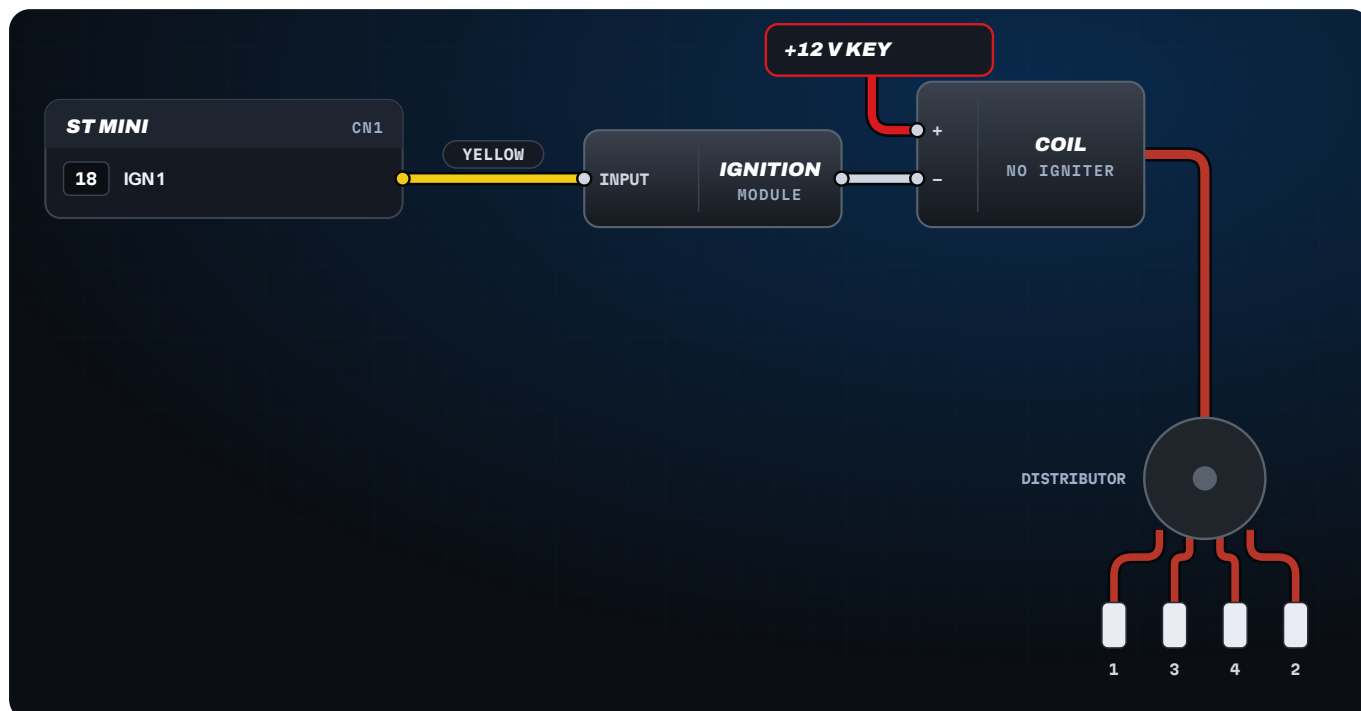


Figure 6.6 Distributor ignition (Single Channel): a single ECU output drives an external ignition module, which charges the coil; the distributor sends the spark to each plug in firing order. The module also needs its switched +12 V and ground, per its own diagram.

PIN / FUNCTION	WIRE	GOES TO
18 · IGN 1	Yellow	Ignition module input
Module · output	—	Coil negative (-)
Coil +	Red	Switched +12 V

6.7 DWELL: HOW LONG THE COIL CHARGES

Dwell is set in [Spark > Dwell settings](#): *Cranking dwell* (while cranking) and *Running dwell* (with the engine running). The values are for 12 V; the ECU corrects them for voltage by itself (section 12.5).

- **Use the coil maker's figure.** If you don't have it, start with low dwell and raise it gradually while checking that the coil doesn't get hot.
- Enable *Use Overdwell protection* with a *Max dwell time* at least 3 ms above your dwell, including the cranking dwell.
- Too much dwell overheats and burns coils; too little gives a weak spark at high RPM.
- With a distributor and many cylinders, at high RPM there isn't always enough time: the ECU shortens the dwell by itself using *Spark duration* (how long the spark lasts).

CAUTION In [Spark > Spark Settings](#), *Spark Outputs triggers* is set to **Going Low** on all SpeedTech ECUs: the coil charges while the signal is high and fires when it goes low. If it is set to *Going High*, the coil stays charged almost all the time and burns out.

6.8 GM HEI MODULE

The GM HEI module is the most common igniter on distributor engines, and it can drive a coil without igniter from any SpeedTech ECU. You need a **7- or 8-pin** module: the 4-pin one has no input for the ECU to control timing.

TERMINAL	WHAT IT IS	CONNECTS TO
E	Timing input (EST)	ECU ignition output: IGN 1 or COIL 1
B	Bypass: at 0 V the module uses its own timing; at 5 V it follows the ECU	ECU +5V REF
+	Module power	Switched, fused +12 V (F2), together with the coil +
C	Output to the coil	Coil negative (-)
P and N	Distributor pickup input	Left free: the pickup goes to the ECU
R	Reference output (tachometer)	Not used
G	Ground (8-pin module)	Block ground. The 7-pin module grounds through its case

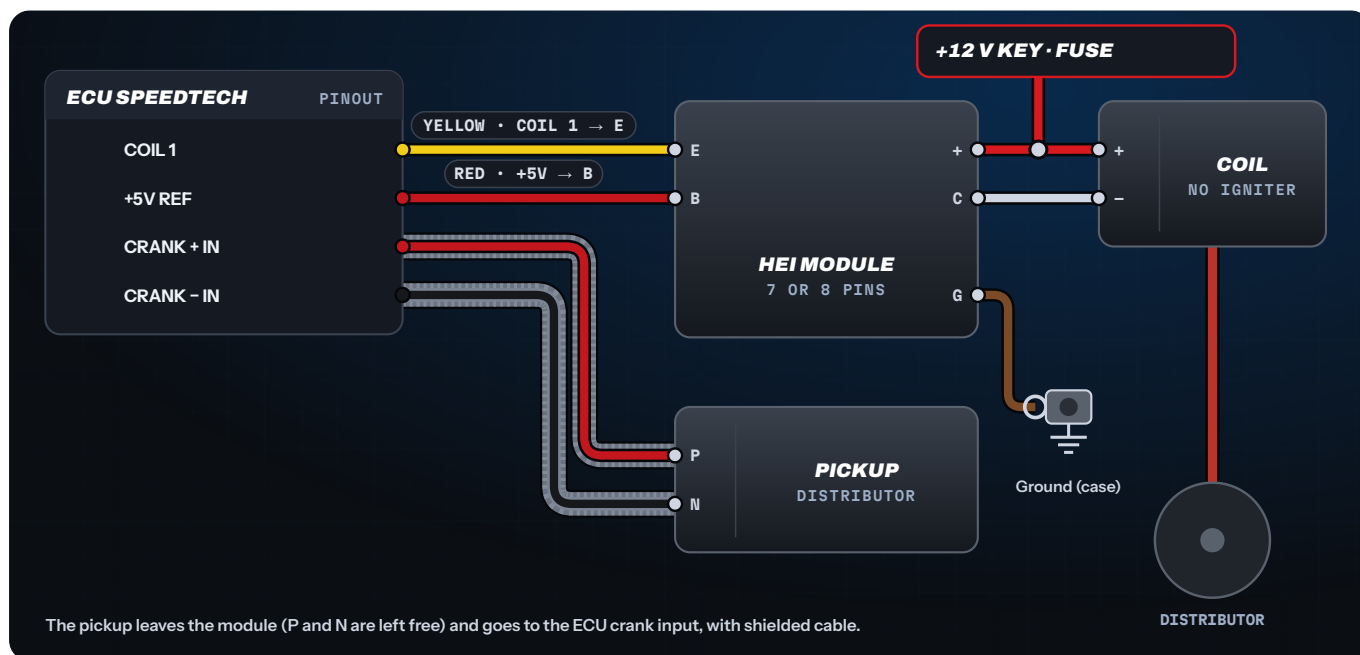


Figure 6.7 7- or 8-pin HEI module used as an igniter: the ECU fires the spark through E, +5 V on B tells the module to follow the ECU, and the distributor pickup goes into the ECU as a VR sensor. In TunerStudio: Basic Distributor and Spark output mode: Single Channel.

PIN / FUNCTION	WIRE	GOES TO
COIL 1	Yellow	Module terminal E
+5V REF	Red	Module terminal B
CRANK + IN / CRANK - IN	Red / black (shielded)	The two pickup wires
+12 V	Red	Module + terminal and coil +
C	—	Coil negative (-)

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Coil (COIL 1)	18	B4	E4	15
+5V REF	20	A1	M1 • F3 • F4	9

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Pickup +	 2	 C6	 A1	 18
Pickup -	 1	 C7	 A3	 19

- 1** Mount the module on metal (the distributor or a heat sink) with **thermal grease** between them: without it, it overheats and fails.
- 2** Run both pickup wires to the ECU crank inputs with shielded cable. If RPM doesn't show or jumps around, swap the two wires.
- 3** In [Settings > Trigger Setup](#) choose *Basic Distributor* (section 9.7) and in [Spark > Spark Settings](#) *Spark output mode: Single Channel*.
- 4** The module charges the coil while E is high and fires when it goes low, like a coil with igniter: check *Spark Outputs triggers* (section 6.7).
- 5** Start with low dwell (section 6.7) and, after a few minutes at idle, check that neither the module nor the coil is hot.
- 6** Calibrate the Trigger Angle with the timing light (section 10.7) using fixed timing.

CAUTION With B at +5 V the module always follows the ECU, including when cranking: the cranking timing is the *Cranking advance Angle* (section 8.6). If B is left at 0 V, the module ignores the ECU and uses its own fixed timing.

07 CHAPTER 7 **TUNERSTUDIO**

TunerStudio is the program used to configure, tune and log the ECU. It runs on Windows, Mac and Linux; this manual uses Windows.

IN THIS CHAPTER

1 Connecting the ECU

2 USB driver

3 Installing TunerStudio

4 Creating the project

5 The main screen

6 Saving, comparing and loading tunes

7 Logs

8 Updating the firmware

7.1 **CONNECTING THE ECU**

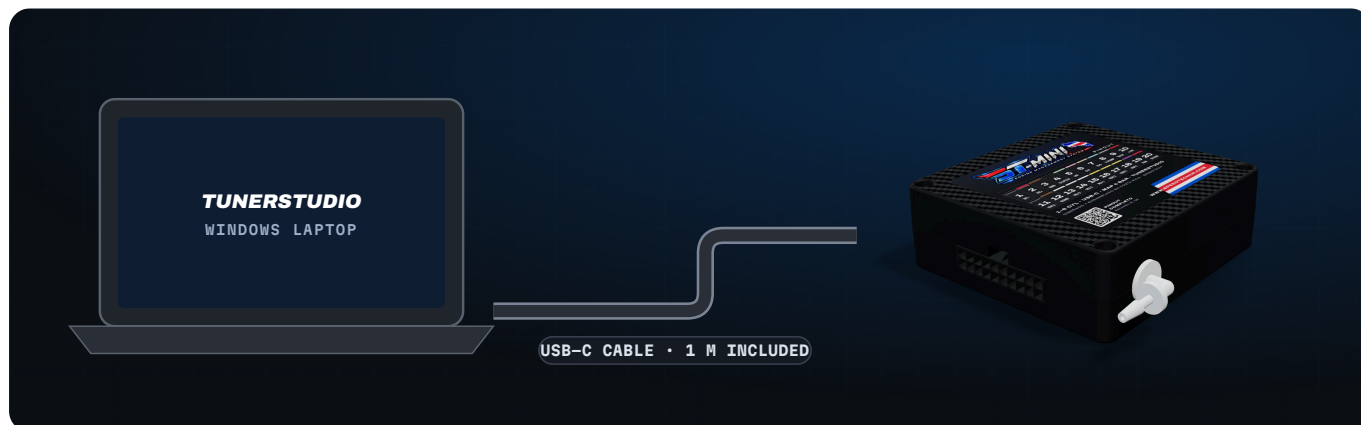


Figure 7.1 Computer connection: USB-C cable from the ST Mini to the laptop. The ST-02 and ST-04 also connect over USB-C; the ST-100, over USB type B.

7.2 **USB DRIVER**

All four ECUs use a CH340 USB chip (the ST-100 with a USB type B cable). Download the driver from speedtechcr.com/drivers, install it and connect the ECU with the key ON. Windows Device Manager should show a *USB-SERIAL CH340 (COMx)* port: write down the COM number.

NOTE With the USB cable connected, the ECU stays powered even with the key off. That is why, with the laptop connected, the fuel pump only primes the first time the ECU is powered.

7.3 **INSTALLING TUNERSTUDIO**

Download TunerStudio from its official site (link at speedtechcr.com/drivers) and install it. The free version is enough to configure and tune; the registered (paid) version adds tools such as VE Analyze Live, the table generator and more screens.

7.4 CREATING THE PROJECT

- 1 Open TunerStudio and create a new project. Name it after the car.
- 2 With the ECU connected, click **Detect**: TunerStudio reads the ECU firmware and loads its configuration.
- 3 In the project properties choose the units: temperature in °C and AFR or lambda, as you prefer.
- 4 In the communication settings choose the COM port from step 7.2 and the speed **115200**. Click **Test Port**: it should confirm the connection was successful.
- 5 Finish the wizard. The connected ECU should appear at the top and the gauges should be moving.

TIP Units can be changed later in the project properties, but do it before tuning: switching from AFR to lambda or from °F to °C halfway through makes old logs confusing to read.

7.5 THE MAIN SCREEN

The main screen shows gauges (RPM, MAP, AFR, temperatures, voltage...) and a row of **indicators** that light up when something happens. The most useful ones:

INDICATOR	WHAT IT MEANS
Full Sync / Half Sync / No Sync	Whether the ECU knows where the engine is. Half Sync: it has the crank but is missing the cam signal (it can't run sequential).
ERROR	A sensor is out of range and the ECU is using a default value (section 14.7).
Rev Limiter ON, Boost Limit ON...	An engine protection is cutting (chapter 14).
TPS Accel / MAP Accel	Acceleration enrichment is being applied.
Warmup, ASE, Cranking	Which start-up or warm-up phase the engine is in.

The RPM and MAP gauge colors are set in [Settings > Gauge Limits](#): *Warning* is where yellow starts, *Danger* where red starts and *High* the top of the scale. After changing them you have to reopen the project.

7.6 SAVING, COMPARING AND LOADING TUNES

- **Burn**: changes take effect immediately, but are only stored in the ECU when you click Burn.
- **Backups**: save your tune on the computer with [File > Save Tune As](#) before and after every tuning session. Put the date in the name.
- **Base maps**: to load a tune (.msq) use [File > Open Tune](#) with the ECU connected and then Burn. ST Premium members have SpeedTech base maps.
- **Compare**: when opening a tune, TunerStudio shows the differences with the one in the ECU and lets you choose which to use. Review them before accepting.
- **Don't mix tunes from another ECU**: a tune from another model or another firmware version can bring the wrong Board Layout or trigger.

7.7 LOGS

A log records all ECU data several times per second. It is the most important tool for tuning and diagnosis.

- **Record:** in TunerStudio's *Data Logging* menu, *Start Logging*. Give it a name that says what you were testing.
- **Review:** open the file in MegaLogViewer (free) and look at RPM, MAP, AFR, timing and the active corrections together.
- **Trigger loggers:** TunerStudio has the *Tooth Logger* (time between teeth) and the *Composite Logger* (crank and cam together). They show the trigger wheel as the ECU sees it (chapters 9 and 17).

TIP Record a log on every start and every test, even if everything looks fine. When something goes wrong, comparing with a good log saves hours. If you contact support, send the log and the tune together.

7.8 UPDATING THE FIRMWARE

The firmware of SpeedTech ECUs is updated **only by SpeedTech**. If your installation needs a new version (a feature or a fix), arrange it with technical support. Don't load firmware from other sources: the ECU can stop working and the warranty is void.

CAUTION Save your tune before sending the ECU or before it is updated. A new firmware version may need a different configuration file in TunerStudio: after the update, detect the ECU again in the project.

08

CHAPTER 8

BASE SETUP

With everything wired and the ECU connected, configure it in this order with the engine off. When you finish each window, click Burn. Don't move on to the first start without completing this chapter.

IN THIS CHAPTER

1 The order

2 Engine Constants

3 Required Fuel

4 Injector Characteristics

5 Trigger Setup

6 Spark Settings and dwell

7 Sensor calibration

8 I/O Summary

9 Testing the outputs

8.1 THE ORDER

WINDOW	MENU
1 Engine Constants	Settings > Engine Constants
2 Injector Characteristics	Settings > Injector Characteristics
3 Trigger Setup	Settings > Trigger Setup
4 Spark Settings and Dwell	Spark > Spark Settings
5 Calibrate sensors	Tools
6 Check pins	Settings > I/O Summary
7 Test outputs	Hardware Testing > Test Output Hardware

TIP If you have a SpeedTech base map for your engine, load it first (section 7.6) and then check these windows one by one: the map brings starting values, but the Board Layout, trigger and sensors are those of your installation.

8.2 ENGINE CONSTANTS

Required Fuel	
1 Required Fuel	calculated
2 Control Algorithm	Speed Density
3 Squirts Per Engine Cycle	2
4 Injector Staging	Alternating
5 Engine Stroke	Four-stroke
6 Number of Cylinders	4
7 Injector Port Type	Port
8 Number of Injectors	4
9 Engine Type	Even fire

Board	
This is a critical setting!	
10 Board Layout	v0.4
11 Stoichiometric ratio	14.7
12 Injector Layout	Paired
13 MAP Sample method	Cycle Average
14 MAP Sample switch point	0

Burn Close

Figure 8.1 The *Engine Constants* window drawn with the same fields as TunerStudio. Example values for a port-injected 4-cylinder with the ST Mini.

- 1 Required Fuel.** Not typed by hand: it is calculated with the calculator button (section 8.3).
- 2 Control Algorithm.** *Speed Density* uses MAP: it is right for almost every engine. *Alpha-N* uses TPS: only for individual throttle bodies or very little vacuum.
- 3 Squirts per Engine Cycle.** How many times it injects per cycle. Paired: 2. Sequential: also 2 with *Alternating*; the ECU adjusts it by itself. 3 or 5 squirts need a cam sensor.
- 4 Injector Staging.** *Alternating* (recommended) spreads the squirts around each cylinder's TDC; *Simultaneous* fires all together with cylinder 1.
- 6 Cylinders and injectors (8):** those of your engine. *Injector Port Type* (7) doesn't change the calculation.
- 9 Engine Type.** *Even fire* except on odd-fire engines (some V6 and twins). In *Odd fire* you enter the angle of each channel.
- 10 Board Layout.** The most important setting: if it isn't your ECU's, the outputs won't work.
- 11 Stoichiometric ratio.** 14.7 for gasoline. With flex fuel, that of the base fuel.
- 12 Injector Layout.** *Paired*, *Semi-Sequential* or *Sequential* (section 5.4).
- 13 MAP Sample method.** *Cycle Average* or *Event Average* for 4 cylinders or more; *Cycle Minimum* for fewer than 4 or individual throttle bodies. *Instantaneous* for testing only.
- 14 MAP Sample switch point.** Below this RPM it uses the instantaneous reading (faster response at idle); above it, the chosen method. 0 disables it.

8.3 REQUIRED FUEL

Required Fuel is the time the injector would stay open to fill the cylinder with the engine at 100 % VE. The whole fuel map is calculated as a percentage of this number: if you change it later, fuel changes across the whole map.

- 1** First complete all the other Engine Constants fields.
- 2** Click the calculator button next to *Required Fuel*.
- 3** Enter the **total displacement**, the **number of cylinders**, the **flow of one injector** (cc/min or lb/h, from its data sheet, at your fuel pressure) and the **stoichiometric AFR**.
- 4** Accept: TunerStudio fills in the field. Click Burn.

CAUTION If you use staged injection (section 16.4), the flow entered in the calculator is the **sum** of one primary and one secondary injector.

8.4 INJECTOR CHARACTERISTICS

Injector Characteristics

Injector opening time

- 1 Injector Open Time
- 2 Battery Voltage Correction Mode
- 3 Injector Duty Limit
- 4 Injector close angles

injector data

Open Time only

85 %

355°

Burn Close

Figure 8.2 The *Injector Characteristics* window.

- 1 Injector Open Time:** the injector dead time (how long it takes to open and close). It comes from the data sheet; if you don't have it, almost all high-impedance injectors are between 0.9 and 1.5 ms at 12 V.
- 2 Battery Voltage Correction Mode:** whether the voltage correction applies only to the opening time (*Open Time only*, the usual) or to the whole pulse. The correction curve is in the same window: 100 % at 12 V.
- 3 Injector Duty Limit:** the maximum open time. If you reach it at full throttle, your injectors are too small.
- 4 Injector close angles:** the angle (after each cylinder's TDC) at which injection ends. 355° works for almost every engine; in sequential it can be set per channel.

8.5 TRIGGER SETUP

Trigger Settings

Trigger

- 1 Trigger Pattern
- 2 Primary base teeth
- 3 Primary trigger speed
- 4 Missing teeth
- 5 Trigger Angle
- 6 Skip Revolutions
- 7 Trigger edge
- 8 Secondary trigger edge
- 9 Missing Tooth Secondary type
- 10 Trigger Filter
- 11 Re-sync every cycle

Missing Tooth

36

Crank Speed

1

to measure

1

RISING

RISING

Single tooth cam

Weak

Yes

Burn Close

Figure 8.3 The *Trigger Settings* window with a 36-1 wheel on the crank and one tooth on the cam (example). Some fields are grayed out depending on the chosen pattern.

- 1 **Trigger Pattern:** the type of wheel. For missing-tooth wheels (36-1, 60-2, 24-1...) it is *Missing Tooth*; for others there are patterns named after the engine. They are all explained in chapter 9.
- 3 **Primary trigger speed:** *Crank Speed* if the wheel is on the crank; *Cam Speed* if it is on the camshaft or the distributor.
- 6 **Skip Revolutions:** how many revolutions the ECU waits when cranking before injecting and firing. 0 to 2; 1 avoids false syncs.
- 9 **Missing Tooth Secondary type:** which wheel is on the camshaft (section 9.4). Only needed for sequential.
- 11 **Re-sync every cycle:** looks for sync again on every cycle instead of just counting teeth. Recommended; if the signal is noisy and sync drops now and then, try disabling it.
- 2 **Primary base teeth and Missing teeth (4):** count the teeth on your wheel, including the missing ones.
- 5 **Trigger Angle:** the degrees after TDC at which tooth 1 passes the sensor (section 9.2). It is confirmed with the timing light (section 10.7).
- 7 **Trigger edge and Secondary trigger edge (8):** which edge of the signal the ECU reads. If sync fails or timing moves with RPM, try the other one.
- 10 **Trigger Filter:** ignores pulses that arrive earlier than expected (noise). Use the lowest setting at which the engine doesn't lose sync: a filter that is too strong can discard good teeth.

8.6 SPARK SETTINGS AND DWELL

Spark Settings

Spark		Locked timing	
1	Ignition load source	5	Enabled Fixed/Locked timing
2	Spark output mode	6	Fixed Angle
3	Cranking advance Angle	7	Enable per tooth timing
4	Spark Outputs triggers		

Buttons: Burn, Close

Figure 8.4 The *Spark Settings* window. Fixed timing (5 and 6) is used only to calibrate with the timing light.

- 1 **Ignition load source:** the load axis of the advance table; normally the same as for fuel (MAP).
- 2 **Spark output mode:** according to your wiring (section 6.2).
- 3 **Cranking advance Angle:** the fixed timing while the engine is cranking. It ignores the advance table.
- 4 **Spark Outputs triggers:** *Going Low* on all SpeedTech ECUs (section 6.7).
- 5 **Fixed/Locked timing:** locks timing at a single value for calibration. When cranking, the cranking timing applies. Turn it off when you finish.
- 7 **Per tooth timing:** calculates the spark tooth by tooth; it improves accuracy with almost every wheel. If you see unstable timing, try disabling it.

Then open **Spark > Dwell settings** and set the dwell for your coil (section 6.7).

CAUTION Set the dwell before cranking for the first time.

8.7 SENSOR CALIBRATION

SENSOR	MENU	HOW
TPS	Tools > Calibrate TPS	Throttle released: <i>Get Current</i> for closed. Wide open: <i>Get Current</i> for open. Do it with the throttle body already fitted on the engine.
CLT and IAT	Tools > Calibrate Temperature Sensors	Choose your sensor from the list, or enter three points (temperature and resistance) from its data sheet.
MAP	Tools > Calibrate Pressure Sensors	Built-in MAP: MPXH6400A (4 bar) on the ST Mini, ST-02 and ST-04; MPX5700A (7 bar) on the ST-100. The external and barometric sensors are also chosen here, if you use them.
Voltage	Tools > Calibrate Voltage Reading	Compare with the multimeter at the battery and adjust if needed.
Wideband	Tools > Calibrate AFR Sensor	Choose your controller from the list, or <i>Custom Linear WB</i> with two points (voltage and AFR) from its manual (ST-02, ST-04 and ST-100).

Temperature sensor not on the list: measure its resistance at three temperatures (for example in ice water, at room temperature and in boiling water) with a thermometer, letting it settle for a few minutes at each. Enter the three points and click *Write to Controller*.

Sensor filters: [Tools > Set analog sensor filters](#) smooths the analog readings. Almost no installation needs to change the default values; more filtering gives steadier but slower readings.

8.8 I/O SUMMARY

[Settings > I/O Summary](#) shows in a single window which pin each enabled function uses (fuel pump, fan, tachometer, clutch, boost, VVT...). Use it to confirm that no function is left without a pin or shares a pin with another.

8.9 TESTING THE OUTPUTS

With [Hardware Testing > Test Output Hardware](#) you switch each output by hand, without starting the engine. Click *Enable Test Mode*, test, and when you finish *Stop Test Mode*:

- **Injectors:** with the fuel pump disconnected, listen for each one clicking.
- **Coils:** with a spark plug out and grounded, confirm it sparks on the right cylinder.
- **Fuel pump and fan:** their relays should click on.

DANGER With fuel pressure, testing injectors fills the cylinder with fuel and can lock the engine (hydrolock). Disconnect the pump first. Don't touch plugs or HT leads while testing coils, and don't leave an ignition output on for long: the coil gets hot.

09 TRIGGER PATTERNS

The ECU calculates everything from the trigger wheel: RPM, when to inject and when to fire. If the pattern, tooth 1 or the Trigger Angle are wrong, the engine won't start or starts with the wrong timing.

IN THIS CHAPTER

1 How the ECU reads rotation

2 Tooth 1 and Trigger Angle

3 Missing teeth

4 With cam sensor

5 Wheel on the camshaft

6 Dual Wheel

7 Distributor

8 Factory patterns

9 Sync options

9.1 HOW THE ECU READS ENGINE ROTATION

The crank sensor produces one pulse per tooth. By timing the gaps between teeth the ECU knows the RPM; by recognizing a mark on the wheel (a gap, an extra tooth or the cam signal), it knows **at what angle** the crank is. Once it knows that, it has **sync** and starts injecting and firing.

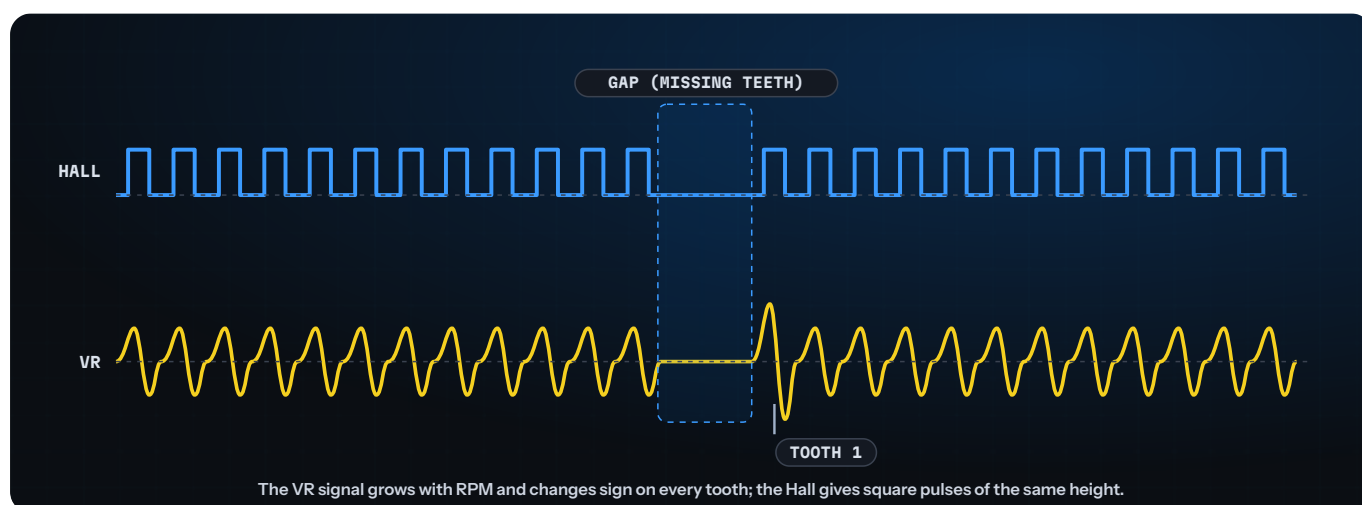


Figure 9.1 This is how the ECU sees a missing-tooth wheel: the gap is the longest time between two teeth, and the first tooth after the gap is tooth 1. The trigger is diagnosed with these logs (TunerStudio's Tooth Logger and Composite Logger).

With the crank alone, the ECU knows the position within one revolution, but not whether cylinder 1 is on compression or exhaust (the 4-stroke cycle takes two revolutions). That requires the cam signal. Without it the engine runs paired and wasted spark; with it, sequential.

NOTE The ST Mini has a single trigger input (crank). It can use the patterns that work with one signal: missing teeth on the crank, a wheel on the camshaft or distributor, and some factory patterns. The ST-02, ST-04 and ST-100 also have the cam input.

9.2 TOOTH 1 AND TRIGGER ANGLE

Tooth 1 is the first tooth that passes the sensor after the mark on the wheel (on a missing-tooth wheel, the first one after the gap). The **Trigger Angle** says how many degrees after cylinder 1 TDC that tooth passes the sensor. With these two pieces of data the ECU locates TDC.

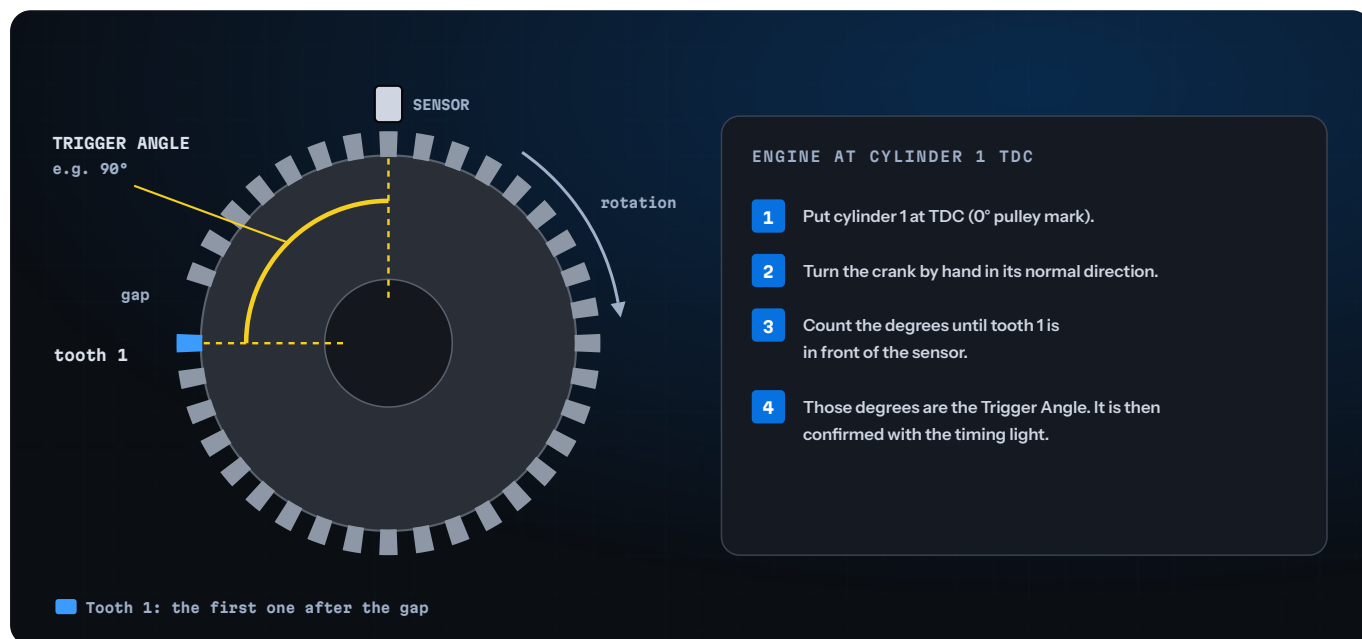


Figure 9.2 36-1 wheel seen with the engine at cylinder 1 TDC. The Trigger Angle is the crank degrees from TDC until tooth 1 (the first after the gap) passes the sensor. The 90° value is only an example: every engine has its own.

- 1 Remove the spark plugs so the engine turns easily by hand.
- 2 Put cylinder 1 at TDC on compression with the pulley mark at 0°.
- 3 Mark the sensor position on the wheel (or note where the sensor sits).
- 4 Turn the crank in its normal direction until tooth 1 is in front of the sensor, counting the degrees with the pulley scale or a degree wheel.
- 5 Enter that value in *Trigger Angle* (from -360° to 360°). You then confirm it with the timing light (section 10.7).

TIP If you can't measure it, enter an approximate value and adjust it with the timing light: with fixed timing at 10°, change the Trigger Angle until the light shows 10° on the pulley. An error of more than 20° almost always means tooth 1 or the pattern is wrong, not the angle.

9.3 MISSING-TOOTH WHEELS

The most common pattern, both factory and aftermarket: evenly spaced teeth and a gap where one or more are missing. Wheels with many teeth (36-1, 60-2) give very good accuracy.

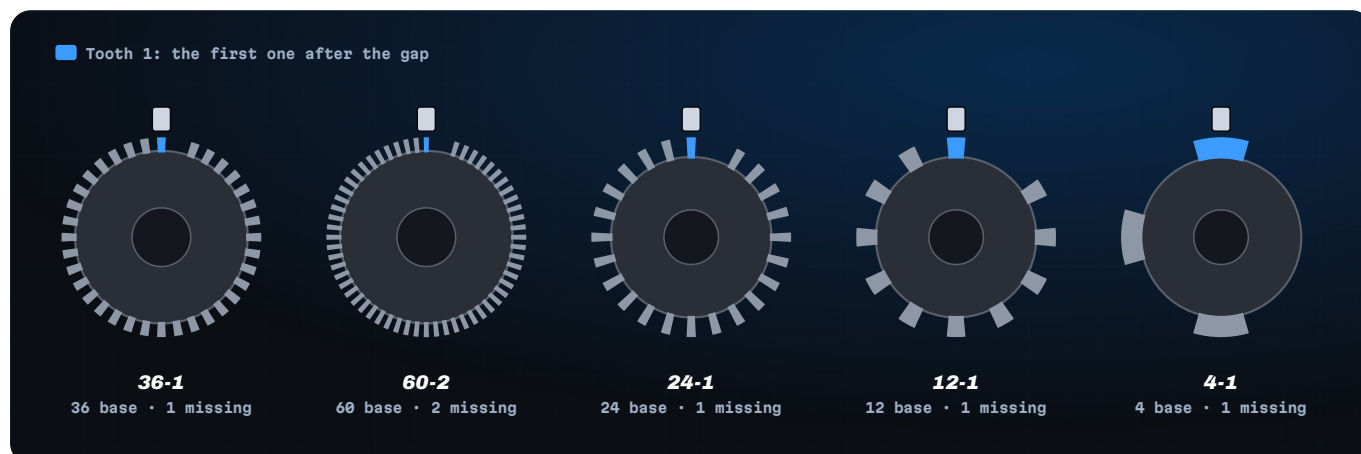


Figure 9.3 Most common missing-tooth wheels, all with tooth 1 in front of the sensor. In TunerStudio you enter the number of teeth as if none were missing (36, 60, 24...) and, separately, how many are missing.

WHEEL	TRIGGER PATTERN	PRIMARY BASE TEETH	MISSING TEETH
36-1	Missing Tooth	36	1
60-2	Missing Tooth	60	2
24-1	Missing Tooth	24	1
12-1	Missing Tooth	12	1
4-1	Missing Tooth	4	1

- The missing teeth must be **all together**, in a single gap. A wheel such as 36-1-1 (two separate gaps) is not Missing Tooth.
- A name with a slash, such as 36-1/1, refers to cam teeth, not missing teeth. One with "+", such as 12+1, means an **extra** tooth: that isn't Missing Tooth either.
- The wheel must turn at an even speed while cranking: the ECU recognizes the gap because it takes longer than the other teeth. With a weak battery or a tired starter motor, the engine "stumbles" on compression and the ECU can get confused.

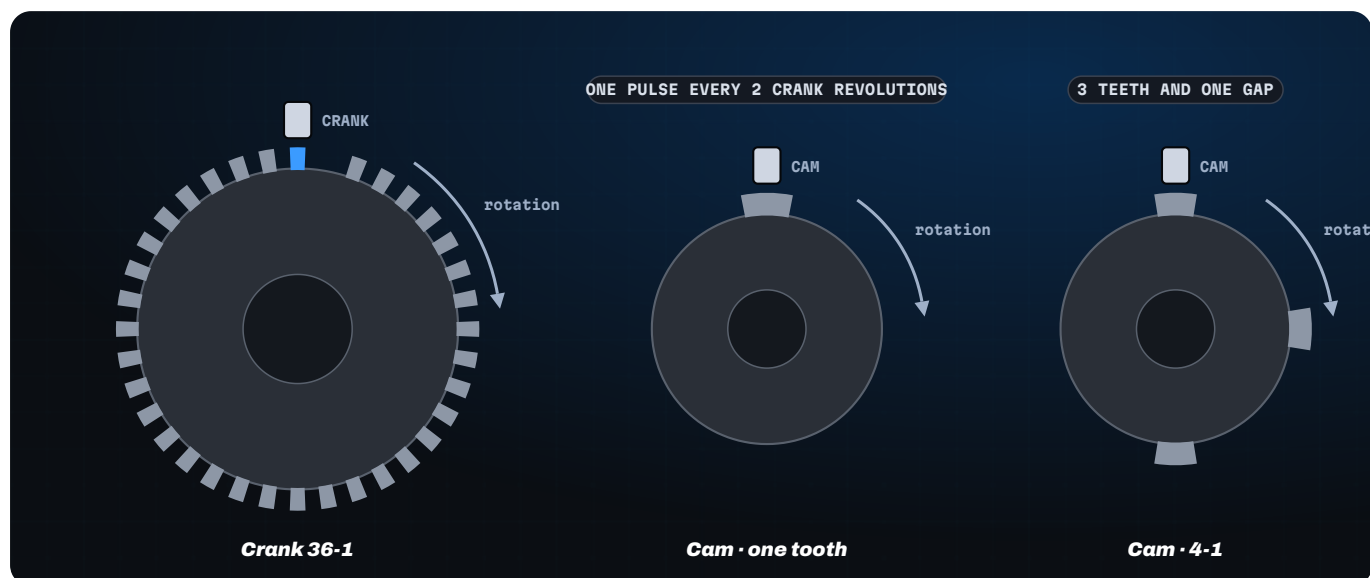


Figure 9.4 For sequential injection or ignition (ST-04 and ST-100) the ECU needs, besides the crank, a camshaft signal that says which revolution of the cycle the engine is on: a single tooth (or half-moon) per camshaft revolution, or a 4-1 wheel.

For sequential, a wheel is added on the camshaft and its type is chosen in *Missing Tooth Secondary type*:

SECONDARY TYPE	WHAT WHEEL IT IS
Single tooth cam	A single tooth (or half-moon) per camshaft revolution: one pulse every two crank revolutions.
4-1 cam	A 4-tooth wheel with one missing tooth on the camshaft.
Poll level	The ECU doesn't count cam pulses: it checks whether the signal is high or low when tooth 1 passes. <i>Level for 1st phase</i> says which level belongs to the first revolution.
Rover 5-3-2 cam	The cam wheel of some Rover engines.
Toyota 3 Tooth	The 3-tooth cam wheel of several Toyota and Lexus engines.

CAUTION If you choose sequential injection or ignition, the ECU **waits** for the cam signal: without it, it won't sync. If you only want paired and wasted spark, it isn't needed.

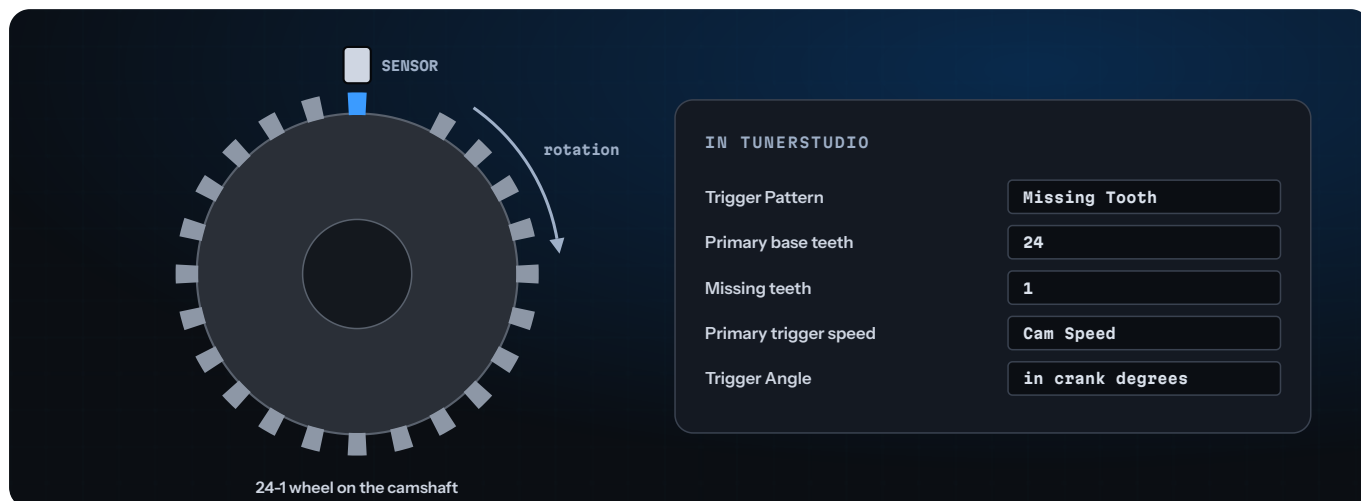


Figure 9.5 Missing-tooth wheel on the camshaft (or in the distributor). It turns at half crank speed, so the gap appears once per complete cycle and also works as the phase signal. It must have at least as many teeth as cylinders.

A missing-tooth wheel mounted on the camshaft (or on a distributor shaft) turns at half crank speed: the gap appears only once per complete cycle, so the same wheel gives position **and** phase. It allows sequential with a single signal. In TunerStudio it is *Missing Tooth* with *Primary trigger speed: Cam Speed*, and the Trigger Angle is still measured in crank degrees.

NOTE Accuracy is slightly lower than with the wheel on the crank, because of timing chain or belt slack. Use as many teeth as fit; at least as many as cylinders (not counting the missing one).

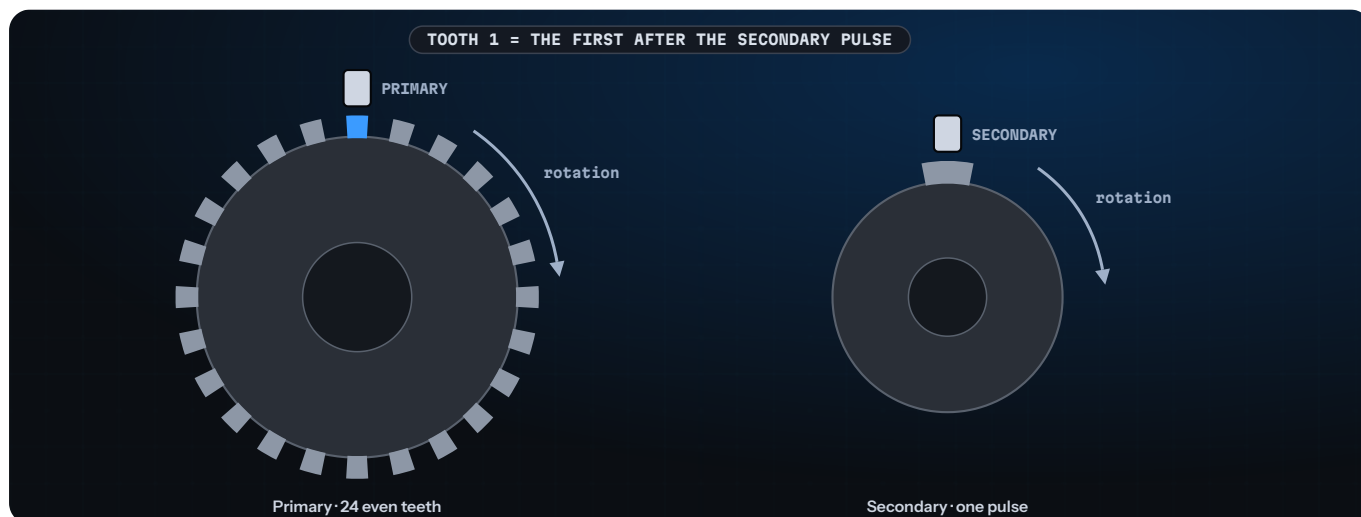


Figure 9.6 Dual Wheel: a primary wheel with all teeth equal (no gaps) and a secondary with a single pulse per revolution. The number of teeth must divide 360 evenly. For sequential, the secondary must be on the camshaft.

A primary wheel with evenly spaced teeth plus a secondary with a single pulse per revolution. It is common on European engines and as an aftermarket kit. Tooth 1 is the first primary tooth after the secondary pulse. If the primary is on the camshaft or in the distributor, enter all its teeth in *Primary base teeth* and choose *Primary trigger speed: Cam Speed*. *Re-sync every cycle* helps if the signal is noisy.

9.7 DISTRIBUTOR (BASIC DISTRIBUTOR)

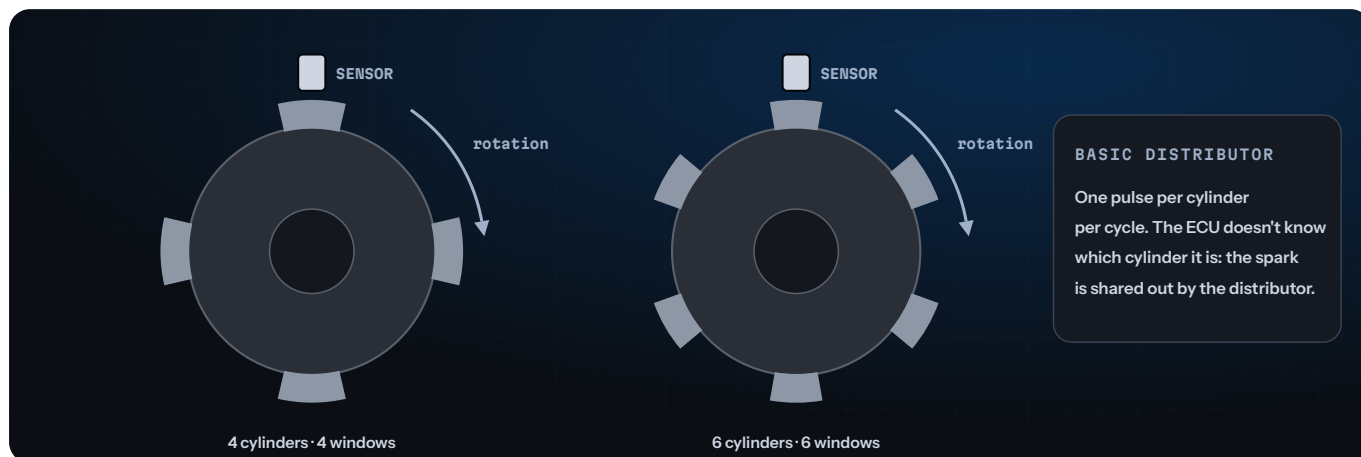


Figure 9.7 Distributor wheel (Basic Distributor): one pulse per cylinder, no missing teeth. It works, but with little resolution; if you can, switch to a missing-tooth wheel on the crank.

One pulse per cylinder, like points or electronic distributors gave. The ECU can't tell which cylinder it is, so the distributor has to share out the spark (*Spark output mode: Single Channel*). With few pulses per revolution, timing accuracy is low: if you will use the ECU for ignition, consider fitting a missing-tooth wheel on the crank.

9.8 FACTORY PATTERNS

For many engines there is no need to change the wheel: TunerStudio has the original pattern. On almost all of them the factory Trigger Angle barely needs adjusting; confirm it with the timing light anyway.

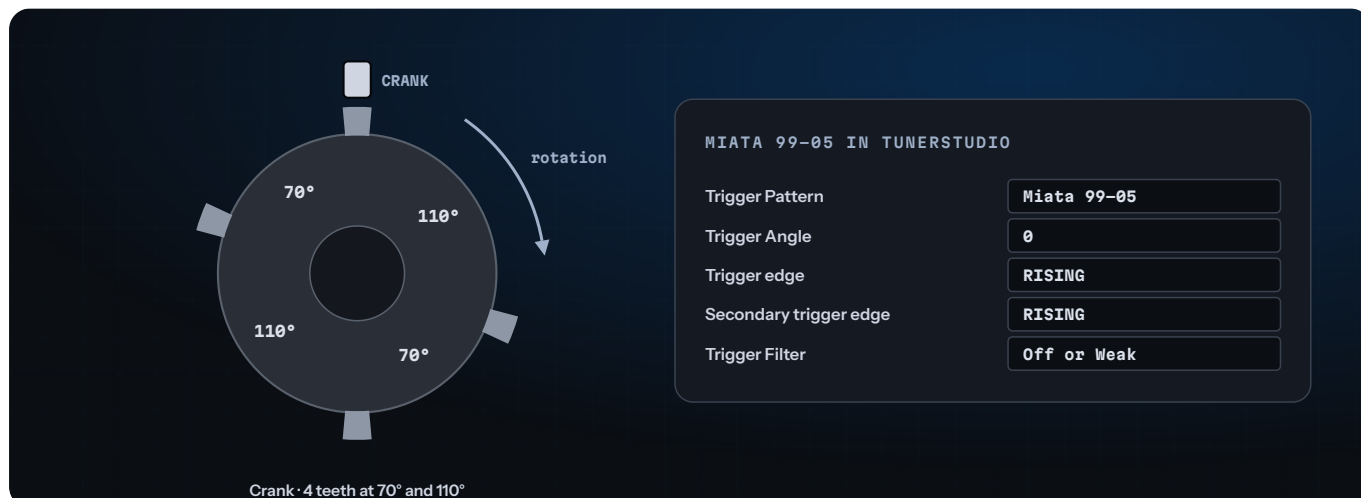


Figure 9.8 Miata 1999-2005: 4-tooth crank wheel with teeth 70° and 110° apart, plus a 3-tooth cam wheel. The ECU syncs by counting cam pulses between each crank tooth, even when the VVT moves the camshaft.

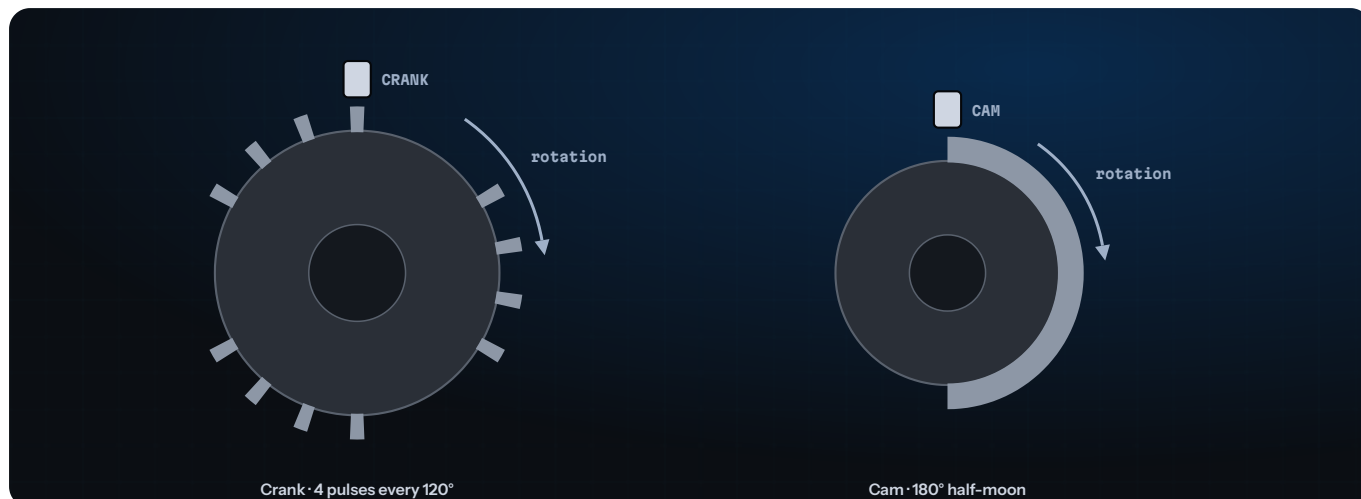


Figure 9.9 Jeep 2000: the crank gives groups of 4 pulses 20° apart, one group every 120°; the camshaft has a half-moon covering half a turn (360° of crank).

TRIGGER PATTERN	TYPICAL ENGINES	SIGNALS AND KEY SETTINGS
4G63 / Miata / 3000GT	Mitsubishi 4G63, Miata up to 1997	Crank and cam (Hall or optical). Enable <i>Fix cranking timing with trigger</i> in Cranking Settings.
Miata 99-05	Miata 1999-2005	4 teeth on the crank and 3 on the cam. Trigger Angle 0, both edges RISING, filter Off or Weak. Works with the VVT.
Honda D17	Honda with 12+1 wheel	12 teeth plus one extra on the crank; tooth 1 is the one after the extra. Without the cam signal: up to semi-sequential and wasted spark.
Nissan 360	CA18, SR20, RB25/26 and others with optical CAS	360 slots in the distributor and inner slots of different sizes. Both edges falling, filter Off, Re-sync Yes. Some 4-cylinder CAS versions are not compatible.
36-2-2-2	Subaru from about 2000 (H4 and H6)	Crank with three 2-tooth gaps. Trigger Angle 0, edge FALLING, Skip Revolutions 1, filter Weak. The H4 and H6 versions differ.
Subaru 6/7	Earlier Subaru	6 teeth on the crank and 7 on the cam. Calibrate the Trigger Angle with the timing light.
GM 24X	GM with 24 teeth	12 wide and 12 narrow teeth. Using <i>Dual Wheel</i> with 24 teeth and edge FALLING is recommended.
GM 7X	GM with 7-notch wheel	6 equal notches and one unequal.
Jeep 2000	Jeep 4.0 and similar	4 pulses every 120° on the crank and a half-moon on the cam.
Chrysler NGC	Chrysler, Jeep and Dodge from 2002	36+2-2 wheel. Trigger Angle around 30° on 4 cylinders and 210° on 6 and 8. Per tooth timing recommended.
Ford ST170	Ford Focus ST170	36-1 on the crank and 5 teeth on the cam (sequential and VVT).
DSM 420a	Mitsubishi Eclipse, Neon	Crank and cam.
Audi 135 / Non-360 Dual	Audi V6, I5 and others	135 pulses per revolution; Non-360 is for tooth counts that don't divide 360. Use <i>Trigger angle multiplier</i> .
K6A	Suzuki K6A 3-cylinder	6+1 teeth on the camshaft. Enable per tooth timing and calibrate the angle with the timing light.

TunerStudio also has *Basic Distributor*, *Mazda AU*, *Daihatsu +1*, *Harley EVO*, *36-2-1*, *Weber-Marelli*, *DRZ400*, *Yamaha Vmax 1990+*, *Renix*, *Rover MEMS* and *Honda J32*.

CAUTION Some factory patterns are recent or have been tested on few engines. Before using one on a street car, record a Composite Logger capture and contact us if in doubt.

9.9 OPTIONS THAT HELP SYNC

OPTION	WHERE	WHEN TO USE IT
Trigger edge	Settings > Trigger Setup	If the engine doesn't sync or the timing light reading moves as RPM rises, try the other edge and recalibrate the Trigger Angle.
Skip Revolutions	Settings > Trigger Setup	1 or 2 if there are backfires or early sparks when cranking.
Trigger Filter	Settings > Trigger Setup	Raise it one level if you lose sync from noise; lower it if the engine loses sync at high RPM.
Re-sync every cycle	Settings > Trigger Setup	Normally on; turn it off if the signal is noisy and sync drops now and then.
Enable per tooth timing	Spark > Spark Settings	More accurate timing. Essential on wheels with few teeth such as K6A.
Fix cranking timing with trigger	Startup/Idle > Cranking Settings	Only on low-tooth patterns that have a pulse aligned with cranking timing: Basic Distributor, 4G63 / Miata / 3000GT, Miata 99-05 and Mazda AU.

10 STARTING AND WARM-UP

With the base setup done, the goal of the first start isn't a perfect engine: it is to start, sync and keep running so you can calibrate the timing. After that, to start just as well cold and hot.

IN THIS CHAPTER

1 Before cranking

2 Priming

3 Cranking Settings

4 Afterstart (ASE)

5 Warmup

6 First start step by step

7 Timing with a timing light

8 First minutes

10.1 BEFORE CRANKING

- Go through the whole checklist in appendix C.
- Have TunerStudio connected and a log recording.
- A well-charged battery: with low voltage the ECU miscalculates dwell and injection, and the engine cranks slowly.

When starting, the ECU goes through several phases, each with its own window:

PHASE	WHEN	WHAT IS ADJUSTED	MENU
Priming	When the key is turned on	One shot of fuel to wet the cylinders	Startup/Idle > Priming Pulsewidth
Cranking	Engine turning on the starter	Extra fuel and fixed cranking timing	Startup/Idle > Cranking Settings
Afterstart (ASE)	The first seconds after firing	Extra fuel that tapers off	Startup/Idle > Afterstart Enrichment (ASE)
Warmup (WUE)	Until the engine reaches temperature	Extra fuel depending on temperature	Startup/Idle > Warmup Enrichment

10.2 PRIMING

When the ECU is powered, all injectors give one pulse to fill the intake with fuel. The pulse length ([Startup/Idle > Priming Pulsewidth](#)) depends on engine temperature: longer when cold. Keep it as short as possible so you don't flood the engine; ethanol fuels (E85) need longer pulses.

10.3 CRANKING SETTINGS

Cranking	
1	Cranking RPM (Max) ≈100 above your cranking
2	Flood Clear level 90 %
3	Fuel pump prime duration seconds
4	Injectors priming delay seconds
5	Cranking enrichment taper time seconds

Cranking Timing	
6	Cranking advance Angle 10°
7	Add cold advance No
8	Cranking bypass Off
9	Fix cranking timing with trigger Off

Burn Close

Figure 10.1 The *Cranking Settings* window. The cranking enrichment curve (*Cranking Enrichment*) is in the same window.

- 1 Cranking RPM (Max):** below this RPM the ECU considers the engine to be cranking. Set it about 100 RPM above the speed your engine turns on the starter.
- 2 Flood Clear level:** if you crank with the throttle above this value, the ECU neither injects nor fires: it clears a flooded engine.
- 3 Fuel pump prime duration:** seconds the pump runs when the ECU is powered, to build pressure.
- 4 Injectors priming delay:** how long it waits after turning on the pump before the priming pulse, so there is already pressure.
- 5 Cranking enrichment taper time:** how long it takes to move from cranking enrichment to afterstart, so there is no step.
- 6 Cranking advance Angle:** fixed timing while cranking. A low value (5 to 10°) avoids kickback on the starter motor.
- 7 Add cold advance:** adds the cold engine advance (section 12.4) to the cranking timing.
- 8 Cranking bypass:** only for old ignition modules that handle their own timing when cranking; the ECU switches an output once the engine has fired.

Cranking Enrichment is a curve against engine temperature: the percentage of extra fuel while cranking (100 % = no change). It adds to the other active corrections, such as warmup.

10.4 AFTERSTART (ASE)

For a few seconds after firing, the engine needs a little more fuel to go smoothly from cranking to idle.

Startup/Idle > Afterstart Enrichment (ASE) has two curves against temperature: **how much** to enrich and **for how long**. When it finishes, the enrichment drops to zero over the *Transition time to disable*.

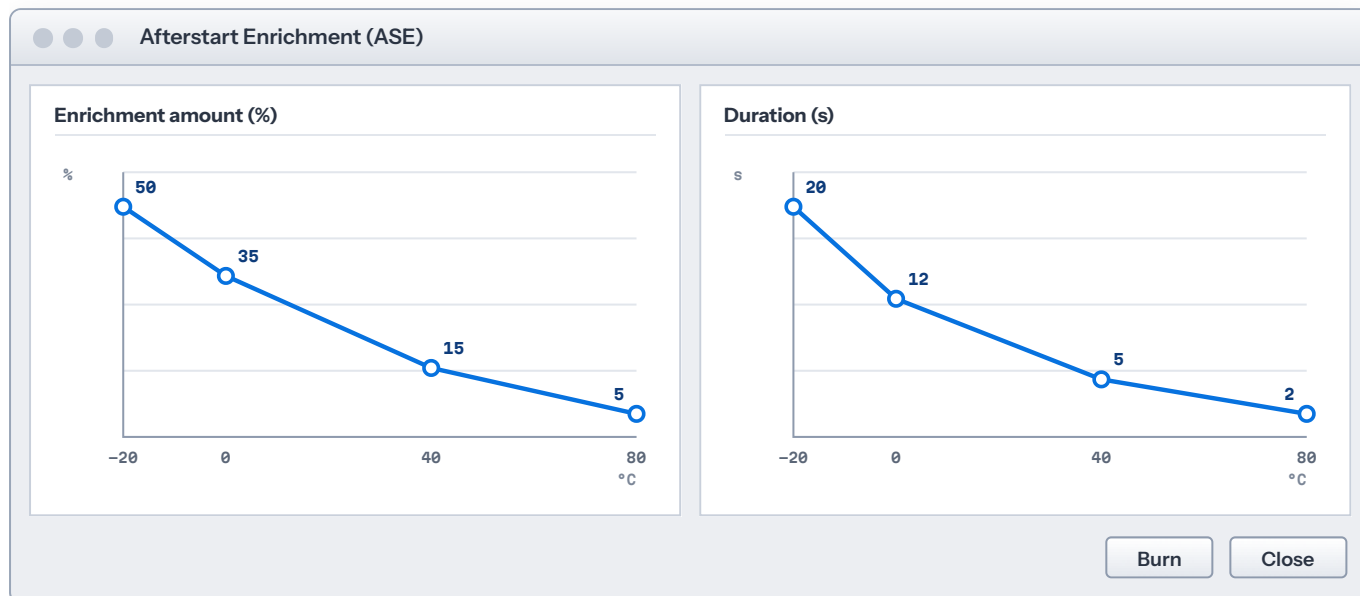


Figure 10.2 Typical shape of the afterstart curves: more fuel for longer with a cold engine. As a reference, around 50 % cold and 5 % hot, and from 20 s cold to 1 or 2 s hot. Example values: every engine needs its own.

10.5 WARMUP

The **Startup/Idle > Warmup Enrichment** curve adds fuel while the engine warms up, based on coolant temperature. The last point of the curve is the normal operating temperature and must be **100 %** (no change): from there on the curve has no effect.

TIP Tune the warmup over several days, starting cold every morning with a log recording. Compare the actual AFR with the target as the temperature rises and correct the matching point of the curve.

10.6 FIRST START STEP BY STEP

- 1** Crank and watch the RPM in TunerStudio: steady values should appear as soon as the engine turns, and the indicator should go to *Full Sync* (or *Half Sync* if there is no cam sensor and you don't use sequential).
- 2** If the RPM stays at zero or jumps around, the problem is the trigger: check chapter 9 and section 17.1 before trying again.
- 3** If it syncs but doesn't fire, check spark and fuel with the output test (section 8.9).
- 4** If it fires and dies, raise the afterstart and warmup and check the AFR in those seconds.
- 5** Once it keeps running, move straight on to calibrating the timing.

10.7 CALIBRATING TIMING WITH A TIMING LIGHT

- 1** In [Spark > Spark Settings](#) enable *Enabled Fixed/Locked timing* with an easy-to-read *Fixed Angle*, for example 10°.
- 2** With the engine running, aim the timing light at the pulley marks.
- 3** If the mark doesn't line up with 10°, change **Trigger Angle** in [Settings > Trigger Setup](#) until it does.
- 4** Raise the RPM to 3000: the mark must stay still. If it moves, try the other *Trigger edge* and recalibrate.
- 5** Disable the fixed timing and click Burn.

CAUTION With wasted spark ignition some timing lights show double sparks. Always use the cylinder 1 mark.

10.8 FIRST MINUTES

- Let the engine reach operating temperature while watching CLT, AFR and voltage.
- Check that the fan comes on at its temperature (section 15.2).
- Check for fuel leaks, vacuum leaks and exhaust leaks before the wideband sensor.
- Save a backup of the tune: it is your starting point.

11

CHAPTER 11

FUEL TUNING

Tuning fuel means adjusting the VE table until the actual AFR is the one you asked for, in every RPM and load area. Then the transitions (acceleration and deceleration) and the corrections are adjusted.

IN THIS CHAPTER

1 How fuel is calculated

2 The VE table

3 Target AFR

4 How to tune VE

5 Acceleration

6 Deceleration

7 Corrections

8 Closed loop

9 Second table

10 Per-cylinder trim

11.1 HOW THE ECU CALCULATES FUEL

For each injection the ECU starts from the **Required Fuel** (section 8.3) and multiplies it by the **VE table** value in the cell where the engine is, by the **MAP pressure** and by every active **correction** (warmup, afterstart, air temperature, barometer, acceleration, closed loop...). Finally it adds the injector opening time.

That is why tuning order matters: first VE with the engine hot and stable; then the starting, warm-up and transition corrections.

11.2 THE VE TABLE

Tuning > VE Table is a 16 × 16 table: RPM on the horizontal axis and load (MAP in kPa with Speed Density, TPS with Alpha-N) on the vertical one. Each cell says what percentage of Required Fuel is injected at that point. Between cells, the ECU interpolates.

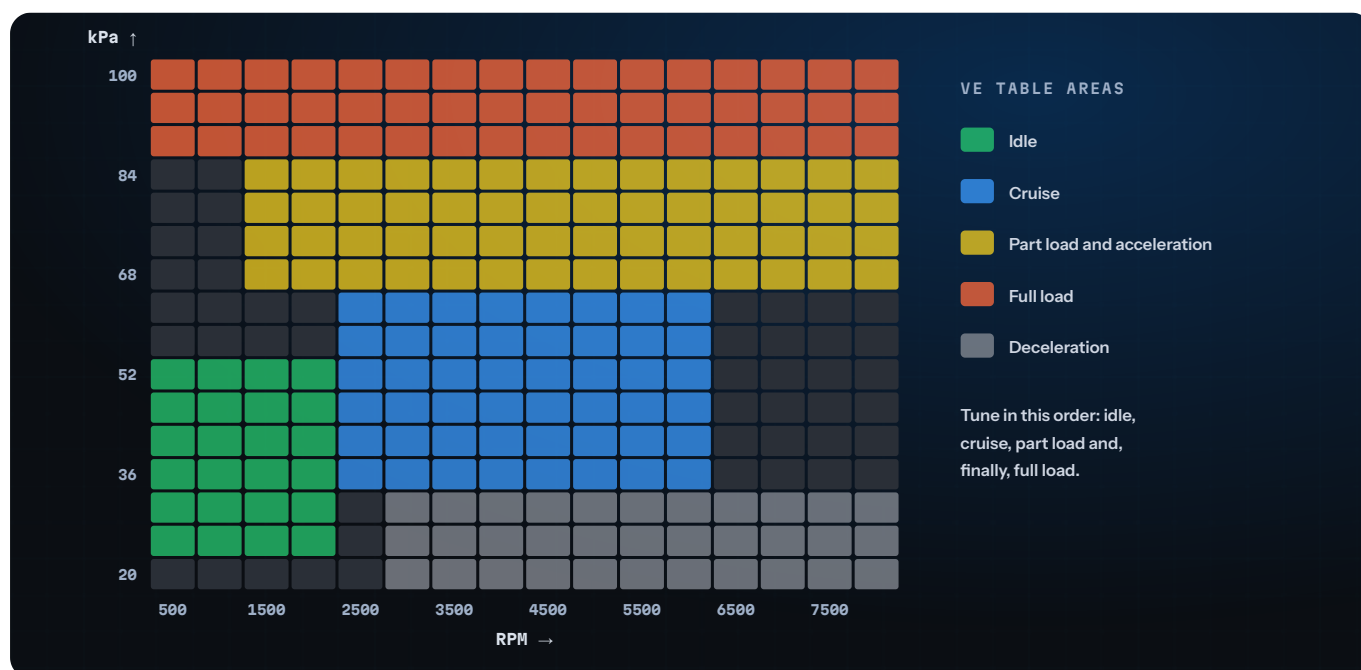


Figure 11.1 Where the engine works within the VE table of a naturally aspirated engine (the axes are examples). Idle and cruise are the areas used most on the street: give them more divisions on the axes.

- **Axes:** put more divisions where the engine spends more time and changes faster: low and mid RPM, and idle to cruise loads. Leave one row below idle vacuum and one column below idle RPM.
- **Maximum load:** on a naturally aspirated engine the top row is atmospheric pressure (about 100 kPa). With a turbo or supercharger, add rows up to the maximum pressure you will use, with margin.
- **Maximum RPM:** up to the rev limiter. There is no need to go beyond.
- **Shape:** VE follows the engine's torque curve: it is highest where the engine makes peak torque. On a naturally aspirated engine, a good starting point is close to 100 in the peak-torque cell at full load, and lower values elsewhere.
- **Changing the axes later** shifts every cell: define the axes before tuning.

Below the table is **Multiply VE value by MAP ratio:** *Fixed* (recommended for new tunes) multiplies each cell by the MAP pressure, so the table stays flatter and more predictable; *Baro* uses the measured barometric pressure; *Off* disables it. The *Legacy Options* are only for old tunes.

CAUTION Changing *Multiply VE value by MAP ratio* or the AFR options means retuning the whole VE table.

11.3 TARGET AFR

[Tuning > AFR Target Table](#) (or *Lambda Target Table* if you work in lambda) says which mixture you want in each area. The ECU uses it for closed loop and for VE Analyze; it doesn't change fuel by itself, unless you enable the options that include it in the calculation.

AREA	STARTING POINT (GASOLINE)
Idle and cruise	Close to stoichiometric (14.7, lambda 1.0).
Medium load	A little richer as load rises.
Full load, naturally aspirated	Quite a bit richer than stoichiometric, for power and exhaust temperature.
Full load with turbo	Richer still: the mixture cools the chamber and protects against knock.

NOTE Final values depend on the engine, the fuel and the use. If you have no experience with turbo engines, start richer than needed and lean it out gradually with a reliable wideband.

11.4 HOW TO TUNE VE

- 1 Start at idle and light load, with the engine hot and closed loop disabled.
- 2 Compare the actual AFR (wideband) with the target in the active cell.
- 3 If the actual AFR is higher (lean), raise that cell's VE; if it is lower (rich), lower it. Small changes, 2 to 5 %.
- 4 Move to higher load and RPM gradually, never to full throttle until the lower areas are right.
- 5 Smooth neighboring cells so the table has no steps; in the 3D view ([3D Tuning Maps > Fuel Table](#)) they show up immediately.
- 6 Record logs and check cell by cell where the error ended up.

TIP The registered version of TunerStudio includes **VE Analyze Live**: it compares actual AFR with the target while you drive and proposes VE changes. Use it once you have a reasonable VE, never to start from scratch, and review every change before accepting it.

11.5 ACCELERATION ENRICHMENT

Acceleration Enrichment

1 Enrichment mode

2 Enrichment method

3 TPSdot Threshold

4 Min. TPS change

5 Accel Time

6 Taper Start RPM

7 Taper End RPM

Cold adjustment

8 Cold adjustment

9 Cold adjustment taper start temperature

10 Cold adjustment taper end temperature

Burn **Close**

Figure 11.2 The *Acceleration Enrichment* window. At the top it has the enrichment curve against throttle speed and a live graph with TPSdot and AFR.

When the throttle snaps open, air gets in before fuel and the mixture goes lean for an instant. The ECU adds fuel depending on how fast the throttle moves (**TPSdot**, in %/s) or how fast MAP rises (**MAPdot**). 100 %/s is full throttle in one second; 1000 %/s, in a tenth.

- 1 **Enrichment mode:** TPS (the usual, needs a calibrated TPS) or MAP.
- 3 **TPSdot / MAPdot Threshold:** below this speed there is no enrichment. Raise it in 5 %/s steps if it triggers by itself without moving the pedal (TPS noise).
- 5 **Accel Time:** how long the enrichment lasts. If the AFR is fine at first and then goes lean, raise it by 10 to 20 ms.
- 6 **Taper Start / End RPM:** at higher RPM less enrichment is needed; between these two RPM it goes from 100 % to zero.
- 8 **Cold adjustment:** a cold engine needs more; this percentage applies at the start temperature and drops to zero at the end temperature.

- 1 With the engine hot and the car stopped, blip the throttle fast and slow while watching the live graph.
- 2 If the engine stumbles or the AFR goes lean when accelerating, raise the curve at the matching TPSdot.
- 3 If it bogs, blows black smoke or the AFR goes very rich, lower it.
- 4 Confirm by driving, with logs.

11.6 DECELERATION

In the same window: **Deceleration Enleanment** removes fuel when the throttle snaps shut (*Fuel Amount*, in %). **Deceleration Fuel Cutoff (DFCO)** cuts injection completely when you lift off at high RPM, to save fuel and avoid backfires.

DFCO FIELD	WHAT IT DOES
Enabled	Enables the cut.
TPS Threshold	Only cuts with the throttle below this value.
Minimum engine temperature	Doesn't cut with a cold engine.
Cutoff delay	Seconds the conditions must hold before cutting.
Cutoff RPM / RPM Hysteresis	Cuts above this RPM; the hysteresis stops it from cutting in and out when RPM oscillates.
Enable cutoff taper	Removes fuel and timing gradually (taper time, fuel amount and advance remove) instead of cutting at once.

11.7 CORRECTIONS

CORRECTION	MENU	WHAT FOR
IAT Density	Settings > IAT Density	Hot air has less oxygen: the curve removes fuel as air temperature rises. The default curve suits almost everyone; with a turbo or a lot of underhood heat the hot end may need adjusting.
Barometric Correction	Settings > Barometric Correction	Corrects fuel for barometric pressure (altitude). 100 % = no correction. Most useful with Alpha-N.
Fuel Temp Correction	Tuning > Fuel Temp Correction	Correction for fuel temperature; it only appears with flex fuel enabled.

NOTE Barometric pressure is read by the MAP sensor when the key is turned on, before starting. On the ST-04 a separate barometric sensor can be used on the external MAP input.

With the sensor connected, [Tuning > AFR/O2](#) corrects fuel live by comparing actual AFR with the target. **It doesn't replace a good tune:** many good tunes use it with very little authority, or not at all.

The screenshot shows the 'AFR/O2' window with two main sections: 'Sensor' and 'Conditions'. The 'Sensor' section includes: 1. Sensor Type (Wide Band), 2. Algorithm (PID), 3. Ignition Events per Step (2 to 5), 4. Controller Auth +/- (≤ 20 %), and 5. Only correct above / below (sensor range). The 'Conditions' section includes: 6. Active Above Coolant (operating temp.), 7. Active Above RPM (above idle), 8. Active Below TPS (%), 9. Active Below / Above MAP (kPa), 10. EGO delay after start (15 s), and 11. PID P / I / D (%). At the bottom right are 'Burn' and 'Close' buttons.

Figure 11.3 The AFR/O2 window with reference values. Calibrate the sensor first in [Tools > Calibrate AFR Sensor](#).

- 1 Sensor Type:** *Wide Band* (0-5 V, recommended) or *Narrow Band* (0-1 V, only knows rich or lean).
- 2 Algorithm:** *PID* is recommended with a wideband. *Simple* is for narrowband and oscillates if VE isn't right. *No correction* only shows the AFR.
- 3 Ignition Events per Step:** how many sparks between recalculations. The sensor takes time to see the change; 2 to 5 is normal.
- 4 Controller Auth:** the maximum it can correct. No more than 20 %; if it needs more, the VE is wrong.
- 6 Conditions:** only with the engine hot, above idle and away from full load.
- 10 EGO delay after start:** the sensor needs to warm up; 15 s is a safe value.

CAUTION If the AFR or the injection pulse oscillates at cruise with closed loop on, disable it and improve the VE table before using it again.

[Tuning > Second fuel Table](#) adds a second VE table with its own load axis. Modes:

MODE	HOW IT WORKS	EXAMPLE USE
Multiplied %	Multiplies both tables as percentages ($80 \times 150 \% = 120$).	Individual throttle bodies: one table by TPS and another by MAP.
Added	Adds both tables.	Same as above, less used.
Switched - Conditional	Uses the second table when RPM, MAP, TPS or ethanol % pass a value.	More resolution in one area, or an alternative fuel.
Switched - Input based	Uses the second table when an input changes state (a switch).	Street map and track map on a switch.

In sequential, [Tuning > Sequential fuel trim \(1-4\)](#) lets you give each cylinder a little more or less fuel, with one table per cylinder. It helps when a cylinder runs leaner because of the manifold shape. It only makes sense with per-cylinder measurement (exhaust temperature of each runner or individual sensors).

12



CHAPTER 12

IGNITION TUNING

Advance sets when the spark fires. With too little the engine makes less power and runs hot; with too much, knock appears, which can break pistons in seconds. Tune it carefully and, if possible, on a dyno.

IN THIS CHAPTER

1 The advance table

2 Cranking and fixed timing

3 IAT Retard

4 Cold Advance

5 Advanced dwell

6 Second spark table

12.1 THE ADVANCE TABLE

[Tuning > Spark Table](#) has the same axes as the VE table: RPM and load. Each cell is the advance in degrees before TDC. Its 3D view is in [3D Tuning Maps > Spark Table](#).

- **Idle:** moderate, stable advance.
- **Light load (cruise):** the mixture burns more slowly: this is where the highest advance goes.
- **High load:** less advance; with a turbo, less still as boost rises.
- **RPM:** advance rises with RPM and then levels off.

DANGER If you hear pinging (knock), remove advance immediately in that area. Add advance 1 or 2 degrees at a time, never at full load before testing medium loads, and stop when the engine no longer gains power. More advance is not always more power.

12.2 CRANKING TIMING AND FIXED TIMING

In [Spark > Spark Settings](#): *Cranking advance Angle* is always used while the engine is cranking, and *Fixed Angle* locks the timing at all RPM to calibrate with the timing light (section 10.7). With fixed timing enabled the table isn't used: turn it off when you finish.

12.3 IAT RETARD

[Spark > IAT Retard](#) removes advance when the intake air is very hot, because hot air encourages knock. It is very common on turbo engines: advance starts coming out when the air temperature is high, and more as it rises. The values depend on each engine.

12.4 COLD ADVANCE

[Spark > Cold Advance](#) adds advance with a cold engine, when the mixture burns more slowly. It helps idle and response in the first minutes. With *Add cold advance* (Cranking Settings) it is also added to the cranking timing.

12.5 **ADVANCED DWELL**

SETTING	MENU	WHAT FOR
Dwell Compensation	Spark > Dwell Compensation	Curve that adjusts dwell for battery voltage (100 % at 12 V). The default suits almost every coil.
Use dwell map	Spark > Dwell settings Spark > Dwell Map	Replaces the fixed dwell with a table by RPM and load, in Spark > Dwell Map .
Spark duration	Spark > Dwell settings	How long the coil takes to discharge; the ECU uses it to shorten dwell when there isn't enough time.

12.6 **SECOND SPARK TABLE**

[Tuning > Second spark Table](#) works like the second fuel table (section 11.9): multiplied, added, or switched by a condition or a switch. For example, a timing map for higher-octane fuel enabled with a switch.

13

CHAPTER 13

IDLE

A good idle stays steady cold and hot, with lights, fan and air conditioning on, and doesn't stall when you lift off the throttle. It is achieved with an air valve (ST-02, ST-04 and ST-100), with timing (all ECUs) or with both.

IN THIS CHAPTER

1 Control types

2 PWM valve

3 Closed loop

4 Idle Up and air conditioning

5 Idle control with timing

6 Tuning the idle

13.1 CONTROL TYPES

ST-02 · ST-04 · ST-100

The type is chosen in [Startup/Idle > Idle Control > Idle control type](#):

IDLE CONTROL TYPE	HOW IT WORKS
None	No valve idle control (air screw, wax valve or timing only).
On/Off	A valve that opens below a temperature (<i>Fast idle temp</i>) and closes above it.
PWM Open loop	Valve opening comes from a curve against temperature. It doesn't correct if RPM changes.
PWM Closed loop	The ECU moves the valve to hold a target RPM.
PWM Closed+Open loop	Recommended. Starts from the open-loop curve and corrects on top with closed loop.
Stepper...	The same options for stepper motor valves.

NOTE The idle outputs of the ST-02, ST-04 and ST-100 are for 2- or 3-wire PWM valves (section 3.3). Stepper motor valves (4 wires) need a separate driver, which these ECUs don't have.

13.2 PWM VALVE

ST-02 · ST-04 · ST-100

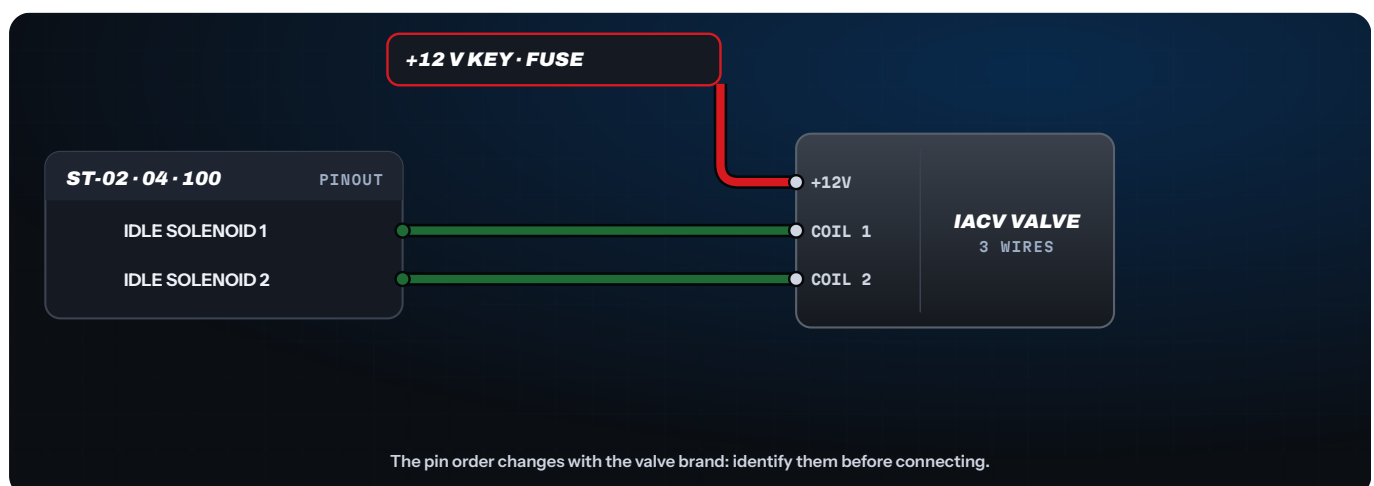


Figure 13.1 3-wire idle valve (IACV) on the ST-02, ST-04 and ST-100: the center pin is usually +12 V and the other two go to the two idle outputs. A 2-wire valve uses IDLE 1 only. In TunerStudio: Number of outputs = 2 for the 3-wire valve.

PIN / FUNCTION	WIRE	GOES TO
IDLE SOLENOID 1	 Dark green	One valve coil
IDLE SOLENOID 2	 Dark green	The other coil
+12 V	 Red	Common valve pin, switched and fused

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Idle 1	—	 B2	 L2	 24
Idle 2	—	 A2	 K2	 23

Idle Settings

PWM Idle

1

Number of outputs

2

2

Idle valve frequency

valve Hz

3

Idle valve direction

Normal

4

Run before start

Yes

Burn

Close

Figure 13.2 Part of the *Idle Control* window for PWM valves.

- 1 Number of outputs:** 1 for 2-wire valves, 2 for 3-wire valves (smoother).
- 2 Idle valve frequency:** the valve frequency, per its maker.
- 3 Idle valve direction:** *Reverse* if the valve opens as duty drops.
- 4 Run before start:** moves the valve before cranking.

Two curves against temperature set the opening: **Idle - PWM Duty Cycle** (running) and **Idle - PWM Cranking Duty Cycle** (cranking, when the engine needs more air). *Crank to run taper* moves smoothly from one to the other.

CAUTION Some PWM valves stay half open when they get no signal (0 %) and close when the signal starts. Test yours with the output test before tuning.

13.3 CLOSED LOOP

In closed loop, the ECU compares RPM with the **Idle - RPM targets** curve (target RPM against temperature) and corrects the valve with a PID.

FIELD	WHAT IT DOES
P / I / D	PID gains. P reacts to the error, I removes the remaining error, D slows the correction so it doesn't overshoot. 1.0 = 100 %.
Minimum / Maximum valve value	Valve limits for closed loop. Leave them wide: they are just a safety stop.
Integral reset above TPS	When you press the throttle (usually above 1 or 2 %) it clears the PID memory so it doesn't fight your foot.
Integral reset RPM Hysteresis	When coasting down without throttle, closed loop only acts again below target + hysteresis. With a 750 target and 500 hysteresis, from 1250 RPM.

13.4 IDLE UP AND AIR CONDITIONING

Startup/Idle > Idle Up Settings opens the valve further when an input is active (for example air conditioning or power steering): *Idle Up Amount* in % or steps. It can also switch an output. In

Accessories > Air Conditioning Control the A/C compressor is set up with its own idle and target RPM increase (section 15.6).

13.5 IDLE CONTROL WITH TIMING (IDLE ADVANCE)

Idle can be stabilized by moving the timing, without a valve: it works on **all ECUs**, including the ST Mini. If RPM drops below target, the ECU adds advance; if it rises, it removes it. The response is much faster than a valve's.

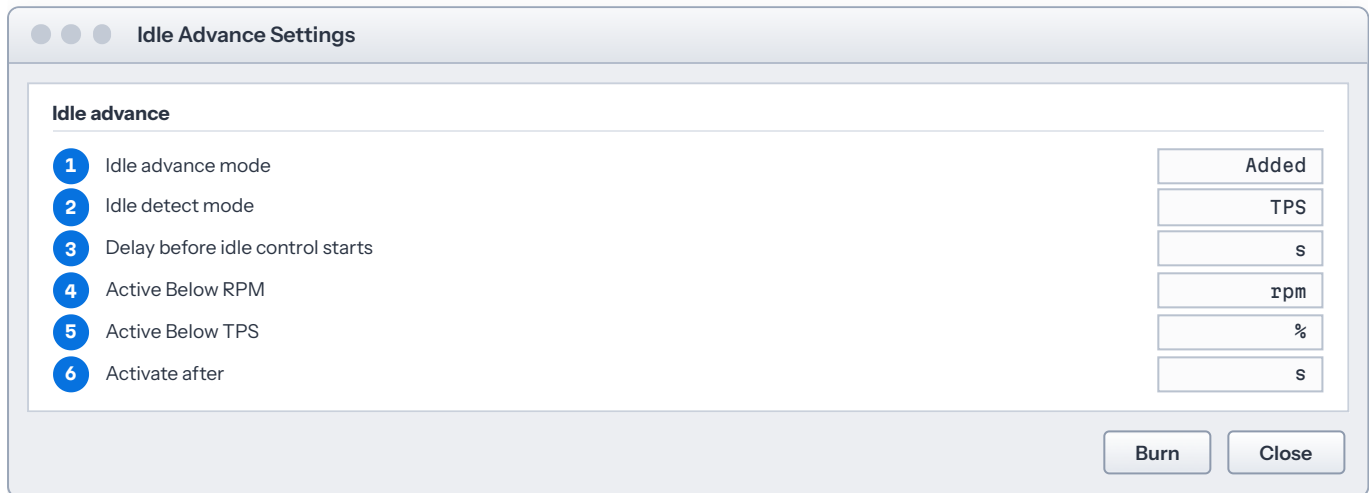


Figure 13.3 The *Idle Advance Settings* window. It uses the same target RPM curve as the valve's closed loop.

- 1 Idle advance mode:** *Added* (the usual) adds or removes degrees from the table advance depending on the RPM difference; *Switched* replaces the advance with the curve's.
- 2 Idle detect mode:** how it knows it is idling: from the TPS or with a closed-throttle switch (CTPS).
- 3 Delay:** lets the RPM settle after lifting off before it starts correcting.
- 4 Active Below RPM / TPS:** only acts below these values.

The **Idle Advance** curve says how many degrees to add or remove depending on the difference between target and actual RPM.

13.6 TUNING THE IDLE

- 1** With the engine hot, leave the idle in open loop (or with P, I and D at zero) and adjust the duty curve until the RPM sits a little above the target.
- 2** Do the same cold, over several days, for the rest of the curve.
- 3** Adjust the cranking duty curve until it starts without touching the throttle.
- 4** Switch to Closed+Open loop and raise P first until it corrects quickly without oscillating; then I until it settles on the target.
- 5** Test with loads: lights, fan and A/C. If it dips when you lift off while driving, check the hysteresis and DFEO.

14 ENGINE PROTECTION

The ECU can cut spark, fuel or both when something puts the engine at risk: too many RPM, too much boost, lack of oil pressure or a lean mixture. They are the last line of defense: set them up before you push the engine.

IN THIS CHAPTER

1 How they work

2 Rev limiter

3 Boost cut

4 Oil pressure

5 AFR protection

6 Indicators

7 Sensor errors

14.1 HOW THE PROTECTIONS WORK

They are set up in the [Tuning > Engine Protection](#) group. The main window, *Common Engine Protection*, defines how all protections cut:

FIELD	WHAT IT DOES
Protection Cut	What is cut: <i>Spark Only</i> , <i>Fuel Only</i> or <i>Both</i> . With <i>Off</i> no protection works, not even the rev limiter.
Cut method	<i>Full</i> cuts everything; <i>Rolling</i> cuts only some cylinders per revolution, more smoothly, with a curve of how much to cut depending on how far over it is.
Protection RPM Limit ('Limp Home')	Below this RPM the oil pressure, boost and AFR protections don't cut: the engine can keep idling so you can reach a safe place. 0 = shut off completely.

NOTE The soft cut of the rev limiter only exists with spark cut. If you choose *Fuel Only*, the limiter only hard cuts.

14.2 REV LIMITER

Rev Limiter

- 1 Soft rev limit
- 2 Soft limiter mode
- 3 Soft limit timing
- 4 Soft limit max time
- 5 Hard limiter mode
- 6 Fixed Rev limit

Burn **Close**

Figure 14.1 The *Rev Limiters* window.

- 1 **Soft rev limit:** from this RPM the ECU changes the timing to hold the engine back.
- 2 **Soft limiter mode:** *Fixed* sets the timing to the *Soft limit timing* value; *Relative* subtracts that value from the timing it had.
- 4 **Soft limit max time:** if the engine stays in the soft cut longer than this, it moves to the hard cut.
- 5 **Hard limiter mode:** *Fixed* cuts at *Fixed Rev limit*; *Coolant based* uses a curve of maximum RPM against engine temperature (for example fewer RPM with a cold or overheated engine).

TIP Set the hard cut a few hundred RPM below your engine's safe maximum, and the soft cut a little earlier. With a cold engine, the temperature-based limit protects it while the oil warms up.

14.3 BOOST CUT

Tuning > Engine Protection > Boost Cut : with *Enable Boost limit*, the ECU cuts when MAP goes above *Boost Limit* (in absolute kPa). It works on every ECU with its built-in MAP sensor (4 bar, or 7 bar on the ST-100). It is the most important protection on a turbo engine: if the wastegate or the boost control fails, it stops the pressure from climbing further.

NOTE The kPa are absolute: at sea level the atmosphere is about 100 kPa. To cut at 1 bar of boost, the limit goes around 200 kPa.

14.4 OIL PRESSURE

ST-04 • ST-100

With the sensor connected and enabled (section 15.7), **Tuning > Engine Protection > Oil Pressure** cuts if the pressure falls below a curve against RPM. Build the curve with the pressure of the **hot** engine, which is lower than when cold. *Oil Pressure cut delay* avoids cuts from a momentary drop.

14.5 AFR PROTECTION

ST-02 • ST-04 • ST-100

Tuning > Engine Protection > AFR Protection cuts if the mixture goes lean under load. It needs a wideband and a well-built target AFR table.

FIELD	WHAT IT DOES
Enable AFR protection	<i>Fixed mode</i> : cuts if the AFR goes above a maximum value. <i>Table mode</i> : cuts if the AFR moves away from the target by more than a difference.
Minimum manifold air pressure / RPM / throttle	Only watches under load: above these MAP, RPM and TPS values.
Maximum AFR (or deviation)	The limit that triggers the cut.
Time before cut	How long it must stay lean before cutting.
Reactivate below throttle	Returns to normal when the throttle drops below this value.

14.6 INDICATORS IN TUNERSTUDIO

Each protection has its indicator on the main screen and in the logs: *Engine Protect ON*, *Rev Limiter ON*, *Boost Limit ON*, *Oil Pres. Protect ON*, *AFR Protect ON* and *Coolant Protect ON*. If the engine "cuts out" for no apparent reason, first look at which one lit up in the log.

14.7 **SENSOR ERRORS**

If a sensor gives an impossible reading (for example a cut or shorted wire), the ECU turns on the *ERROR* indicator and uses a default value so the engine keeps running and you can get home:

ERROR	WHAT HAPPENED	VALUE THE ECU USES
2 / 3	Air sensor (IAT) shorted to 5 V / to ground	40 °C
4 / 5	Coolant sensor (CLT) shorted to 5 V / to ground	40 °C
6 / 7	O2 sensor shorted to 5 V / to ground	AFR 14.7
8 / 9	TPS shorted to 5 V / to ground	50 %
10 / 11	Battery voltage above 20 V / below 5 V	13 V
12 / 13	MAP sensor shorted to 5 V / to ground	240 kPa / 80 kPa

CAUTION With an active error the engine runs, but badly. Check the sensor wiring before pushing the engine any further.

15



CHAPTER 15

ACCESSORIES

Besides injecting and firing, the ECU controls accessories. On almost all of them, the Board Default pin option already points to the right output on your ECU.

IN THIS CHAPTER

1 Fuel pump

2 Fan

3 Tachometer

4 Launch control and flat shift

5 Speed and gears

6 Air conditioning

7 Pressure sensors

8 Programmable outputs

15.1 FUEL PUMP

In [Accessories > Fuel Pump](#): *Fuel pump pin* on Board Default and the priming time when the ECU is powered. The output drives a **relay** (figure 3.2): never connect the pump directly. The pump switches off by itself if the engine isn't turning, for safety in a crash.

15.2 FAN

The screenshot shows a window titled "Fan Settings" with a tab labeled "Fan". Inside the window, there are seven numbered settings, each with a corresponding value in a text box on the right:

Setting	Value
1 Fan Mode	On/Off
2 Allow fan when off	No
3 Allow fan when cranking	No
4 Fan output pin	Board Default
5 Fan Output Inverted	No
6 Fan switching temperature	95 °C
7 Fan hysteresis	°C

At the bottom right of the window are two buttons: "Burn" and "Close".

Figure 15.1 The Thermo Fan window.

- 2 **Allow fan when off:** whether the fan can keep running with the engine off (key ON).
- 3 **Allow fan when cranking:** normally No, so all the current goes to the starter.
- 6 **Fan switching temperature:** switches on above this temperature.
- 7 **Fan hysteresis:** how many degrees it must drop before switching off, so it doesn't cycle on and off.

15.3 TACHOMETER

In [Accessories > Tacho Output](#):

FIELD	WHAT IT DOES
Output pin	Board Default.
Tacho pulse mode	<i>Fixed Duration</i> (fixed-length pulses) or <i>Match Dwell</i> (copies the dwell, as the original coil did).
Output speed	<i>Half</i> if the tachometer reads double.
Pulse duration	Pulse length, 1 to 6 ms. Raise it if the needle trembles or doesn't read.
Tacho sweep on boot	Sweeps the needle up to <i>Tacho sweep Max RPM</i> when the key is turned on.

NOTE The ST-04 tachometer output is for modern (signal input) tachometers. An old tachometer that connects to the coil negative won't work with it.

15.4 LAUNCH CONTROL AND FLAT SHIFT

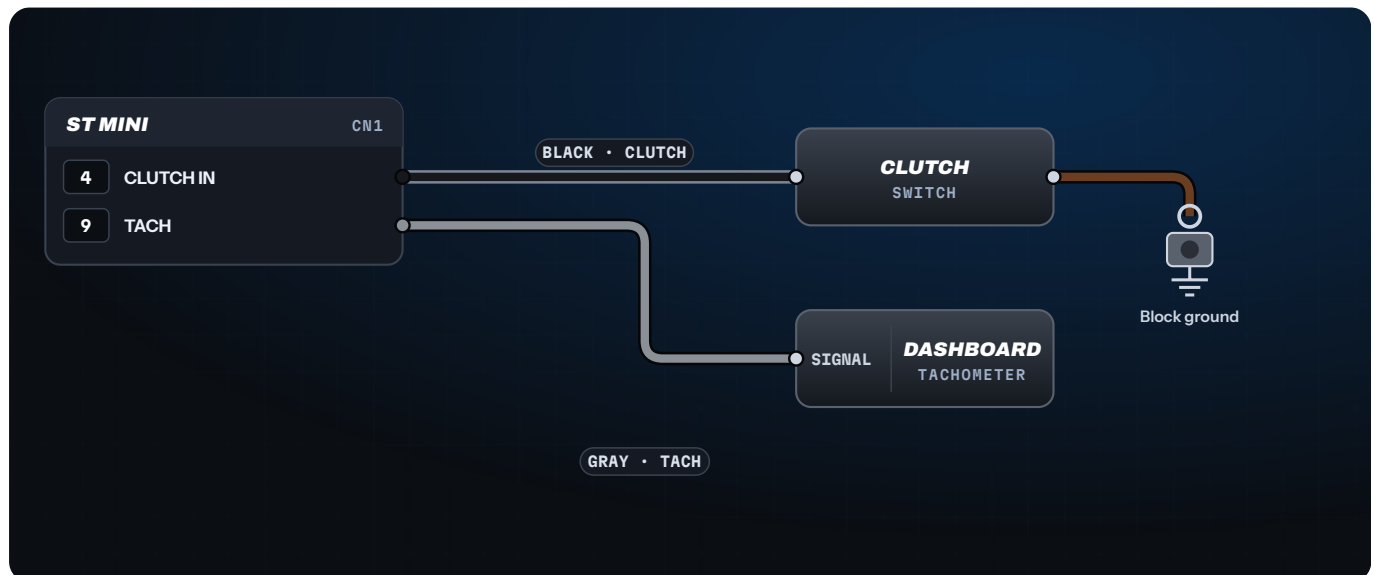


Figure 15.2 Clutch input for launch control and flat shift (the switch closes to ground with the pedal pressed) and output to the dashboard tachometer.

PIN / FUNCTION	WIRE	GOES TO
4 • CLUTCH IN	Black	Clutch switch; the other side to ground
9 • TACH	Gray	Tachometer signal input

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Clutch	4	C5	D1	21
Tachometer	9	C4	E1	30

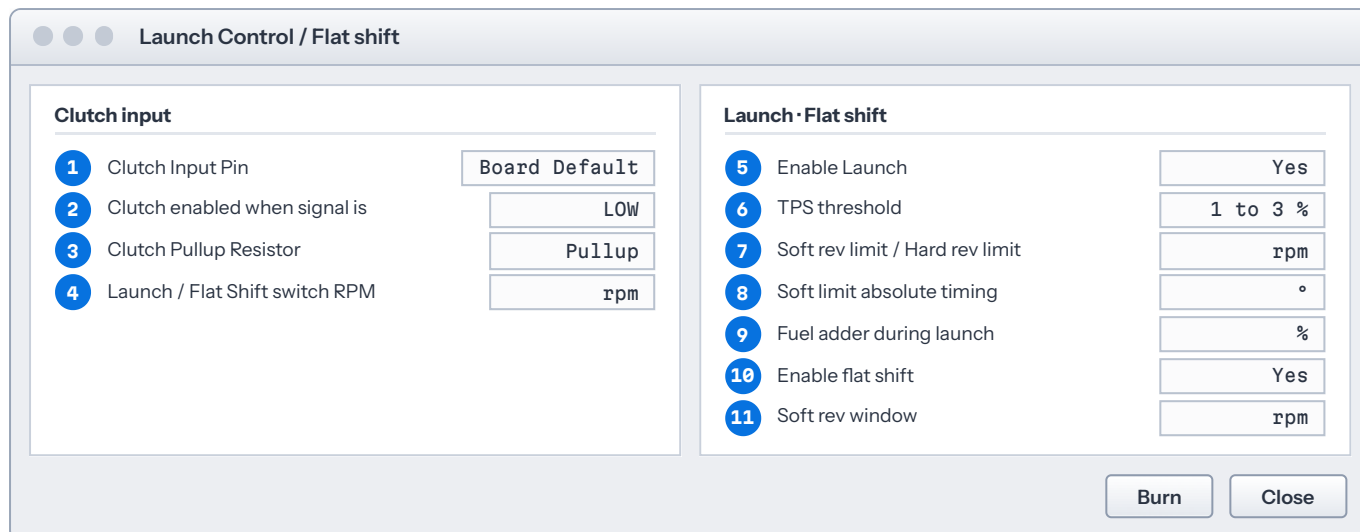


Figure 15.3 The Launch Control / Flat Shift window.

- 2 Clutch enabled when signal is:** LOW if the switch closes to ground with the pedal pressed (the usual), with *Clutch Pullup Resistor* on Pullup.
- 6 TPS threshold:** launch only acts with the throttle above this value.
- 9 Fuel adder during launch:** extra fuel during launch; it helps build boost on turbo engines.
- 4 Switch RPM:** the ECU decides which function to use from the RPM when the clutch is pressed: below it is launch (car stopped), above it is flat shift (gear change).
- 7 Soft / Hard rev limit:** in the soft cut the ECU changes the timing to *Soft limit absolute timing*; in the hard cut it cuts spark.
- 11 Soft rev window:** in flat shift, the RPM window below the shift point where the soft cut timing applies.

TIP Adjust the clutch switch so it triggers as close as possible to where the clutch starts to bite: launch response improves a lot.

15.5 VEHICLE SPEED AND GEAR DETECTION

ST-04 • ST-100

With the sensor connected (figure 4.7), in [Accessories > VSS and Gear detection](#):

- 1** Choose *VSS Input Mode: Pulses per KM* and the pin on Board Default.
- 2** Enter the pulses per kilometer if you know them, or drive at exactly 60 km/h (with GPS) and click **60km/h auto-calibrate**.
- 3** If the reading jumps, raise *Smoothing Factor* (0 to 50 % is normal).
- 4** For the gear: with someone else driving, select first, accelerate to about 2500 RPM and click **Set Gear 1**. Repeat in each gear.

With vehicle speed, launch can use a speed threshold, idle advance can be limited by speed and boost can change by gear (section 16.1).

15.6 AIR CONDITIONING

ST-04

[Accessories > Air Conditioning Control](#) receives the A/C request (a dashboard switch) and drives the compressor through a relay. It cuts the compressor with RPM out of range, at full throttle or with a very hot engine, raises the idle when it switches on and can turn on the fan.

SIGNAL	ON THE ST-04	PIN IN TUNERSTUDIO
A/C request (dashboard switch, closes to ground)	Generic input (pin 14·B2)	13
Compressor (through a relay)	Programmable output (pin 9·J1)	3

- The compressor relay is wired like the programmable output relay (section 15.8). Never connect the compressor clutch directly to the ECU.
- If the A/C doesn't respond to the switch, change the request polarity in the same window.
- The ST-100 has the programmable output but no free input for the request; the ST Mini and ST-02 have no free output for the compressor. On those ECUs the A/C keeps its original control.

15.7 PRESSURE SENSORS

ST-04 · ST-100

With the oil and fuel pressure sensors connected (figure 4.8), in [Accessories > Fuel/Oil pressure](#) enable each one, choose its pin and its calibration: a common sensor from the list, or the pressure at 0 V and at 5 V from its data sheet. The pressures show on the gauges and in the logs, and oil pressure can be used as a protection (section 14.4).

15.8 PROGRAMMABLE OUTPUTS

ST-04 · ST-100

[Settings > Programmable outputs](#) switches an output when your conditions are met (8 rules). The ST-04 and ST-100 have a dedicated output, *PROGRAMMABLE OUT*: on the ST-04 and the ST-100 it is TunerStudio pin **3** in *Output Pin Num*.

FIELD	WHAT IT DOES
Output Pin Num	The output the rule drives.
Rule Alias	Rule name, shown in the logs.
Output Polarity	Switches to ground or to 5 V.
Activation Delay	Time the conditions must hold first (0 = at once).
Condition 1 and 2	A value (RPM, MAP, temperature...), a comparator (>, <, =...) and a number.
2nd Condition	How they combine: <i>And</i> (both), <i>Or</i> (either) or <i>XOR</i> (only one).
Limit time active	Minimum or maximum time it stays on.

Example: a shift light at 6500 RPM: Condition 1 = RPM, comparator ">", value 6500; to have it work only with a hot engine, add Condition 2 = coolant temperature > 70 with *And*.

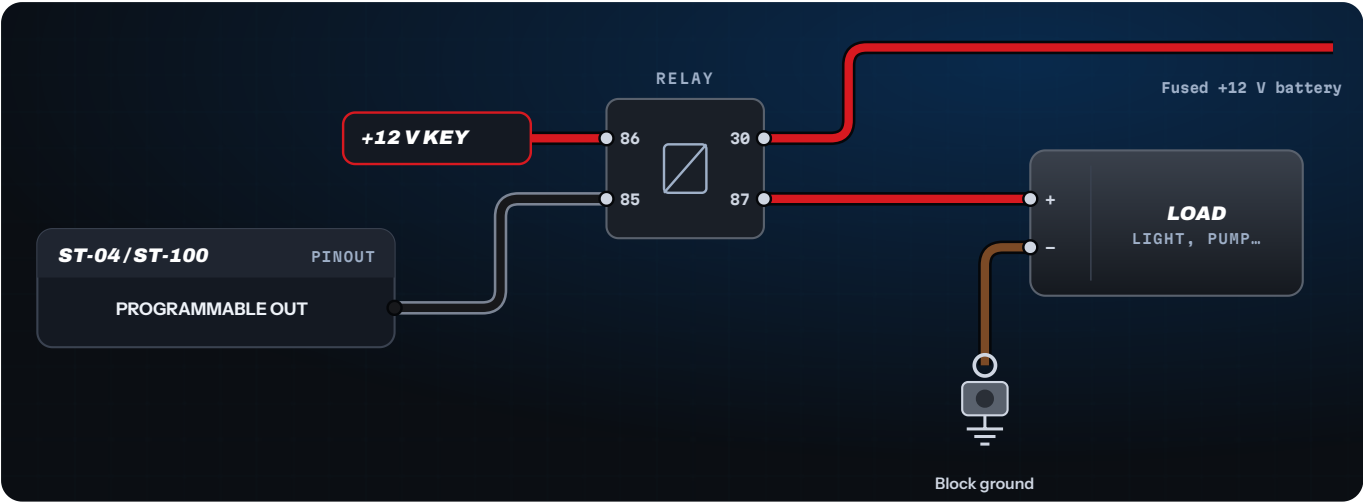


Figure 15.4 ST-04 and ST-100 programmable output driving a relay: the ECU switches the relay coil (terminal 85) and the relay feeds the load. Never connect a power load directly to the output.

PIN / FUNCTION	WIRE	GOES TO
PROGRAMMABLE OUT	 Black	Relay, terminal 85
Relay • 86	 Red	Switched +12 V
Relay • 30 and 87	 Red	30: fused battery • 87: load

ON EACH ECU	ST MINI	ST-02	ST-04	ST-100
Programmable output	—	—	 J1	 26

16 ADVANCED FUNCTIONS

These functions get more out of the engine, but only work well on top of a good base tune. Enable them one at a time, with logs, and with the chapter 14 protections already set.

IN THIS CHAPTER

1 Boost control

2 VVT

3 Flex fuel

4 Staged injection

5 Nitrous

16.1 BOOST CONTROL

ST-02 • ST-04 • ST-100

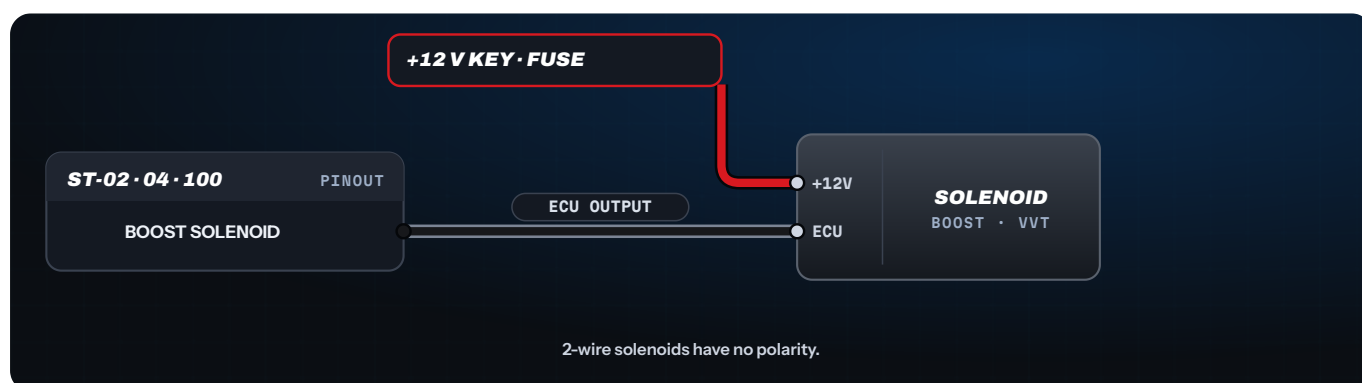


Figure 16.1 Boost solenoid connected to the ECU: one side to switched, fused +12 V and the other to BOOST SOLENOID. The VVT solenoid connects the same way on VVT SOLENOID (VVT on the ST-02).

PIN / FUNCTION	WIRE	GOES TO			
BOOST SOLENOID	Black	One solenoid terminal			
+12 V	Red	The other terminal, switched and fused			
ON EACH ECU	ST MINI	ST-02	ST-04	ST-100	
Boost	—	C3	H1	27	
VVT 1	—	C2	L1	25	
VVT 2	—	—	K1	22	

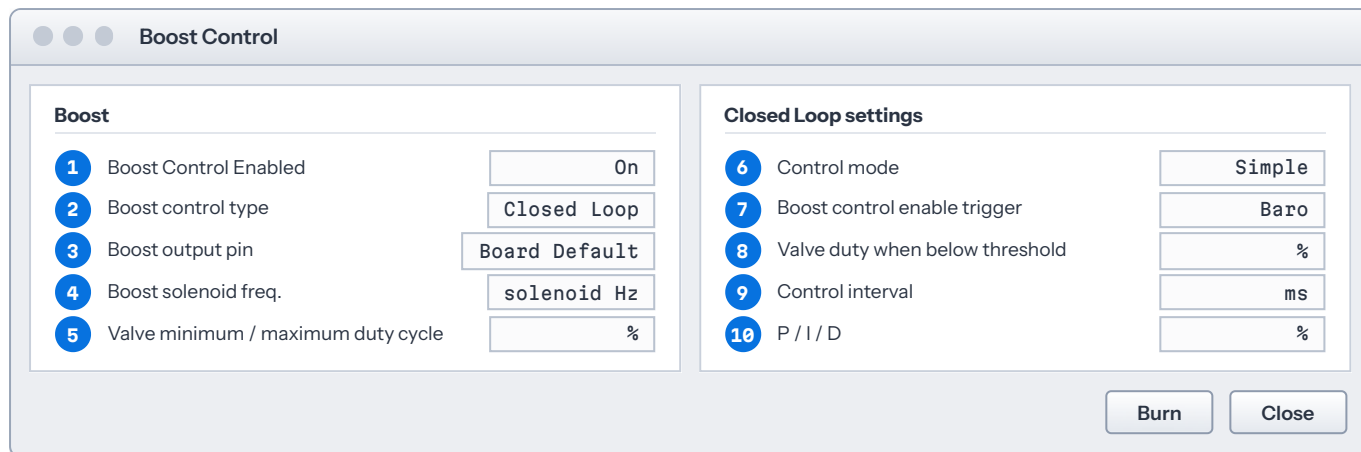


Figure 16.2 The *Boost Control* window.

- 2 Boost control type:** *Open Loop* applies the table duty without measuring; *Closed Loop* uses the table as a pressure target (kPa) and corrects with a PID.
- 4 Frequency:** the solenoid's, per its maker (most between 15 and 500 Hz).
- 6 Control mode:** *Simple* tunes the PID by itself, with a sensitivity control (easier, but to avoid spikes it can end up slow); *Full* lets you enter P, I and D.
- 7 Enable trigger and threshold:** below a certain pressure the control doesn't act and the valve stays at *Valve duty when below threshold*.

The table is edited in [Accessories > Boost Targets/Duty](#); in closed loop it holds the target pressures by RPM and TPS; in open loop, the duty values. **Boost by Gear** (in the same window, with gear detection on the ST-04 or ST-100) limits or multiplies boost in each gear.

DANGER Set the boost cut (section 14.3) before enabling boost control. Start with low duty or low targets and raise them gradually, with a separate gauge to confirm the reading.

16.2

VVT

[ST-02](#) · [ST-04](#) · [ST-100](#)

[Accessories > VVT Control](#) drives the variable valve timing solenoid (wired like the boost solenoid). The ST-02 has one output; the ST-04 and ST-100, two.

VVT MODE	HOW IT WORKS	EXAMPLES
On/Off	The output switches on where the table is 100 and off elsewhere (use 0 and 100).	VTEC, single Vanos
Open Loop	The table is the valve duty against RPM and load.	Simple proportional systems
Closed loop	The table is the camshaft angle you want; the ECU measures it and corrects with a PID.	Double Vanos, ST170, Miata 99-05

- **VVT Minimum CLT** and **VVT Delay:** VVT works with oil; wait for the engine to be hot and a few seconds more.
- **Load source:** MAP or TPS for the table load axis.
- **VVT solenoid freq.:** the solenoid's (between 10 and 510 Hz).
- **Closed loop:** for now it is experimental and only works with some patterns (Missing Tooth, Miata 99-05 and ST170).

Calibrating closed loop: first, in Open Loop, see what angle the ECU reads at 0 % duty and enter it in *Cam angle @ 0% duty*. Adjust it so the readings stay between 1 and 99° across the whole range (also at high RPM). Set *Minimum* and *Maximum Cam angle* as safety limits: if the reading leaves that range, the ECU flags *VVT Error* and leaves the valve at 0 %. *Increased duty direction* says whether more duty advances or retards the camshaft.

16.3 FLEX FUEL

ST-04 • ST-100

With an ethanol sensor (figure 4.6), [Tuning > Flex Fuel](#) corrects fuel and timing for the ethanol percentage. Ethanol has less energy (it needs more fuel) but more octane (it takes more advance).

FIELD	WHAT IT DOES
Flex Fuel Sensor	Enables the function.
Low (EO) / High (E100)	Sensor frequency with 0 % and 100 % ethanol. On common GM/Continental-type sensors, 50 and 150 Hz.
Fuel curve	How much extra fuel by ethanol %. With the tune done on ethanol-free gasoline, 100 % at EO; at E100 the theory gives about 163 %, to be confirmed with the wideband.
Advance curve	Extra degrees by ethanol %; added at the end.
Boost curve	How much the boost target changes with ethanol.

NOTE With flex fuel enabled, the fuel temperature correction also appears (section 11.7). The *Stoichiometric ratio* in Engine Constants stays at the base fuel's.

16.4 STAGED INJECTION

Two sets of injectors: small ones for idle and cruise (primaries) and large ones that come in with load (secondaries). It is set up in [Tuning > Staged Injection](#), available up to 4 cylinders.

ECU	ENGINE	PRIMARIES	SECONDARIES
ST-04 and ST-100	4 cylinders (paired)	INJECTOR 1 and 2	INJECTOR 3 and 4
ST-04 and ST-100	3 cylinders	INJECTOR 1, 2 and 3	INJECTOR 4
ST Mini	2 cylinders	INJ 1	INJ 2
ST-02	1 or 2 cylinders	INJ 1	INJ 2

1 Size of primary / secondary injectors: the flow of each type, in cc/min.

2 Staging mode: *Automatic* (recommended to start): uses the primaries up to their *Injector Duty Limit* and the secondaries provide the rest; you only tune VE as usual. *Table:* an 8 × 8 table with the % of fuel the secondaries provide (0 % = primaries only, 100 % = secondaries only).

DANGER With staging, Required Fuel is calculated with the **sum** of one primary and one secondary (for example 300 + 700 = 1000 cc/min). Otherwise the engine runs very rich or very lean. With staging, keep *Injector Duty Limit* at 85 % or less. The ECU assumes the same opening time for both types.

Accessories > Nitrous controls a one- or two-stage nitrous system, with stages that can work separately or together, and adds fuel for "dry" systems.

FIELD	WHAT IT DOES
Nitrous Mode / Arming Pin	1 or 2 stages and the input that arms the system (normally a switch to ground: LOW polarity).
Minimum CLT / TPS, Maximum MAP	Only activates with the engine hot, the throttle wide open and below a certain pressure.
Leanest AFR	Only activates (and stays active) if the mixture is richer than this value.
Minimum / Maximum Engage RPM	RPM window of each stage.
Fuel adder @ Min / Max RPM	Extra fuel in ms, which changes between the two RPM.
Ignition retard when active	Degrees removed with the stage active. If both stages are active, they add up.

The ST-04 can drive **one stage**: the arming switch goes into the **generic input** (pin 14 · B2, pin **13** in TunerStudio, LOW polarity) and the stage solenoid, through a relay, is driven by the **programmable output** (pin 9 · J1, pin **3**). They are the same ones the A/C uses (section 15.6): use one function or the other. The other ECUs have no free input and output for nitrous.

DANGER Nitrous multiplies the load on the engine. Only use it on a well-tuned base, with the protections active and the solenoids driven through relays.

17 CHAPTER 17 TROUBLESHOOTING

Most faults have a simple cause. Check the simplest things first: power, grounds, fuses and connectors. Then the logs.

IN THIS CHAPTER

1 Symptom, cause and fix

2 Diagnosis with logs

3 Warranty and support

17.1 SYMPTOM, CAUSE AND FIX

SYMPTOM	LIKELY CAUSE	WHAT TO DO
TunerStudio won't connect	Driver, COM port or speed	Install the CH340 driver, check the COM port in Device Manager and use 115200. Try another USB cable.
Connects and disconnects	Electrical noise or bad ground	Check the grounds to the block and route the USB away from coils and plug leads.
RPM at zero when cranking	No crank signal	Check the sensor wiring, the trigger pattern and the teeth. On a VR, measure its resistance. Look at the Tooth Logger.
RPM jumps or loses sync	VR polarity, edge or noise	Swap VR+ and VR-, try the other Trigger edge, check the shielding and the Trigger Filter.
Loses sync only at high RPM	Filter too strong or weak signal	Lower the Trigger Filter; check the sensor-to-wheel gap.
Stays in Half Sync	Cam signal missing	Check the cam sensor and the Secondary type. Without cam it can't run sequential.
Syncs but no spark	Ignition mode, dwell or coil power	Check Spark output mode, fuse F2 and test the outputs.
Sparks but won't start	Fuel or timing	Check pressure, fuse F3, Req Fuel, Injector Layout and the Trigger Angle.
Backfires or starts badly	Crossed pairs or firing order	Check that each output goes to its cylinders per chapters 5 and 6.
Starts and dies	Afterstart, warmup or idle	Raise afterstart and warmup; check the AFR in those seconds.
Idle hunts up and down	Idle PID or duty curve	Tune the open loop first; then lower P or I (chapter 13).
Stumbles on acceleration	Not enough acceleration enrichment	Raise the TPSdot curve or the Accel Time (section 11.5).
AFR oscillates at cruise	Closed loop with a poorly tuned VE	Disable closed loop, tune the VE and enable it again with little authority.

SYMPTOM	LIKELY CAUSE	WHAT TO DO
Engine cuts out for no reason	An active protection	Look in the log for which indicator lit up (section 14.6).
ERROR indicator on	Sensor disconnected or shorted	Check the table in section 14.7 and that sensor's wiring.
Timing light doesn't match	Trigger Angle	Calibrate with fixed timing (section 10.7).
Hot or burnt coils	High dwell or inverted output	Lower the dwell and check Spark Outputs triggers.
Tachometer reads double or nothing	Speed or pulse length	Change Output speed or Pulse duration (section 15.3).
Fan doesn't come on	Temperature, pin or relay	Check Fan switching temperature, that the pin is Board Default, and the relay.
TPS reversed or at 0 %	Calibration, or 5 V and ground swapped	Recalibrate in Tools and check the wiring.
Unrealistic temperatures	Calibration or sensor ground	Choose the right sensor and confirm its ground goes to SGND.

17.2 DIAGNOSIS WITH LOGS

- **Starting or sync problems:** open the *Composite Logger* and crank. You should see even crank teeth, the gap (or mark) on every revolution and, if there is a cam, its pulse always in the same place. Extra missing teeth or double pulses point to noise or a badly adjusted sensor.
- **Faults while running:** record a log reproducing the fault and look at RPM, sync, voltage, MAP, AFR, timing and the protection indicators together.
- **Mixture:** compare actual AFR against target, and check which corrections were active (warmup, acceleration, closed loop).

17.3 WARRANTY AND SUPPORT

- **Warranty:** 1 year against manufacturing defects. Details at speedtechcr.com/politica-de-garantia.
- **Technical support:** speedtechcr.com/soporte and WhatsApp. Have your tune (.msq), a log of the problem and your engine data sheet (appendix F) at hand: it saves us a lot of time.
- **ST Premium:** tested base maps, technical notes and a direct channel with SpeedTech.

18 INSTALLATION EXAMPLES

Three engines popular in Costa Rica, installed from start to finish with COP coils: which ECU to use, how each sensor and output is wired, and how the TunerStudio setup looks for the first start.

IN THIS CHAPTER

1 Before following an example

2 Nissan SR20VE NEO VVL

3 Toyota 2JZ-GTE VVT-i

4 Honda B series with VTEC

18.1 BEFORE FOLLOWING AN EXAMPLE

Each example is a **starting configuration**: it gets the engine ready to start and tune, but it isn't a finished tune. All three use the ST-04 or the ST-100, because they need sequential, VVT outputs or the cam input.

- **Confirm your version:** each engine had several versions depending on year and market. Check colors, pins and sensors against the factory diagram for yours (section 3.8).
- **Pin codes:** the tables give the ST-04 and ST-100 pin with the wire color of the SpeedTech harness.
- **What isn't repeated in each example:** power, grounds and fuses (chapter 3), fuel pump and fan relays (section 3.4), wideband (section 4.5) and fuel system (section 5.6).
- **The work order:** wire, configure with the engine off (chapter 8), test the outputs (section 8.9), go through appendix C, first start (chapter 10) and tune (chapters 11 and 12).

CAUTION Before buying parts, check that your engine has no electronic throttle or any other part from section 2.8, and measure the injectors (section 5.1).

Nissan's SR20VE (Primera, Bluebird and Wingroad, 1997 to 2003) is a 2.0 L 4-cylinder with **NEO VVL**: two cam profiles switched by two solenoids, one on the intake camshaft and one on the exhaust. It reads rotation with Nissan's optical CAS. Versions with a distributor are converted to COP and the CAS is still used as the sensor.

DATA

Engine	1998 cc · inline 4 · firing order 1-3-4-2
ECU	ST-04 or ST-100
Trigger	Optical CAS with two signals: POS (360 slots, 1°) and REF (180° windows) → <i>Nissan 360</i>
Injection	Sequential: one injector per output, in firing order
Ignition	4 COP coils with igniter, sequential
VVL	Two solenoids switched to ground → VVT SOLENOID 1 and 2, in On/Off mode
Load	Built-in MAP (Speed Density). The factory MAF is left unplugged

CONNECTIONS

ENGINE SIDE	ECU SIGNAL	ST-04	ST-100	NOTE
CAS: power and ground	Switched +12 V · ground	—	—	Fused; ground to the block
CAS: POS (1°)	CRANK - IN	 A3	 19	Inputs in Hall mode (section 4.1)
CAS: REF (180°)	CAM - IN	 A4	 11	Shielded cable, like POS
Injectors of cylinders 1/3/4/2	INJECTOR 1 / 2 / 3 / 4	 M3/M4/L3/L4	 34/33/32/31	The other wire of each to +12 V (F3)
Coils of cylinders 1/3/4/2	COIL 1 / 2 / 3 / 4	 E4/D4/C4/B4	 15/16/7/8	+12 V (F2) and ground on each coil
Intake VVL solenoid	VVT SOLENOID 1	 L1	 25	The other wire to switched, fused +12 V
Exhaust VVL solenoid	VVT SOLENOID 2	 K1	 22	Same as the intake one
Idle valve	IDLE SOLENOID 1 / 2	 L2/K2	 24/23	If it is a 2- or 3-wire PWM valve (chapter 13)
TPS	TPS	 D2	 13	With +5V REF and SGND
Coolant temperature	CLT	 E2	 5	The other wire to SGND
Air temperature	IAT	 H2	 14	A separate one if the factory one is inside the MAF

TUNERSTUDIO

WINDOW	FIELD	VALUE
Engine Constants	Number of Cylinders · Injectors	4 · 4
Engine Constants	Injector Layout	Sequential
Trigger Setup	Trigger Pattern	Nissan 360
Trigger Setup	Trigger edge · Secondary trigger edge	FALLING · FALLING
Trigger Setup	Trigger Filter · Re-sync every cycle	Off · Yes
Spark Settings	Spark output mode	Sequential
VVT Control	VVT Mode	On/Off, with VVT 1 and VVT 2 enabled

THE VVL

- VVL works with oil pressure: in [Accessories > VVT Control](#) set *VVT Minimum CLT* so it only acts with a hot engine.
- In the VVT 1 and VVT 2 tables enter 0 below the switch-over RPM and 100 above it, the same in both: the two solenoids switch together.
- The switch-over point is found on the dyno: it is where the torque curve with VVL rises above the curve without VVL. Start with a conservative value and adjust it with logs.
- Before starting, test each solenoid with [Hardware Testing > Test Output Hardware](#) : you should hear a click.

CAUTION Some 4-cylinder CAS versions are not recognized by the *Nissan 360* pattern (section 9.8). Before the first start, crank with the Composite Logger open and confirm that the ECU syncs.

18.3 TOYOTA 2JZ-GTE VVT-I

[ST-04](#) · [ST-100](#)

Toyota's 2JZ-GTE is a 3.0 L turbocharged inline 6. This example is the **VVT-i** version, which has COP coils with igniter, a 36-2 wheel on the crank and 3 teeth on the intake cam. It assumes the common conversion to a **single turbo**: the factory sequential twin-turbo system uses several control valves this guide doesn't cover.

DATA

Engine	2997 cc · inline 6 · firing order 1-5-3-6-2-4 · turbo
ECU	ST-04 (4 bar MAP: up to about 3 bar of boost) or ST-100 (7 bar MAP: for more boost)
Trigger	Crank 36-2, VR sensor → <i>Missing Tooth</i> . Cam: 3 teeth, VR sensor → <i>Toyota 3 Tooth</i> , only for VVT-i
Injection	Paired: 3 outputs with 2 injectors each
Ignition	6 COP coils with igniter in wasted spark: 3 outputs with 2 coils each
VVT-i	OCV valve → VVT SOLENOID 1, in closed loop
Boost	Boost solenoid → BOOST SOLENOID

CONNECTIONS

ENGINE SIDE	ECU SIGNAL	ST-04	ST-100	NOTE
Crank sensor (NE)	CRANK + IN · CRANK - IN	 A1  A3	 18  19	Shielded cable. If the RPM jumps, swap the two wires
Cam sensor (G)	CAM + IN · CAM - IN	 A2  A4	 10  11	Shielded cable
Injectors 1 and 6 / 5 and 2 / 3 and 4	INJECTOR 1 / 2 / 3	 M3/M4/L3	 34/33/32	Two per output, spliced (section 5.3)
Coils 1 and 6 / 5 and 2 / 3 and 4 (IGT)	COIL 1 / 2 / 3	 E4/D4/C4	 15/16/7	IGF unconnected; +B to F2 and ground to the block
VVT-i OCV valve	VVT SOLENOID 1	 L1	 25	The other wire to switched, fused +12 V
Boost solenoid	BOOST SOLENOID	 H1	 27	The other wire to switched, fused +12 V
Idle valve (ISC)	IDLE SOLENOID 1 / 2	 L2/K2	 24/23	If it is a 2- or 3-wire PWM valve (chapter 13)
TPS (VTA)	TPS	 D2	 13	VC to +5V REF and E2 to SGND
Coolant temperature (THW)	CLT	 E2	 5	The other wire to SGND
Air temperature (THA)	IAT	 H2	 14	After the intercooler

CAUTION The factory injectors depend on the market: the 440 cc/min ones (Japan) are high impedance; the 550 cc/min ones (US and European Supra) are **low impedance** and need a series resistor on each one (section 5.1). With 2 injectors per output, each injector with its resistor must measure 10 Ω or more.

TUNERSTUDIO

WINDOW	FIELD	VALUE
Engine Constants	Number of Cylinders · Injectors	6 · 6
Engine Constants	Injector Layout	Paired
Trigger Setup	Trigger Pattern · Primary base teeth · Missing teeth	Missing Tooth · 36 · 2
Trigger Setup	Primary trigger speed	Crank Speed
Trigger Setup	Missing Tooth Secondary type	Toyota 3 Tooth
Spark Settings	Spark output mode	Wasted Spark
Calibrate Pressure Sensors	MAP	4 bar (ST-04) or 7 bar (ST-100)
Boost Control	Boost control type	Closed Loop, after setting the boost cut

THE VVT-I

- Start with VVT-i disabled and the OCV unplugged: with no current, the intake camshaft stays in its rest position and the engine runs, with a little less low-end torque.
- With the cam sensor connected, check in the Composite Logger that its 3 pulses always fall in the same place relative to the crank gap.
- With the engine tuned, enable VVT in *Closed loop* and calibrate the angle as in section 16.2. Closed loop is experimental: if the angle reading isn't stable, leave it disabled.

NOTE Check the throttle body: some VVT-i versions have an electronic throttle, which has to be replaced with a cable one (section 2.8).

DANGER Set the boost cut (section 14.3) and the AFR protection (section 14.5) before raising boost. Tune first on the wastegate's minimum boost and raise it gradually, with a separate gauge.

18.4

HONDA B SERIES WITH VTEC

ST-04 · ST-100

Honda's B16A and B18C (Civic, CRX, Del Sol and Integra) are 4-cylinder engines with **VTEC**: a second cam profile engaged by a solenoid and oil pressure. They come with a distributor from the factory; in this example they are converted to COP coils and the distributor is kept only as a sensor: inside it are the CKP and CYP, which are VR sensors.

DATA

Engine	B16A: 1595 cc · B18C: 1797 cc · inline 4 · firing order 1-3-4-2
ECU	ST-04 or ST-100
Trigger	CKP (24 pulses per distributor revolution) and CYP (1 pulse) → <i>Dual Wheel</i> at cam speed
Injection	Sequential: one injector per output, in firing order
Ignition	4 COP coils with igniter (for example from a Honda K series, with their valve cover adapter), sequential
VTEC	Single-wire solenoid switched on with +12 V → relay driven by VVT SOLENOID 1, in On/Off mode
Load	Built-in MAP (Speed Density)

CONNECTIONS

ENGINE SIDE	ECU SIGNAL	ST-04	ST-100	NOTE
CKP + / -	CRANK + IN · CRANK - IN	 A1  A3	 18  19	Shielded cable
CYP + / -	CAM + IN · CAM - IN	 A2  A4	 10  11	Shielded cable
TDC	—	—	—	Not used: insulate it
Injectors of cylinders 1/3/4/2	INJECTOR 1/2/3/4 / 4	 M3/M4/L3/L4	 34/33/32/31	The other wire of each to +12 V (F3)
Coils of cylinders 1/ 3/4/2	COIL 1/2/3/4	 E4/D4/C4/B4	 15/16/7/8	+12 V (F2) and ground on each coil
VTEC relay (terminal 85)	VVT SOLENOID 1	 L1	 25	86: key +12 V · 30: fused +12 V · 87: solenoid wire
Idle valve (IACV)	IDLE SOLENOID 1 / 2	 L2/K2	 24/23	If it is a 2- or 3-wire PWM valve (chapter 13)
TPS	TPS	 D2	 13	With +5V REF and SGND
Coolant temperature (ECT)	CLT	 E2	 5	The other wire to SGND
Air temperature (IAT)	IAT	 H2	 14	The other wire to SGND

- 1 Leave the distributor in place with its cap: the sensors are inside. The distributor's coil and ignition module are disconnected; the rotor and plug leads are no longer needed.
- 2 Fit the COP coils with their adapter and give them +12 V (F2), ground and the signal of each COIL in firing order.
- 3 Wire the VTEC relay like the programmable output relay (section 15.8), with VVT SOLENOID 1 instead of PROGRAMMABLE OUT.

CAUTION The factory ECU sends +12 V to the VTEC solenoid, while SpeedTech outputs switch to ground: that is why it needs a relay. Connected directly to the output, VTEC won't engage.

TUNERSTUDIO

WINDOW	FIELD	VALUE
Engine Constants	Number of Cylinders · Injectors	4 · 4
Engine Constants	Injector Layout	Sequential
Trigger Setup	Trigger Pattern · Primary base teeth	Dual Wheel · 24
Trigger Setup	Primary trigger speed	Cam Speed
Trigger Setup	Trigger edge · Secondary trigger edge	From the Composite Logger (section 9.9)
Spark Settings	Spark output mode	Sequential
VVT Control	VVT Mode	On/Off

THE VTEC

- Set *VVT Minimum CLT* so VTEC only engages with a hot engine. If you have an oil pressure sensor, also enable the protection in section 14.4.
- In the VVT table enter 0 below the switch-over RPM and 100 above it. You can leave 0 at light load so it doesn't engage while cruising.
- The switch-over point is found on the dyno, where the torque curve with VTEC rises above the curve without VTEC.
- The VTEC pressure switch isn't needed: insulate it.

TIP For more accurate timing you can fit a 36-1 wheel on the crank (section 4.7) and keep the distributor CYP as the cam sensor: *Missing Tooth* with *Missing Tooth Secondary type: Single tooth cam*.

A**PINOUT OF EACH MODEL**

The connector sheets and pin tables are in chapter 2: ST Mini (figure 2.1), ST-02 (figure 2.2), ST-04 (figure 2.3) and ST-100 (figure 2.4). They can also be downloaded from speedtechcr.com/manuales.

B**ST COLOR CODE**

See the table in section 3.5. It is the same code as the per-meter wires in the SpeedTech store.

C**PRE-START CHECKLIST**

- ☐ Main fuse, main relay and fuse box installed
- ☐ ECU on its 2 A F1; coils and injectors with their own fuse
- ☐ ECU, coil and battery grounds on the same block stud
- ☐ Sensor grounds to SGND only
- ☐ Crank sensor with shielded cable and the shield grounded at the ECU end
- ☐ High-impedance injectors, in the right pairs or order
- ☐ Coils with igniter (or external module), in the right pairs or order
- ☐ MAP hose connected after the throttle, with no kinks
- ☐ Wideband sensor installed per section 4.5, with its controller connected
- ☐ Fuel pressure measured and no leaks
- ☐ Engine Constants, Required Fuel, Injector Characteristics and Trigger Setup configured
- ☐ Spark output mode, dwell and Spark Outputs triggers checked
- ☐ TPS, temperatures and voltage calibrated
- ☐ I/O Summary checked: every function with its pin
- ☐ Output test done: injectors click and spark on the right cylinder
- ☐ Rev limiter set (and boost cut if turbocharged)
- ☐ Tune backup saved on the computer

TRIGGER PATTERNS: QUICK REFERENCE

WHEEL OR ENGINE	TRIGGER PATTERN	SIGNALS	KEY SETTING
36-1, 60-2, 24-1...	Missing Tooth	Crank only (cam optional)	Base teeth and missing teeth; measured Trigger Angle
Wheel on cam or distributor	Missing Tooth + Cam Speed	One only	Trigger Angle in crank degrees
Even teeth + 1 pulse	Dual Wheel	Crank and secondary	Tooth 1 = the first one after the pulse
Distributor	Basic Distributor	One only	Spark output mode: Single Channel
Mitsubishi / Miata up to 1997	4G63 / Miata / 3000GT	Crank and cam	Fix cranking timing with trigger: On
Miata 1999-2005	Miata 99-05	Crank and cam	Angle 0, RISING edges
Honda 12+1	Honda D17	Crank	Up to semi-sequential
Nissan optical CAS	Nissan 360	Two CAS signals	Falling edges, filter Off, Re-sync Yes
Subaru from 2000	36-2-2-2	Crank	Angle 0, FALLING, Skip 1, filter Weak
GM 24 teeth	Dual Wheel (24)	Crank and cam	Edge FALLING
Chrysler from 2002	Chrysler NGC	Crank and cam	Angle $\approx 30^\circ$ (4 cyl.) or $\approx 210^\circ$ (6 and 8)

TUNERSTUDIO MENUS

MENU	WINDOWS
Settings	Engine Constants, Injector Characteristics, Trigger Setup, IAT Density, Barometric Correction, Reset Control, Gauge Limits, I/O Summary, Programmable outputs
Tuning	Realtime Display, Acceleration Enrichment, AFR/O ₂ , Engine Protection (Common Engine Protection, Rev Limiters, Boost Cut, Oil Pressure, AFR Protection), Flex Fuel, VE Table, Spark Table, AFR Target Table, Lambda Target Table, Second fuel Table, Second spark Table, Sequential fuel trim, Staged Injection, Fuel Temp Correction
Spark	Spark Settings, Spark Table, Dwell settings, Dwell Compensation, Dwell Map, IAT Retard, Cold Advance
Startup/Idle	Cranking Settings, Priming Pulsewidth, Warmup Enrichment, Afterstart Enrichment (ASE), Idle Control, Idle - RPM targets, Idle - PWM Duty Cycle, Idle - PWM Cranking Duty Cycle, Idle Up Settings, Idle Advance Settings
Accessories	Thermo Fan, Launch Control / Flat Shift, Fuel Pump, Nitrous, VSS and Gear detection, Air Conditioning Control, Fuel/Oil pressure, Boost Control, Boost Targets/Duty, VVT Control, VVT Target/Duty, Tacho Output, Canbus/Secondary Serial IO Interface, Local Auxillary Input Channel Configuration
Tools	Calibrate TPS, Calibrate Pressure Sensors, Calibrate Voltage Reading, Calibrate Temperature Sensors, Calibrate AFR Sensor, Set analog sensor filters
3D Tuning Maps	Fuel Table, Spark Table, AFR Target Table, Lambda Target Table and the boost, VVT and staging tables when enabled
Hardware Testing	Test Output Hardware

Some windows only appear when you enable the function that uses them (for example, the boost tables with boost control on).

F **YOUR ENGINE DATA SHEET**

Fill it in before configuring and keep it with your tune. It is the first thing support will ask for.

Car, engine and year

Displacement and number of cylinders	
Firing order	
Injectors: brand, flow (cc/min) and impedance	
Fuel pressure	
Coils: type (with or without igniter) and ignition mode	
Crank trigger wheel (teeth and missing teeth)	
Crank sensor (VR or Hall) and cam sensor	
Measured Trigger Angle	
Temperature sensors (model or resistances)	
TPS: closed and open readings	
Turbo or naturally aspirated; maximum boost	
Fuel (gasoline, E85, flex)	
Engine maximum RPM	
SpeedTech ECU and serial number	