PECU

PROGRAMMABLE ENGINE CONTROL UNIT

M52

Item no. 5813



Manual

Plug & play engine management for BMW M52 (Siemens MS41)

Date: November 2026

Applies to all board revisions up to R04 (differences in Appendix D.2), rusEFI firmware release_20260812 and CAN module firmware 1.3.1.

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About this manual

This manual describes all functions of the PECU M52, the plug & play engine control unit from k-data for the BMW M52. It is written for workshops, tuners and experienced private users.

If you are installing the PECU for the first time and only want to get the engine running, start with the separate document **“PECU Getting Started”**. It takes you to the first start in twelve steps and refers to the chapters of this manual for details.

Structure of this manual

Chapter	Content
1	Safety and legal notes
2	Product overview, variants, scope of delivery, technical data
3	Connections and functions: every function with its vehicle connector pin, signal and setting
4	Installation in the vehicle
5	Software: TunerStudio, rusEFI Console, firmware
6	TunerStudio menus item by item
7	Tuning basics
8	CAN module with OLED display: all firmware functions, Wi-Fi, vehicle profile, updates
9	Diagnostics and troubleshooting
10	Maintenance, warranty, support
Appendix	uaEFI pinout, vehicle connector pinout, glossary

Conventions

- TunerStudio menu paths are written as **Fuel › Injector Setup › Injection configuration**. This manual assumes TunerStudio in English.
- Settings in dialogs are written in *italics*, e.g. *Trigger Angle Advance*.
- uaEFI pins are given in square brackets, e.g. [D9] for the MAP input. Vehicle connector pins are written as **X1 number**, e.g. **X1-54**.

Structure of each section: A box first shows the essentials: what the function does and how it is set up at the factory. Connection and settings follow, technical details come last. If the box tells you that a function does not concern you, skip to the next section.

> **Note:** Menu names match the rusEFI firmware **release_20260812** that the PECU is delivered with. Other versions may name some items differently or show them elsewhere. The TunerStudio search function (magnifier at the top right, or Ctrl+F in the menu) finds every setting by its name.

1 Safety and legal notes

1.1 Intended use

The PECU is a freely programmable engine control unit for **motorsport and off-road use away from public roads**. It replaces the original control unit of the specified engine and plugs into the original wiring harness.

Use on public roads is only permitted if the vehicle with the PECU complies with the applicable regulations (emissions, noise, EMC, type approval). The operator is responsible for this.

1.2 Safety instructions

> **Warning:** Wrong settings can destroy the engine within a short time (knock, lean running, over-revving). Only change maps if you understand the effects, and check every change with a wideband lambda sensor and data logging.

- **Disconnect the battery** before any work on the wiring harness. Never plug or unplug the PECU with the ignition on.
- Petrol is highly flammable. Ensure ventilation when testing the fuel system, no open flames, keep a fire extinguisher ready.
- The ignition system produces life-threatening high voltage. Do not touch ignition leads or coils with the engine running or during the ignition test.
- Only work on a running engine outdoors or with exhaust extraction.
- Strap vehicles securely on test benches. Full-load tuning only on a chassis dynamometer or a closed track.
- The injectors are really actuated during the ignition and injection tests. For testing, disconnect the fuel pump or remove the injectors.

1.3 Liability

k-data supplies the PECU with a base calibration that starts and runs a standard engine in good condition. It is **not a finished tune** for a particular vehicle. k-data accepts no liability for damage caused by settings made by the customer or third parties.

1.4 Open-source firmware

The PECU runs the open-source firmware **rusEFI** (GPL-3). The firmware, its source code and documentation are freely available at rusefi.com. The firmware of the CAN module is made by k-data.

2 Product overview

2.1 Concept

The PECU consists of three assemblies in one housing:

1. **uaEFI module** – the actual engine control unit. An unmodified uaEFI board from the rusEFI project with processor, drivers for injection and ignition, wideband lambda controller, MAP sensor, SD card and USB. The module plugs onto the carrier board and can be replaced if necessary.
2. **PECU carrier board** – adapts the uaEFI to the specific vehicle. It carries the original vehicle connector, the ignition power stages (IGBT) for conventional ignition coils, the drivers for main relay and idle valve, protection circuits and the additional connectors.
3. **CAN module with OLED** – an OLED module with its own CAN interface. It shows engine data, generates the CAN messages the vehicle expects from the original DME (e.g. rev counter, temperature gauge, warning lights) and provides a Wi-Fi dashboard.

The assignment of inputs and outputs is fixed by the carrier board and already entered in the base calibration.

2.2 PECU M52 variant

Function: The PECU M52 replaces the Siemens MS41 of the BMW M52. It is plugged onto the 88-pin vehicle connector X1 in place of the original DME; the engine wiring harness stays unchanged. Only the camshaft sensor is replaced by the one from the M52TU (e.g. HELLA 6PU 009 121-641, chapter 3.2).

From the factory: base calibration “PECU M52 Alpha-N” for the rusEFI firmware release_20260812, load detection via the throttle (Alpha-N), Vanos controlled.

Feature	PECU M52
Engine	BMW M52B20, M52B25 and M52B28 with Siemens MS41 (inline six, 24 valves, Vanos)
Original ECU	Siemens MS41
Vehicles	BMW E36 320i/323i/328i, E39 520i/523i/528i and Z3 with M52 up to the introduction of the M52TU (approx. 1998)
Vehicle connector	X1, 88-pin, like the original DME
Load detection from the factory	Alpha-N (throttle angle); speed density possible with the MAP sensor of the uaEFI
CAN bus	on the vehicle connector (X1-85/86) and on the additional connector X4 (chapter 3.14)
Additional functions of the carrier board	Vanos (chapter 3.10.4), A/C compressor via the CAN module (chapter 3.17), vehicle speed (chapter 3.9), knock sensor (chapter 3.8), switchable CAN termination

Distinction from other PECU variants

Engine	Original DME	Matching PECU
M50 without Vanos	Motronic M3.1, 88-pin	PECU M50
M50 with Vanos (M50B25TU)	Motronic M3.3.1, 88-pin	PECU M50B25TU
M52	Siemens MS41	**PECU M52**
M52TU (from approx. 1998, double Vanos)	Siemens MS42	not suitable
M54	Siemens MS43	PECU M54

The MS41 has an 88-pin connector like the Motronic of the M50, but its own pin assignment. The PECU M52 only fits if the original DME is a Siemens MS41 (label on the type plate). The M52TU with double Vanos and MS42 is not supported.

2.3 Scope of delivery

- PECU in a housing in RAL 4008 signal violet, with type plate (variant, item number, QR code)
- Mating connectors with crimp contacts for the additional connectors
- microSD card for data logging, already inserted in the slot of the uaEFI module
- Base calibration (stored on the unit and also supplied as an .msq file) for rusEFI firmware release_20260812

A Bosch LSU 4.9 wideband lambda sensor with weld-in boss, harnesses and further sensors are available as accessories.

2.4 Housing and connectors





Connector	Type	Function
Vehicle connector (X1)	88-pin, like the original DME Siemens MS41	connection to the standard engine wiring harness
Additional connector X4	Molex Micro-Fit 3.0, 24-pin	free inputs/outputs, CAN, knock sensor, EGT, drive-by-wire (chap. 3.12)
Additional connector X7	Molex Micro-Fit 3.0, 14-pin	injection 1–6 and ignition signals for external power stages (chap. 3.13)
Lambda sensor (connector E)	Molex Micro-Fit 3.0, 6-pin (2 × 3)	Bosch LSU 4.9
USB	type B	TunerStudio, rusEFI Console, firmware update
microSD	slot on the uaEFI module	data logging

2.5 Technical data

Feature	Value
Operating voltage	9–16 V (12 V vehicle system)
Platform	uaEFI (rusEFI), 32-bit microcontroller
Injection	6 sequential outputs for high-impedance injectors, 2 further outputs usable as injector 7/8
Ignition	6 ignition power stages (IGBT ISL9V3040, each with a 2.5 A self-resetting fuse) for conventional coils, plus 6 logic signals for coils with integrated igniter
Crankshaft / camshaft	2 VR inputs (inductive sensors), 3 Hall inputs (12 V tolerant)
Analogue inputs	CLT, IAT, TPS 1/2, PPS 1/2, MAP, 3 AUX, battery/ignition
Wideband lambda	integrated controller for Bosch LSU 4.9
MAP sensor	KD6400AP on the uaEFI module, 20–400 kPa absolute (MPXH6400 curve), suitable for turbo up to approx. 3 bar boost
Knock sensor	1 input, software knock detection
Exhaust gas temperature	input for 1 type K thermocouple; components not fitted on the uaEFI module, retrofit required
Switched outputs	4 low-side outputs (3 of them with flyback diode), 2 low-side for relays, 2 H-bridges (drive-by-wire, stepper motor or 2 switched outputs)
Communication	USB, CAN 500 kbit/s
Data logging	microSD card (inserted on delivery)
CAN module	OLED module with CAN, Wi-Fi 2.4 GHz, switchable CAN termination, A/C compressor control
Software	TunerStudio MS (Lite free, Ultra recommended), rusEFI Console; PECU Konfigurator (Windows) for the CAN module via USB (chap. 8)

3 Connections and functions

This chapter describes each function of the PECU M52 with its connection to the engine wiring harness: pin on vehicle connector X1, uaEFI pin, type of signal and setting in TunerStudio. The complete assignment of all 88 pins of X1 with signal direction and uaEFI pin is in Appendix B, the assignment of the uaEFI in Appendix A.

> **Important:** The assignment of inputs and outputs is defined by the carrier board and entered in the base calibration. Do not change settings marked **[fixed]** in this chapter. Otherwise sensors or outputs stop working.

3.1 Power supply, ground and main relay

Function: The PECU detects the switched-on ignition at X1-49 and switches the main relay (DME relay) via X1-73. Through the relay, the PECU, injectors, ignition coils and sensors receive their supply.

From the factory: set up. Nothing to adjust.

X1	Signal	uaEFI	Properties
49	Ignition on (terminal 15)	[A7]	ignition detection, voltage measurement
87	+12 V from main relay	[A8]	supply of the uaEFI and the carrier board
73	Main relay control	[B9]	low-side output, switches the relay coil to ground, without flyback diode
4, 7, 25, 32, 34, 38, 41, 55, 56, 61, 79	Ground	GND	power and electronics ground, shields, return of the ignition coils
28, 39, 40, 42, 43, 58, 63, 67, 70, 71, 72	Sensor ground	GNDA	reference ground of the sensors, do not connect to body ground

Setting: TunerStudio **Setup › Outputs** › *Main relay output*: *Output* = B9 **[fixed]**. *Main Relay Disable Time* defines how long the relay stays on after the ignition is switched off.

Details

- After the ignition is switched off, the uaEFI keeps the main relay on briefly to store settings safely.
- As an assembly option, the carrier board has a second way to switch the main relay directly from the ignition signal. On the PECU M52 it is not populated.
- With USB alone the uaEFI can be reached by TunerStudio; sensor values, outputs and the CAN module only work with the ignition switched on.

3.2 Crankshaft and camshaft sensors

Function: The crankshaft sensor provides engine speed and crankshaft position (trigger wheel 60-2, Hall sensor). The camshaft sensor (Hall sensor) distinguishes compression and exhaust stroke.

Important: The camshaft sensor must be replaced by the one from the M52TU (e.g. HELLA 6PU 009 121-641). The original MS41 sensor does not match the pin assignment of the PECU.

From the factory: crankshaft and camshaft sensors set up. If the camshaft signal is missing, the PECU automatically continues to fire in wasted-spark mode.

X1	Signal	uaEFI	Properties
83	Crankshaft sensor, signal	[C5]	Hall sensor, square wave
48	Crankshaft sensor, supply	+5 V	
40	Crankshaft sensor, ground	GNDA	
64	Camshaft sensor, signal	[C6]	Hall sensor, square wave
65	Camshaft sensor, supply	+5 V	
43	Camshaft sensor, ground	GNDA	

Setting: Setup › Trigger

- *Trigger type* = 60-2, *Primary channel* = C5 **[fixed]**.
- **Cam Inputs:** *Cam sensor bank 1 intake* = C6 **[fixed]**, *VVT offset bank 1 intake* **[fixed]**. The offset defines which crankshaft revolution belongs to the compression stroke of cylinder 1.
- **Setup › Advanced Trigger**: *Require cam/VVT sync for ignition* = no **[fixed]**. This setting provides the fallback when the camshaft signal is missing.
- Check *Trigger Angle Advance* with the timing light (chapter 7.2), especially after a firmware update.

Details

- Both sensors are Hall sensors and are supplied with +5 V by the PECU. The VR LEDs 5 and 6 on the uaEFI module show nothing on the PECU M52. Whether a speed signal arrives is shown by TunerStudio while cranking (*RPM* and *Trigger errors*, chapter 9).
- **Replacing the camshaft sensor:** The pin assignment of the PECU M52 at the camshaft sensor intentionally differs from the MS41. With the original sensor no signal or a wrong signal arrives. Install the sensor from the M52TU before the first start-up (e.g. HELLA 6PU 009 121-641).
- The sensor wires are shielded in the original harness; keep the shield intact during repairs.

Fallback when the camshaft signal is missing

With the camshaft signal the PECU knows which cylinder is in the compression stroke. Each coil then fires once per working cycle (single spark), and injection is sequential. If the signal is missing, for example due to a faulty sensor or a broken wire:

	with camshaft signal	without camshaft signal
Ignition	single spark	wasted spark: each coil fires once per crankshaft revolution, i.e. also in the exhaust stroke
Injection	sequential	still once per cylinder per working cycle, but at a random position
Display	–	no value for “VVT: bank 1 intake” in TunerStudio

Prerequisite is *Require cam/VVT sync for ignition* = no. If this setting is yes, the engine does not start without the camshaft signal.

3.3 Injection

Function: Six outputs control the injectors individually (sequential injection).

From the factory: set up for the original injectors, constant fuel pressure.

X1	Cylinder	uaEFI	Output in TunerStudio
6	1	[B6]	Injector 1
33	5	[B5]	Injector 2
22	3	[B4]	Injector 3
23	6	[B3]	Injector 4
5	2	[B2]	Injector 5
24	4	[B1]	Injector 6

The injectors receive +12 V via the main relay; the PECU switches them to ground. The outputs are designed for high-impedance injectors (approx. 12–16 Ω). The same signals are also available on additional connector X7 pins 1–6.

Setting: Fuel › Injector Setup (chapter 6.2.1). The assignment of the outputs is **[fixed]**. Enter other injectors (e.g. for a power upgrade) via *Injector flow* and the dead time curve (*Injector lag*).

Details: The carrier board routes the outputs to the cylinders in firing order: output 1 to cylinder 1, output 2 to cylinder 5 and so on (chapter 3.4).

3.4 Ignition

Function: Six ignition drivers on the carrier board switch the individual ignition coils.

From the factory: individual ignition, dwell time for the original ignition coils.

X1	Cylinder	uaEFI	Output in TunerStudio
29	1	[B15]	Coil 1
31	5	[B14]	Coil 2
30	3	[B12]	Coil 3
3	6	[B11]	Coil 4
1	2	[B13]	Coil 5
2	4	[B10]	Coil 6

The ignition coils receive +12 V via the main relay. Each driver (IGBT ISL9V3040) switches the primary side of its coil to ground and is protected by a self-resetting fuse (2.5 A). The logic signals of the six ignition outputs are also available on X7 pins 8–13 for coils with integrated driver.

Setting: Ignition (chapter 6.3), dwell time under **Ignition › Dwell**.

Note on the firing order: On the PECU M52 this reads 1-2-3-4-5-6 because the carrier board already routes the outputs to the cylinders in firing order (chapter 3.4). Do not change it to 1-5-3-6-2-4.

Warning: The dwell time determines the coil current. Too long a dwell time overheats coils and drivers; the fuses then trip and reset themselves after cooling down. Only change values according to the coil data sheet.

3.5 Temperature sensors

Function: Coolant temperature and intake air temperature for warm-up, start and mixture correction.

From the factory: curves of the original BMW sensors (NTC) entered.

X1	Signal	uaEFI	Properties
10	Coolant temperature (CLT)	[D16]	NTC to sensor ground, pull-up on the uaEFI
14	Intake air temperature (IAT)	[D15]	NTC to sensor ground

Setting: Sensors › CLT sensor, **Sensors › IAT sensor**. Only change if other sensors are fitted.

Details: The temperature gauge in the instrument cluster has its own sender on the M52 and is independent of the PECU. A faulty coolant sensor shows in TunerStudio as an implausible value (e.g. −40 °C with a broken wire).

3.6 Throttle and load

Function: The throttle potentiometer provides the opening angle. From the factory the PECU calculates the engine load from it (Alpha-N).

From the factory: load detection Alpha-N; the hot-film air mass meter of the M52 is not evaluated.

X1	Signal	uaEFI	Properties
12	Throttle potentiometer	[D13]	0–5 V
44	+5 V sensor supply	+5 V	supply of the potentiometer
42	Sensor ground	GNDA	
–	Manifold pressure (MAP)	On-board MAP	sensor KD6400AP on the uaEFI module, 20–400 kPa absolute

Setting

- **Sensors › TPS**: recalibrate *TPS low value* and *TPS high value* after installation (throttle closed or fully open, buttons in the dialog). This is necessary on every vehicle because the potentiometers vary.
- **Setup › Vehicle Information** › *Fuel strategy*: Alpha-N (factory) or speed density.
- **Sensors › MAP sensor**: *MAP input* = On-board MAP, *MAP sensor type* = MPXH6400 **[fixed]**.

Details

- Alpha-N suits the naturally aspirated engine without modifications and is insensitive to leaking vacuum hoses. For speed density, run a hose from the intake manifold to the pressure port of the PECU (chapter 4.2).
- The air mass meter can stay installed; it remains part of the intake path. X1-8 is routed to analogue input AUX1 (chapter 3.9.3); from the factory the signal is not used.

3.7 Wideband lambda control

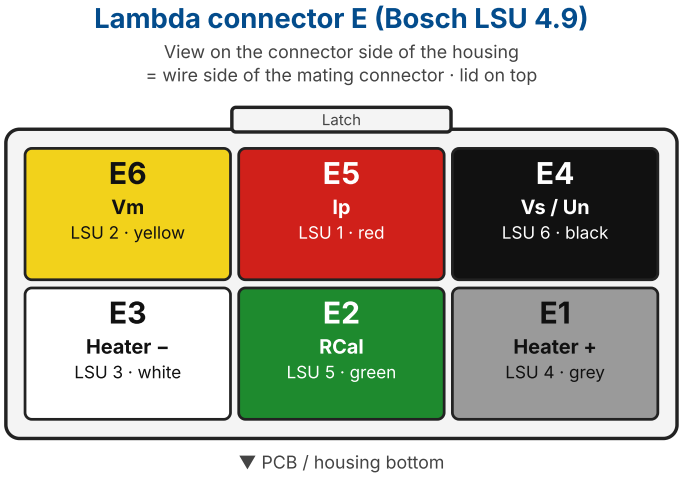
Function: The controller on the uaEFI module operates a Bosch LSU 4.9 wideband sensor and reports the lambda value to the engine control.

Factory setting: controller and gauge *Lambda 1* set up; the sensor plugs into the 6-pin connector E.

The uaEFI module has its own controller for a **Bosch LSU 4.9** (connector E, 6-pin). It heats the sensor, controls it and delivers the lambda value to the engine control via the internal CAN bus. No external lambda controller is needed.

- Weld in the sensor after the exhaust manifold pipes merge and at least 50 cm before the tailpipe, inclined at least 10° from horizontal, connector facing up.
- Only fit the sensor once the cable is connected. A cold, unheated sensor in the exhaust gas is damaged by condensation.
- The controller only starts heating once the engine is running.

Connecting the sensor to connector E



Lambda connector E, view onto the wire side of the mating connector, latch on top

Position (rear view of cable connector)	LSU 4.9 wire colour	Signal	LSU pin	uaEFI pin
top left	yellow	Vm / Vs/Ip	2	E6
top centre	red	Ip, pump current	1	E5
top right	black	Vs / Un	6	E4
bottom left	white	heater –	3	E3
bottom centre	green	RCal, trim resistor	5	E2
bottom right	grey	heater + 12 V	4	E1

The wire colours apply to the original Bosch LSU 4.9 with moulded cable. For extensions or third-party sensors, check the assignment by LSU pin.

The wideband controller shows its status on its own LEDs on the uaEFI module (chap. 3.16): the green LED 8 flashes quickly while the sensor heats up and slowly once control is active; the blue LED 9 flashes an error code.

TunerStudio: **Sensors › CAN O2 sensors**, **Sensors › rusEFI Wideband Tools** (firmware update of the controller), gauge *Lambda 1*.

3.8 Knock sensor and exhaust gas temperature

Function: Input for a knock sensor and for a thermocouple (exhaust gas temperature).

From the factory: knock sensor of the engine harness connected at X1-57; knock control is set during tuning. For exhaust gas temperature, components are missing on the uaEFI module (see note).

Input	Connection	uaEFI	Setting
Knock sensor	X1-57, in parallel X4-2	[D14]	**Ignition › Knock Control**
Exhaust gas temperature (retrofit)	X4-12 (+), X4-24 (–)	[C10]/[C20]	**Sensors › Turbo sensors › EGT**

Note: The standard uaEFI module in the PECU does not have the components for the thermocouple input populated. Without retrofitting these components the EGT input shows no reading. Contact k-data if required.

The M52 has two knock sensors. The PECU evaluates one of them (X1-57); the second sensor at X1-59 is not evaluated. rusEFI detects knock in software and retards the ignition timing. X4-2 is the same wire as X1-57 and therefore not free.

3.9 Inputs: vehicle speed, buttons and analogue inputs

3.9.1 Vehicle speed

Function: The PECU reads the speed signal at X1-15.

From the factory: input set up; the conversion factor must be matched on the vehicle.

X1	Signal	uaEFI	Properties
15	Vehicle speed signal	[C7]	square wave, open collector; pull-up 4.7 kΩ, protection circuit and Schmitt trigger on the uaEFI

Setting: Sensors › Chassis sensors › Vehicle speed sensor: *Input* = C7 **[fixed]**. Adjust *Wheel revolutions per kilometer*, *Speed sensor gear ratio* and *Speed sensor tooth count* so that the displayed speed matches a GPS device. The base calibration contains placeholder values.

Details: In the vehicle, the wire at X1-15 is also connected to other control units (e.g. on-board computer, radio, cruise control). The PECU loads it only with the pull-up of the uaEFI.

3.9.2 Buttons and digital inputs

Function: Four free inputs for switches and sensors, e.g. clutch switch, launch control, map switching or ethanol sensor.

From the factory: free, only on additional connector X4.

Input	X4	uaEFI	Typical use
BUTTON1	3	[D2]	clutch switch, launch control
BUTTON2	14	[D10]	map switching, free
BUTTON3	15	[C9]	idle/neutral switch, free
FLEX	17	[D5]	ethanol sensor (flex fuel)

The inputs are 12 V tolerant and have a pull-down resistor. In TunerStudio the pin is selected in the respective function, e.g. **Advanced › Launch Control** *Launch Button*.

3.9.3 Analogue inputs AUX

Function: Three analogue inputs 0–5 V for additional sensors (fuel pressure, oil pressure, boost pressure).

From the factory: free.

Input	Connection	uaEFI
AUX1	X4-4 and X1-8	[D1]
AUX2	X4-16	[C3]
AUX3 / fuel pressure	X4-5	[C15]

Connect sensors to +5 V (X4-1) and sensor ground (X4-13). AUX1 is also routed to X1-8, the signal wire of the air mass meter; AUX1 is therefore only free if the air mass meter is unplugged. Setting under **Sensors** in the respective function.

3.10 Switched outputs

Function: Fuel pump relay, rev counter, Vanos and free outputs for fan or additional functions.

From the factory: fuel pump, rev counter and Vanos set up, fan output at X4-10 prepared.

Function	Connection	uaEFI	Properties
Fuel pump relay	X1-69	[B16]	low-side with flyback diode, switches the relay coil to ground
Rev counter	X1-36, X4-22	[B17]	low-side, pull-up 1 kΩ to +12 V on the carrier board; X4-22 only free if X1-36 is not connected
Fan relay	X4-10	[B8]	weak low-side without diode, for relay coils only
Vanos solenoid valve	X1-21, X4-8	[B7]	low-side with flyback diode (chapter 3.10.4); X4-8 is the same wire
VVT2 / LS2	X4-20	[B18]	used by the idle actuator (chapter 3.11); free if the idle actuator is removed
H-bridge 1	X4-9, X4-21	[A5]/[A1]	drive-by-wire throttle or two switched outputs

3.10.1 Fuel pump

When the ignition is switched on, the pump runs for a few seconds to build up pressure, and afterwards only while the engine is running. Setting: **Setup › Outputs** › *Fuel Pump*: *Output* = B16 **[fixed]**, *Prime duration* (factory 4 s).

3.10.2 Rev counter

The rev counter of the M52 receives a square wave signal with three pulses per crankshaft revolution. Setting: **Setup › Outputs** › *Tachometer output*: *Output* = B17 **[fixed]**, *Pulse per Rev* = 3. If the rev counter shows too much or too little, only adjust *Pulse per Rev*.

3.10.3 Electric fan

On the M52 the temperature switch in the radiator or the air conditioning switches the auxiliary fan; the PECU is not needed for this. If the PECU is to switch a fan, connect the fan relay to X4-10. Setting: **Setup › Cooling Fans** (factory on at 92 °C, off at 88 °C).

3.10.4 Vanos

The Vanos solenoid valve moves the intake camshaft between two positions. The PECU switches it to ground via X1-21; the valve receives +12 V via the main relay. As with the original DME, Vanos is switched on and off depending on engine speed and load.

X1	Signal	uaEFI	Properties
21	Vanos solenoid valve	[B7]	low-side with flyback diode, also at X4-8

Setting: Output B7 and the switching points are entered in the base calibration; the output is **[fixed]**. Only change the switching points if the engine has been modified. For a check at standstill the output can be switched briefly under **Controller › Output test**; the valve clicks audibly.

> **Note:** The outputs switch to ground. Connect loads via a relay or directly to +12 V from the main relay. On [B8] only relay coils, no solenoid valves or motors.

3.11 Idle actuator

Function: The PECU controls the rotary idle actuator of the M52 with two windings and thus holds the idle speed.

From the factory: control with fixed actuator position (open loop) via the coolant temperature.

X1	Signal	Drive
53	Idle actuator, winding 1	low-side semiconductor output of the carrier board
27	Idle actuator, winding 2	low-side semiconductor output of the carrier board

The actuator has two coils with a common centre tap, which is connected to +12 V in the harness. It is driven by a single uaEFI output, [B18]; the carrier board splits it onto the two coils. The duty cycle of [B18] determines the position.

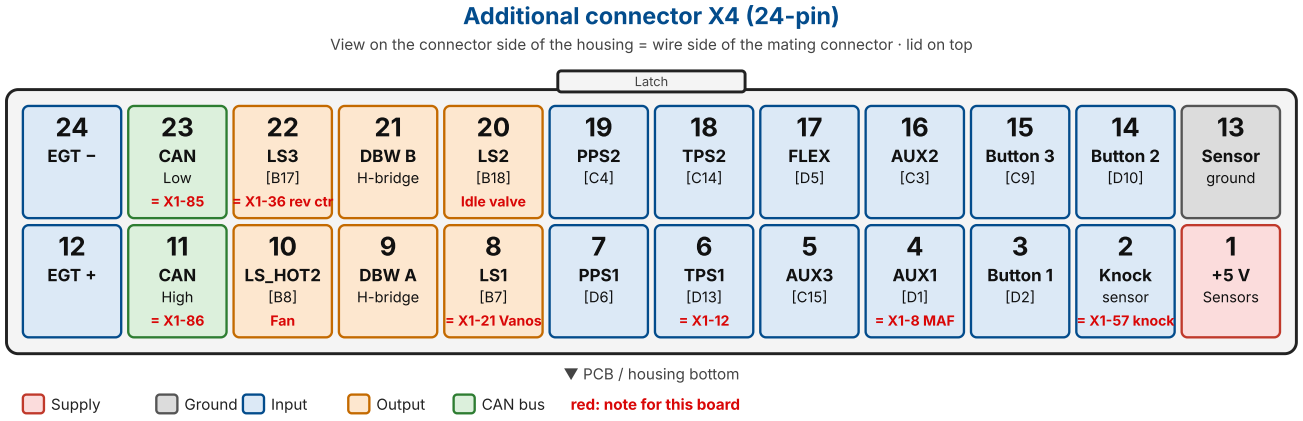
Setting

- **Idle › Idle hardware**: *Idle Solenoid Primary output* = B18, output mode *default* (not inverted), *Frequency* 100 Hz, no second output **[fixed]**.
- **Idle › Idle settings** and the tables in the **Idle** menu (chapter 6.5): base position and target speed. For closed-loop control to the target speed, *Idle control mode* = Closed Loop.

Details: The drive of the two coils only works with output B18. The output is also brought out to X4-20. It may only be used otherwise there if the idle actuator is removed or unplugged; then switch off idle control in the tune or assign the output to the new function.

3.12 Additional connector X4 (24-pin)

Function: Free inputs and outputs of the uaEFI, CAN bus, knock sensor, exhaust gas temperature and drive-by-wire.
Factory setting: not used; mating connector supplied.



Additional connector X4, view onto the wire side of the mating connector

The picture shows the connector as you see it when wiring, looking onto the wire side of the mating connector: lid on top, pin 1 at the bottom right. Pins marked in red already have a task on the PECU M52 or are in parallel with the vehicle connector ("= …": the same line as the named pin of the vehicle connector).

Pin	Signal	Pin	Signal
1	+5 V sensor supply	13	sensor ground
2	knock sensor	14	BUTTON2 [D10]
3	BUTTON1 [D2]	15	BUTTON3 [C9]
4	AUX1 [D1]	16	AUX2 [C3]
5	AUX3 / fuel pressure [C15]	17	FLEX [D5]
6	TPS1 [D13]	18	TPS2 [C14]
7	PPS1 [D6]	19	PPS2 [C4]
8	VVT1 / LS1 [B7]	20	VVT2 / LS2 [B18]
9	DBW motor A (H-bridge 1)	21	DBW motor B (H-bridge 1)
10	LS_HOT2 [B8]	22	LS3 [B17]
11	CAN High	23	CAN Low
12	EGT +	24	EGT –

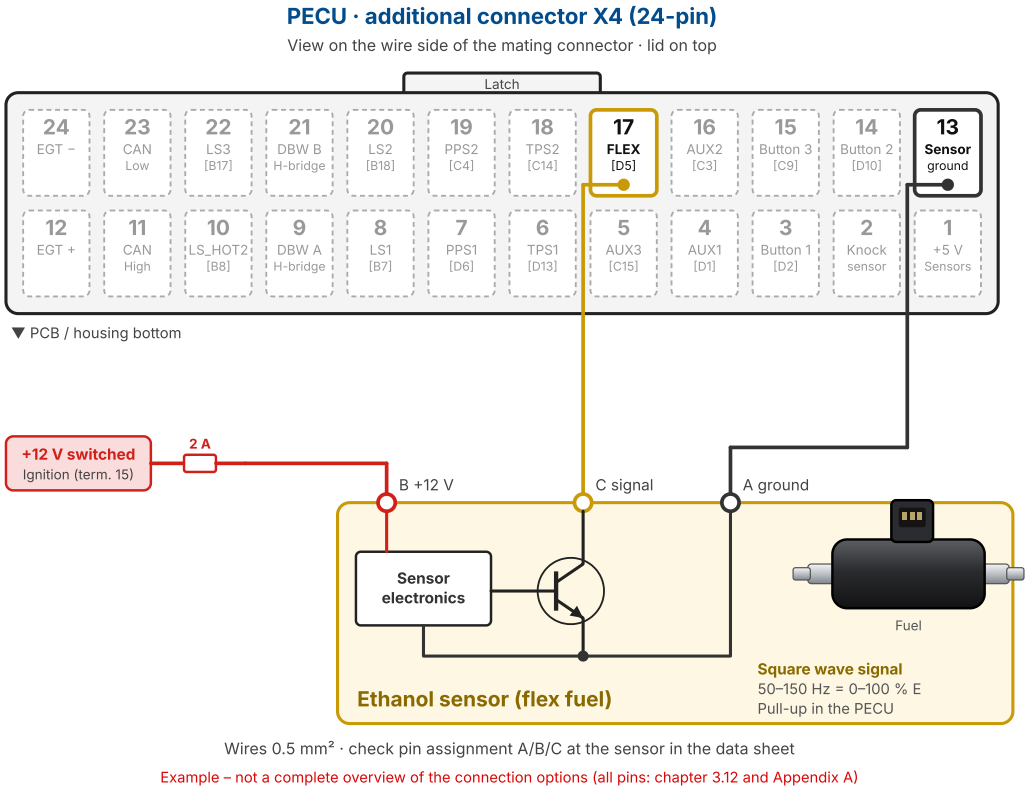
Pins brought out twice: Some pins of X4 and X7 are the same line as a pin of the vehicle connector (marked red in the picture). Such an output can only be used at the additional connector if the original component in the engine harness is no longer connected. Example: if the idle valve is removed or unplugged, its output at the additional connector is free for another function. The same applies to inputs: a sensor at the vehicle connector and a second one at the additional connector on the same line interfere with each other.

X4 lets you add functions the original harness does not have: electronic throttle, fuel pressure sensor, flex fuel, launch control button, exhaust gas temperature, external CAN devices (display, data logger).

3.12.1 Connection examples

The following pictures show typical additions at X4, each using pins that are free on the PECU M52. They are examples, not a complete overview; all pins are listed in the table above and in Appendix A. X4 has no +12 V pin: connect sensors, buttons and relays that need +12 V to switched +12 V (terminal 15) via their own fuse.

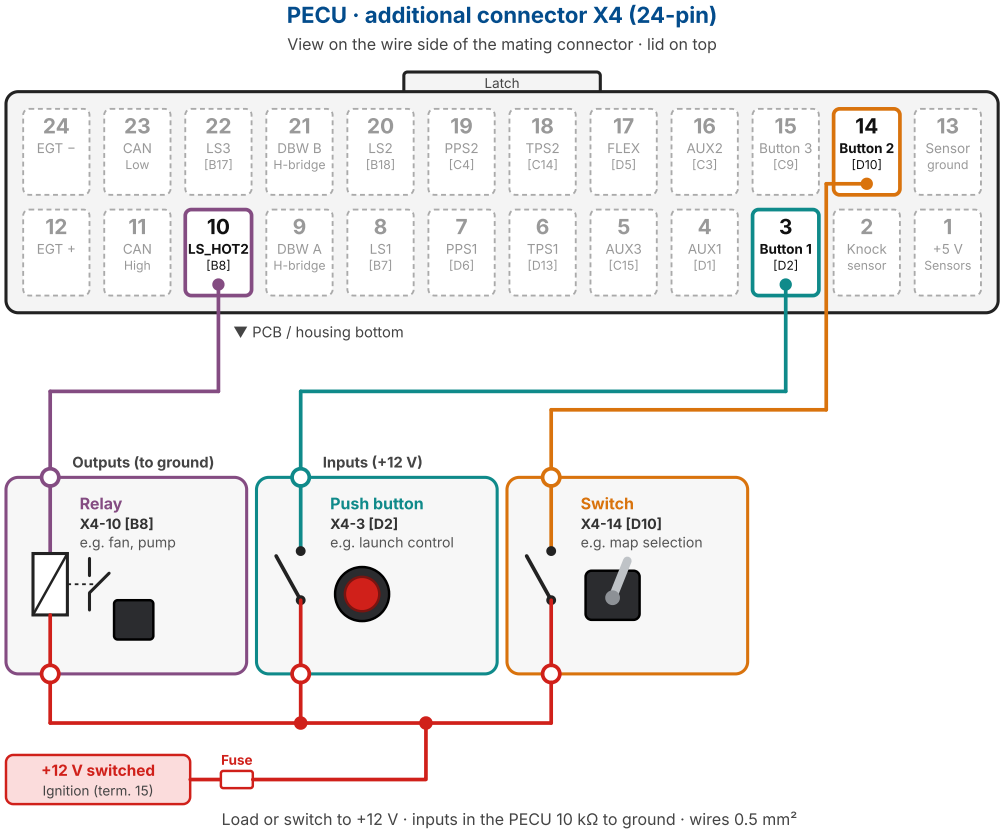
Flex fuel sensor: signal to X4-17 [D5], ground to X4-13 (sensor ground), supply +12 V via a fuse. The sensor delivers a square wave of 50 to 150 Hz for 0 to 100 % ethanol; the pull-up resistor is inside the PECU M52. The A/B/C assignment on the sensor differs between manufacturers, so check the data sheet.



Connecting an ethanol sensor (flex fuel) to X4

Inputs and outputs: The button inputs have 10 kΩ to ground inside the PECU M52; buttons and switches therefore switch +12 V onto the input. The outputs switch to ground: the load (relay coil, valve) is connected with its other terminal to switched +12 V. For a relay (e.g. fan or additional pump) we recommend X4-10 [B8]: a weak output without flyback diode, intended for relay coils only. X4-8 [B7] has a flyback diode and suits pulsed valves such as a boost control valve.

On the PECU M52 no further switched output is free: X4-8 [B7] drives the Vanos, X4-20 [B18] the idle valve and X4-22 [B17] the rev counter. A boost control valve can therefore only be operated on an output that is used twice: on X4-20 if the idle valve is no longer needed (e.g. after converting to drive-by-wire), or on X4-8 if you do without the Vanos. In both cases unplug the original component and assign the output to the new function in TunerStudio (see note “Pins brought out twice”). X4-22 can only be used if the rev counter is not needed.

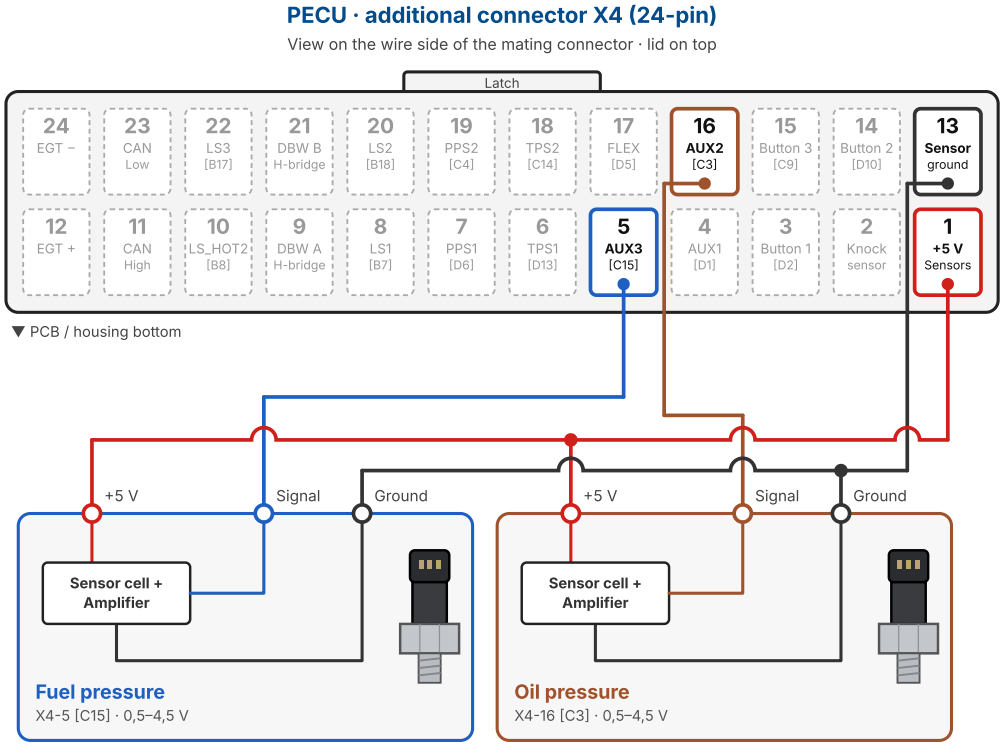


Load or switch to +12 V · inputs in the PECU 10 kΩ to ground · wires 0.5 mm²

Example – not a complete overview of the connection options (all pins: chapter 3.12 and Appendix A)

Connecting buttons, switches and switched outputs to X4

Pressure sensors: Sensors with three terminals and 0.5 to 4.5 V output (e.g. fuel or oil pressure) are supplied from X4-1 (+5 V) and X4-13 (sensor ground). The signal goes to a free analogue input. Enter the characteristic (voltage to pressure) from the data sheet in TunerStudio.



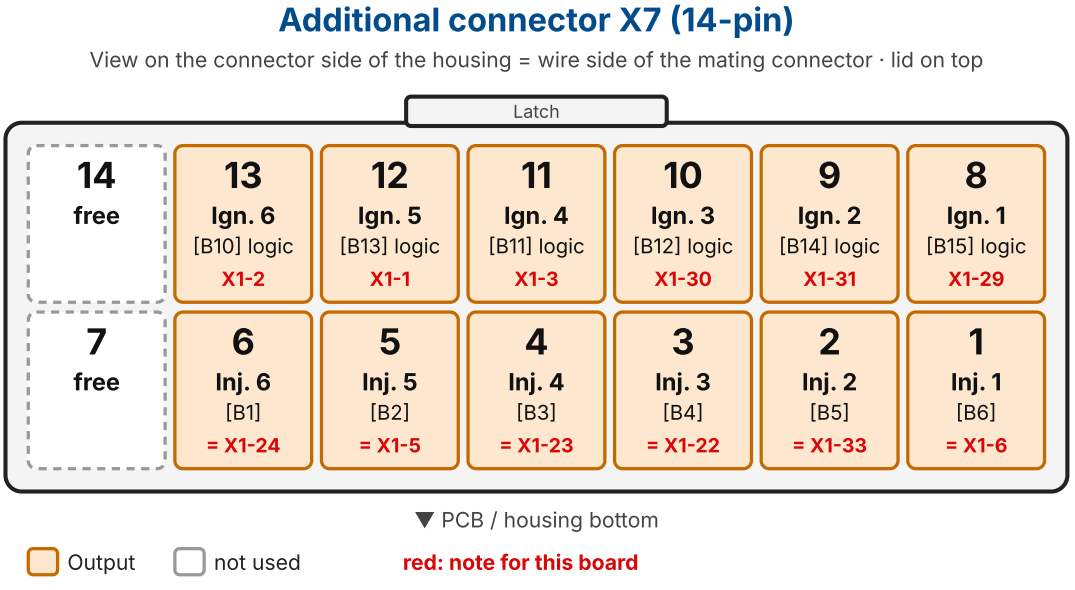
Pressure sensors with 3 terminals (0.5–4.5 V) · curve in TunerStudio as per data sheet · wires 0.5 mm²
Example – not a complete overview of the connection options (all pins: chapter 3.12 and Appendix A)

Connecting pressure sensors to X4

3.13 Additional connector X7 (14-pin)

Function: Injection signals 1–6 and ignition signals 1–6 (logic level) for a separate harness.

Factory setting: not used.



Additional connector X7, view onto the wire side of the mating connector

The injection signals at X7 are the same lines as at the vehicle connector (red: "= ...") and can only be used if the corresponding injectors are not connected to the engine harness. The ignition signals at pins 8–13 are the logic signals before the ignition power stages; in red is the vehicle connector pin at which the corresponding power stage switches the ignition coil. If coils with integrated igniter are driven via X7, no ignition coils may remain connected to these pins of the vehicle connector.

Pin	Signal	Pin	Signal
1–6	injection 1–6 (in parallel with the vehicle connector)	8–13	ignition signal 1–6, logic level, for coils with igniter
7	not used	14	not used

X7 is used to connect a separate injection or ignition harness, e.g. when converting an engine to individual coils with igniters.

3.14 CAN bus

Function: Shared data bus of uaEFI, CAN module and connected devices.

Factory setting: the uaEFI sends its readings as rusEFI broadcast; termination resistor on.

The PECU has one CAN bus (500 kbit/s) that the uaEFI [D7]/[D8], the CAN module and connected devices **share**. On the PECU M52 the CAN bus is also on the vehicle connector (X1-86 CAN High, X1-85 CAN Low) and thus connected to the vehicle CAN, if the vehicle has one (e.g. E39, E36 from approx. 1997). The uaEFI sends its readings as "rusEFI CAN broadcast"; the CAN module translates them into the vehicle's messages (chap. 8).

A CAN bus needs a 120 Ω termination resistor at each end. The PECU has its own switchable termination, which the CAN module switches on (chap. 8.8). It is on at the factory.

TunerStudio: **CAN-bus › CAN Bus Settings** (chap. 6.8).

3.15 USB and microSD card

Function: Connection to the laptop and data logging inside the control unit.

Factory setting: microSD card inserted.

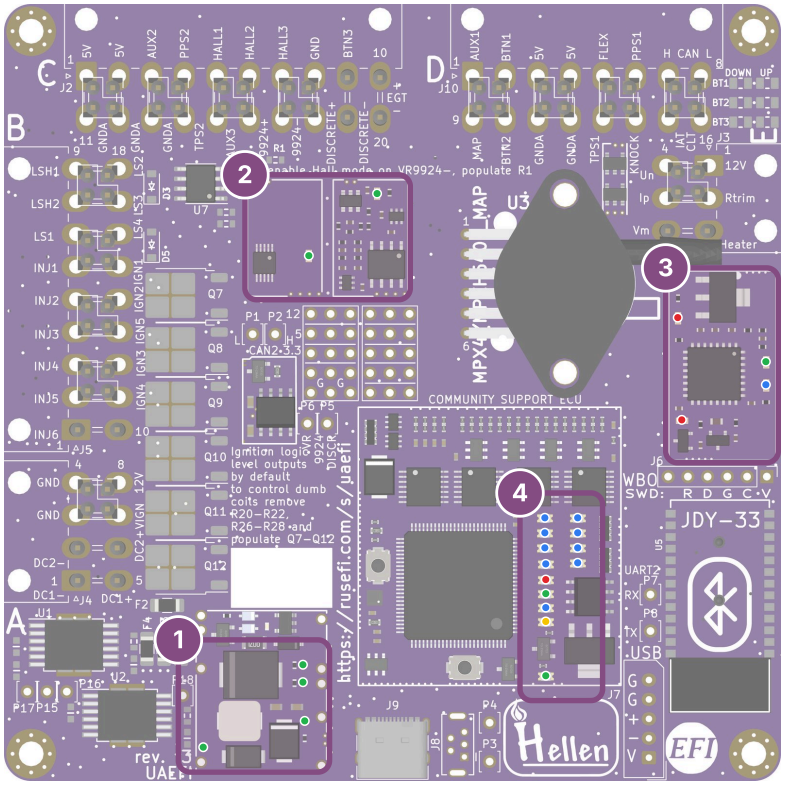
- **USB:** connection to TunerStudio and rusEFI Console. The PC detects the PECU as a serial port and additionally as a drive containing the matching TunerStudio definition file.
- **microSD:** data logging inside the control unit, independent of the laptop. The card is already in the slot of the uaEFI module on delivery. Only remove or insert the card with the ignition off. TunerStudio: **Controller › SD Card Logger** (chap. 6.9).

3.16 LEDs on the uaEFI module

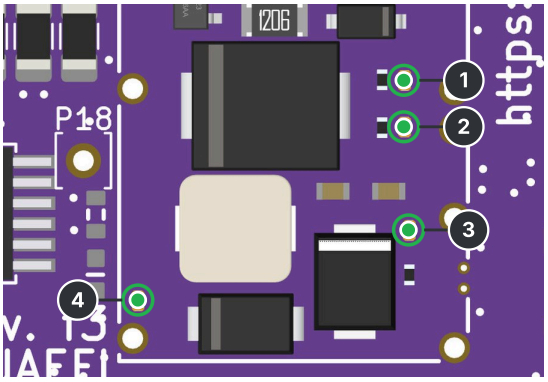
Function: 23 LEDs show supply, speed signals, wideband lambda controller, processor and outputs.

Factory setting: always active.

The LEDs are visible once the lid is removed. They help with troubleshooting. The numbers in the pictures belong to the tables next to them. When switching on, LEDs 11 to 14 light up briefly together (self-test).

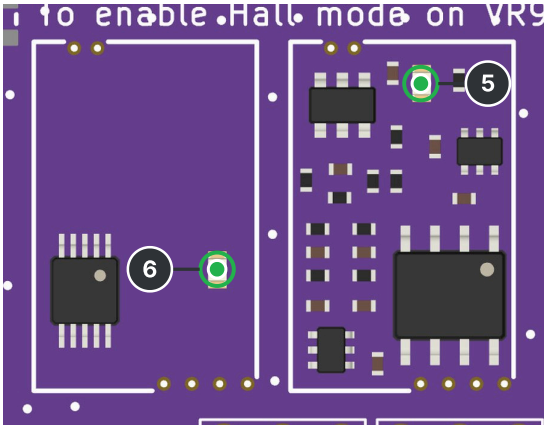


Position of the LED groups on the uaEFI module (top view)



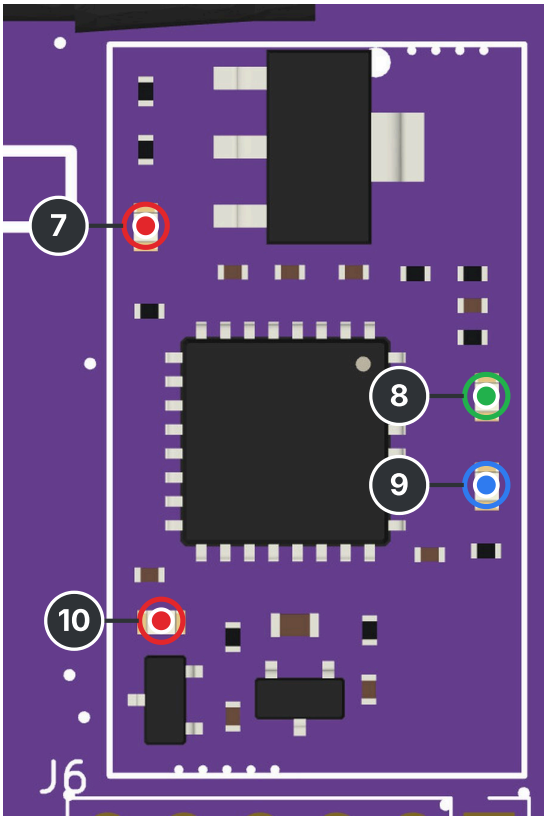
1 Supply

No.	Colour	Meaning
1		on: 12 V supply present
2		on: ignition on
3		on: 5 V supply OK
4		on: 5 V sensor supply OK



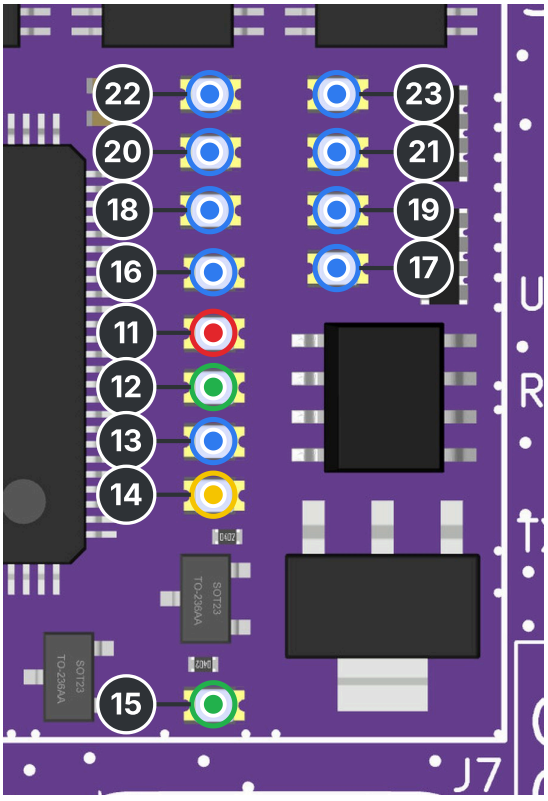
2 Speed signals

No.	Colour	Meaning
5		input VR1 (C18/C19). Not used on the PECU M52; crankshaft and camshaft sensors are Hall sensors.
6		input VR2 (C17). Not used on the PECU M52; crankshaft and camshaft sensors are Hall sensors.



3 Wideband lambda controller

No.	Colour	Meaning
7		on: sensor heater is driven, brightness depends on heater power
8		flashing fast: sensor heating up · flashing slowly: control active · off: error, see 9
9		flashes in groups: error code of the lambda controller, count the flashes
10		on: supply of the lambda controller OK



4 Processor and outputs

No.	Colour	Meaning
11		on or long flashes: serious firmware error, read out with TunerStudio
12		on while cranking, flashes with the engine running
13		always flashes (heartbeat) · faster when connected to TunerStudio
14		flashing: error in the speed signal · steady: after an unexpected restart, error report on the microSD card
15		on: 3.3 V processor supply OK
16		ignition output 1 (B15) driven
17		ignition output 2 (B14) driven
18		ignition output 3 (B12) driven
19		ignition output 4 (B11) driven
20		ignition output 5 (B13) driven
21		ignition output 6 (B10) driven
22		output B9 driven (main relay at the factory)
23		output B8 driven (fan at the factory)

> **Note:** The output LEDs only show that the processor drives the output, not that current actually flows. An LED that lights while the function is missing points to the wiring, a fuse or the load.

Quick check with the LEDs

Observation	Meaning
1 or 2 off with ignition on	no supply or no ignition signal: check fuses, main relay, connector
11 on	firmware reports a serious error: read the error message with TunerStudio
14 flashing	speed signal disturbed: check sensor, gap, wiring and shielding
8 still flashing fast after minutes	sensor does not get warm: check heater, sensor, connector E
9 flashing	lambda controller reports an error: check sensor and wiring

3.17 Air conditioning

Function: The CAN module switches the A/C compressor relay when the air conditioning is on, the pressure switch enables it and the engine is running.

From the factory: off. The compressor only runs once the function is switched on in the settings page of the CAN module (chapter 8.12).

X1	Signal	Evaluation	Properties
16	Enable: A/C on and pressure OK	input of the CAN module	0 V when the air conditioning is on and the pressure switch reports pressure OK
74	A/C compressor relay	CAN module → low-side semiconductor output	switches the relay coil to ground

How the control works: In the vehicle the wire at X1-16 runs via the pressure switch of the system. It is at 0 V when the air conditioning is on and the refrigerant pressure is correct. The CAN module evaluates it as a request and switches the compressor relay at X1-74 as long as the signal is present and the engine is running. The second A/C signal of the MS41 (X1-19, A/C on) is not connected on the PECU M52; it is not needed for this control.

Setting: settings page of the CAN module › *Klimakompressor* (A/C compressor, chapter 8.12): *Anforderung* (request) = Eingang (input), *Anforderung aktiv bei* (request active at) = 0 V, *Druckschalter* (pressure switch) = nicht vorhanden (not present). Then check that the “Klima-Anforderung” (A/C request) indicator in the dashboard follows the A/C switch.

Details

- The A/C function is in the CAN module, not in the uaEFI. The uaEFI settings under **Setup › Air Conditioning** (*A/C Relay*, *A/C Switch*) stay empty.
- The idle speed increase with the air conditioning on is not set up in the base calibration. If required, increase the base position of the idle actuator slightly (chapter 6.5).
- If the CAN module fails or the uaEFI sends no data, the compressor stays off.

3.18 Tank venting

Function: The tank venting valve at X1-68 is not pulsed by the PECU.

From the factory: X1-68 is permanently connected to ground on the carrier board via a 0 Ω bridge (R343).

The original DME pulses the tank venting valve to purge the activated carbon canister. On the PECU M52 the pin is permanently connected to ground. The uaEFI function “Canister purge” is not used.

3.19 Unused pins and functions of the original DME

All X1 pins marked as *not used* in Appendix B are not connected on the carrier board. This removes the following functions of the Siemens MS41:

Function of the original DME	On the PECU M52
Lambda sensors (narrowband)	replaced by the wideband sensor on connector E (chapter 3.7). The heater ground of the original sensors (X1-25, 55, 61, 79) is permanently on ground: if the sensors stay installed and plugged in, they heat permanently.
Air mass meter	not evaluated, load detection via the throttle (chapter 3.6)
Second knock sensor (X1-59)	not evaluated (chapter 3.8)
A/C on (X1-19)	not connected (chapter 3.17)
Check engine light, fuel consumption signal	not connected
Diagnostic line	not connected; diagnostics via USB with TunerStudio (chapter 9)
Tank venting (X1-68)	permanently on ground (chapter 3.18)

4 Installation

4.1 Preparation

1. Check that the PECU matches the engine (type plate, chap. 2.2).
2. Check the condition of the engine: spark plugs, ignition leads, fuel pressure, vacuum hoses, sensors. The PECU cannot compensate for a faulty sensor.
3. Back up the original DME data if you plan to convert back.
4. Have a laptop with Windows 10/11, macOS or Linux and TunerStudio installed, plus a USB-A to USB-B cable ready (chap. 5). The cable is not included in the scope of delivery.
5. Have the wideband lambda sensor welded in (chap. 3.7).
6. **Replace the camshaft sensor:** fit the sensor from the M52TU (e.g. HELLA 6PU 009 121-641, chap. 3.2).

4.2 Installing the control unit

1. Ignition off, remove the key, **disconnect the battery negative terminal**.
2. Release the original control unit in the ECU box and unplug the vehicle connector.
3. Check the connector contacts for corrosion and bent pins.
4. Fit the PECU in place of the original DME and secure it.
5. Plug in the vehicle connector and close the lock completely.
6. Connect the lambda sensor to the 6-pin connector and route the cable away from the manifold, ignition leads and moving parts.
7. If manifold pressure (MAP) is used: run a hose from the intake manifold (after the throttle) to the pressure port of the PECU. A tee in the vacuum line of the fuel pressure regulator is quick and effective. Keep the hose free of kinks, as short as possible, without a fuel trap.
8. Only connect additional connectors X4/X7 if they are used.
9. Reconnect the battery.

4.3 Grounding and wiring for extensions

- Always connect sensors to **sensor ground** (GNDA), never to chassis ground. Otherwise ground offsets distort the readings.
- Use shielded wiring for crankshaft and knock sensors; connect the shield to ground at the control unit end only.
- Supply load outputs (solenoid valves, relays) with +12 V from the switched main relay and switch them to ground via the PECU.
- All additional connectors (X4, X7 and lambda connector E) are Molex Micro-Fit 3.0. Use the matching crimp tool and contacts suitable for the wire cross-section; 0.35–0.5 mm^2 is usual.

5 Software

5.1 Overview

Program	Purpose	Source
TunerStudio MS	configuration, tuning, gauges, data logging	tunerstudio.com; Lite free, **Ultra** (paid) recommended for VE analysis, autotune and map tools
rusEFI Console	firmware update, diagnostics, Lua console	in the rusEFI bundle for the uaEFI (rusefi.com)
MegaLogViewer	analysis of data logs	tunerstudio.com (HD version recommended)
Web browser	Wi-Fi dashboard and settings of the CAN module	any smartphone/laptop

5.2 Installing TunerStudio and creating a project

1. Download TunerStudio MS from tunerstudio.com and install it.
2. Connect the PECU via USB. No driver is needed on Windows 10/11.
3. In TunerStudio, **File › New Project**.
4. Enter a project name, e.g. “PECU M52 customer Smith”.
5. Under *Firmware*, click **Detect**. TunerStudio reads the firmware signature and loads the matching definition file (.ini). Without internet: **Other / Browse** and select the .ini file from the drive that the PECU presents to the PC.
6. Connection: select the port (COM port or /dev/tty…) or use **Detect**. The baud rate does not matter with USB.
7. Create the project. TunerStudio connects and reads the settings from the PECU.
8. Make a backup straight away: **File › Save Tune As…** (file extension .msq).

> **Tip:** Create a separate project for each vehicle and save a new .msq with the date in its name before every larger change.

5.3 Basic operation of TunerStudio

Function	Operation
Change values	Click the field, enter the value, Enter. Changes take effect immediately in the working memory of the PECU.
Save permanently (“Burn”)	**Burn** button in the dialog or **Ctrl+B**. Without Burn, changes are lost when switching off.
Edit tables	Select an area, then **+** / **–** (step), **Shift+/–** (large step), **=** (set value), ***** (percent), **H**/**V** (interpolate), **S** (smooth).
Current operating point	The crosshair cursor in tables shows where the engine is currently running.
Gauges	Main screen with round gauges; right-click a gauge to choose another reading.
Data logging	**Data Logging › Start Logging** (F2), stop with F3.
Compare tunes	**File › Compare Tune** (TunerStudio Ultra: differences between two .msq files).
Work offline	Open the project without the PECU, save changes, transfer them later.

5.4 Updating the firmware

The uaEFI firmware is updated with the **rusEFI Console**.

1. Close TunerStudio (the USB port may only be used by one program).
2. Save the current calibration as .msq.
3. Use the rusEFI bundle for **uaEFI** released by k-data (currently **release_20260812**). Only install other versions, especially nightly builds, when instructed by k-data: the base calibration and this manual apply to the released version.
4. Unpack the bundle, start `rusefi_console`, connect the PECU via USB.
5. Select **Update Firmware** and follow the instructions. The PECU restarts afterwards.
6. Open TunerStudio. If TunerStudio reports a new firmware signature, accept the new .ini and load the saved .msq with **File › Open Tune**, then **Burn**.

> **Warning:** Do not disconnect USB or interrupt the power supply during the update.

The firmware of the CAN module is updated separately via Wi-Fi (chap. 8.11).

6 TunerStudio menus

This chapter describes the menus that matter for a plug & play PECU. Items fixed by the carrier board are marked **[fixed]**: they are entered correctly in the base calibration and must not be changed, otherwise outputs or sensors stop working.

6.1 Menu “Setup”

6.1.1 Vehicle Information

Setting	Meaning
Number of cylinders	number of cylinders
Displacement	displacement in litres; used for the fuel calculation
Firing order	firing order **[fixed]**. On the PECU M52 this reads 1-2-3-4-5-6 because the carrier board already routes the outputs to the cylinders in firing order (chapter 3.4). Do not change it to 1-5-3-6-2-4.
Fuel strategy	load detection: Speed Density, Alpha-N or MAF
Tuning View	shows or hides expert menus
Lambda display	display in lambda or AFR
Engine Make / Engine Code / VIN	documentation, stored in logs

6.1.2 Limits and protection

- **Limits and fallbacks:** rev limiter. Choose *Cut fuel on RPM limit* / *Cut spark on RPM limit*, set *RPM hard limit*, *RPM limit hysteresis* (re-enable). Optionally *Use Engine Temperature RPM limit curve* for a lower limit with a cold engine. *Boost cut pressure* is also set here.
- **Low/High oil pressure protection:** shutdown on missing oil pressure (requires an oil pressure sensor).
- **Lambda protection:** power limitation with a lean mixture under load.
- **Misfire Detection:** misfire detection.

6.1.3 Trigger

Setting	Meaning
Trigger type	type of trigger wheel, e.g. 60-2 **[fixed]**
Trigger Angle Advance	offset between trigger wheel and TDC of cylinder 1. Checked with the timing light (chap. 7.2).
Crank Sensor / Cam Sensor (Primary channel)	input of the crankshaft sensor **[fixed]**
Primary Edge	evaluated edge; only change in case of sync problems
Cam Inputs: *Cam mode, Cam sensor bank 1 intake, VVT offset*	camshaft sensor for sequential injection and Vanos **[fixed, except VVT offset]**

6.1.4 Check Engine Settings

Output and conditions of the check engine light. On vehicles with a CAN instrument cluster the CAN module drives the light (chap. 8.9).

6.1.5 Battery and alternator, Ignition key input Settings

Voltage measurement and ignition detection **[fixed]**.

6.1.6 Outputs, Cooling Fans, Air Conditioning

Dialog	Important settings
Outputs	main relay, fuel pump, rev counter output **[fixed]**; *Fuel pump prime duration* = pump run time after ignition on (default 3–4 s)
Cooling Fans	*On temperature* / *Off temperature* of the electric fan, *Disable when engine stopped*, *Idle adder* (idle increase with fan on)
Air Conditioning	A/C compressor enable, cut-off at full load and high rpm

6.2 Menu “Fuel”

6.2.1 Injector Setup

Injection configuration

Setting	Meaning
Injection	injection on/off (switch off for ignition tests)
Mode	Sequential (with camshaft signal), Batch, Simultaneous
Injection timing control mode	end of injection relative to TDC
Injector flow	injector flow in cc/min at reference pressure. **Must match the fitted injector.**
Fuel rail pressure sensor / *Injector flow compensation mode*	fuel pressure compensation. On standard BMWs with the regulator referenced to the manifold: “Fixed rail pressure” or referenced to the manifold, depending on the fuel system. Requires a restart.
Injector reference pressure	pressure at which *Injector flow* applies (usually 3 bar)
Stoichiometric ratio	14.7 for petrol, 9.0 for E85 (automatic with flex fuel)

Injector deadtime (BatV vs fuel pressure): opening delay of the injector over battery voltage. Important for idle and part load; take the values from the injector data sheet.

Injection hardware: assignment of the injector outputs **[fixed]**. **Injector Test** lets you drive individual injectors.

Injector small-pulse correction: correction for very short injection times.

6.2.2 VE (volumetric efficiency)

The **VE table** is the central fuel map: volumetric efficiency in % over rpm and load (MAP or TPS). From it, the displacement, the air density and the lambda target, rusEFI calculates the injection time. Because injector size, dead time and lambda target are handled separately, the VE table remains valid when injectors are changed.

6.2.3 Target lambda / Target AFR

Lambda target over rpm and load. Typical values:

Operating range	Lambda
Idle, part load	1.00
Medium load	0.95–0.98
Full load, naturally aspirated	0.86–0.90
Full load, boosted	0.78–0.82

6.2.4 Corrections

Dialog	Function
Warmup enrichment	additional fuel in % over coolant temperature
IAT multiplier	correction over intake air temperature
Deceleration fuel cutoff (DFCO)	overrun fuel cut-off: *Enable Fuel Cutoff*, rpm limits, *Cut fuel below MAP*, *No cut below CLT*
Short term fuel trim/Closed loop	lambda control: continuously corrects the fuel quantity towards the lambda target. Limits and enable conditions (temperature, rpm, load)
Long term fuel trims	learning correction
Cylinder fuel trims	fuel trim of individual cylinders
TPS Acceleration Enrichment / Wall Wetting AE	acceleration enrichment from throttle and MAP changes
Wall wetting AE	physical wall film model, alternative to classic acceleration enrichment
Barometric pressure correction	altitude compensation

6.3 Menu “Ignition”

Dialog	Function
Ignition advance	ignition advance in degrees before TDC over rpm and load
CLT / IAT timing correction	timing correction for a cold engine or hot intake air
Dwell	coil dwell over rpm and battery voltage
Ignition hardware	*Spark* on/off, *Mode* (Individual Coils, Wasted Spark), *Timing Mode* (Dynamic or **Fixed** for checking), *Fixed Timing*, outputs **[fixed]**
Cylinder ign trims	timing correction per cylinder
Knock Control, **Max knock retard**	knock control and maximum retard
Multispark	multiple sparks at low rpm

> **Warning:** Too much ignition advance causes knock and destroys pistons. Only increase advance in small steps (1–2°) and only with knock monitoring or on a dyno.

6.4 Menu “Cranking”

Dialog	Function
Cranking settings	*Cranking RPM limit* (cranking mode applies up to this rpm, typ. 400–550 rpm), *Injection mode* while cranking, *Fixed cranking advance* (ignition advance while cranking, typ. 8–10°), *Flood clear* (no injection at full throttle while cranking, to clear a flooded engine)
Cranking Fuel multiplier	cranking fuel over coolant temperature
After-start enrichment	after-start enrichment, decays within a few seconds
Priming pulse	injection pulse at ignition on, wets the intake manifold
Cranking ignition advance	cranking advance over rpm
Cranking Air Amount vs CLT	idle valve opening while cranking

6.5 Menu “Idle”

Dialog	Function
Idle settings	*Idle control mode*: Open Loop (fixed valve position) or Closed Loop (PID control to target rpm); detection thresholds (*TPS threshold, RPM upper limit*); adders for A/C and fan; PID parameters
Idle hardware	type of idle valve, outputs and frequency **[fixed]**
Idle Target RPM from CLT	target idle speed over temperature (e.g. 1200 rpm cold, 750 rpm warm)
Idle Position from CLT vs Idle Target RPM	base opening of the valve; the most important table for a stable idle
Idle After Start Taper	transition from cranking opening to idle opening
Closed-loop Ignition idle timing	idle stabilisation via ignition advance (fast)
Idle VE, **Idle Ignition advance**	separate maps for idle (enable in *Idle settings › Extra Idle Features*)
Coasting Idle position	valve position during overrun (prevents stalling when declutching)

6.6 Menu “Advanced”

Dialog	Function
Launch Control, **Rolling Launch Control**	launch rev limiter for standing starts
Torque Control (Shift Torque Reduction, Flat Shift)	ignition cut when upshifting without lifting
Boost Control	boost control via a pulsed valve
Generic PWM	freely configurable PWM outputs (e.g. water pump, intake manifold switch-over)
VVT outputs and PID, **VVT intake target**	Vanos: output **[fixed]**, control parameters, target angle over rpm and load
Electronic Throttle Body actuator, **ETB pedal target**	electronic throttle (only with retrofit via X4)
Lua	Lua script in the control unit. For the CAN module, `pecu_io.lua` is inserted here (chap. 8.10).
Nitrous Control, **Anti-Lag ALS**	motorsport functions

6.7 Menu “Sensors”

Dialog	Function
CLT sensor, **IAT sensor**	NTC characteristic (three points temperature/resistance) **[fixed for standard sensors]**
TPS	throttle calibration: ignition on, engine off. Throttle closed → *Grab closed throttle position*; full throttle → *Grab wide open throttle position*; Burn. TPS must then show 0 % and 100 %.
Accelerator pedal	pedal calibration, same procedure
MAP sensor, **MAP sampling**	sensor type and characteristic; averaging over the intake stroke
Baro sensor	ambient pressure
MAF sensor, **MAF transfer function**	air mass meter (variant with MAF)
CAN O2 sensors	internal wideband controller: must be enabled for lambda to be shown
rusEFI Wideband Tools	firmware update and status of the wideband controller
Vehicle speed sensor	vehicle speed (alternatively via CAN)
Oil / Fuel / Turbo / Aux sensors	additional sensors on AUX inputs

6.8 Menu “CAN-bus”

CAN Bus Settings – mandatory settings for operation with the CAN module:

Setting	PECU value
Bitrate (Primary CAN)	500 kbit/s
CAN read enabled / CAN write enabled	on
Enable rusEFI CAN broadcast	**on**
rusEFI CAN data base address	**512** (= 0x200)
rusEFI CAN data address type	11 bit
rusEFI CAN data period	**20 ms**
CAN dash type	**None**

> **Important:** *CAN dash type* must be set to **None**. The messages for the instrument cluster are generated by the CAN module. If the uaEFI additionally sends e.g. “BMW E46”, duplicate messages result; the CAN module then reports “ID!” (chap. 8.4).

CAN Vehicle speed sensor: vehicle speed from the vehicle CAN (e.g. BMW E46 wheel speeds).

6.9 Menu “Controller”

Dialog	Function
Bench test	individual test of injectors, ignition coils, fuel pump, fan, idle valve, main relay. Essential for the first commissioning.
Injector test	flow check of injectors
SD Card Logger	*SD Card Logging* on, *Always start in Logging mode*, *SD logger mode*, logging rate; conditional logging from rpm/load
Base Tunes	factory settings for known engines. **Do not use**: overwrites the PECU pin assignment.
Tune Lock	protect the tune with a password
Traction Control	traction control (requires wheel speeds)
Full pinout	overview of the pins and their current function

6.10 Live data and gauges

Readings, status displays and diagnostic pages are available via **View** (or the main screen). The most important channels:

Channel	Meaning
RPM, Sync	engine speed, trigger synchronisation (must be stable without error count)
MAP, TPS, CLT, IAT, VBatt	basic sensors
Lambda 1, Target lambda	actual and target mixture
Fuel: VE, Injector pulse width, Duty cycle	injection; keep injector duty below 85 %
Ignition advance, Dwell	ignition
Idle position, Idle target RPM	idle
Warning / Error codes	error messages

7 Tuning basics

This chapter summarises the procedure. It does not replace training; the rusEFI wiki (wiki.rusefi.com) and specialist literature go into more depth.

7.1 Order

1. Check and calibrate sensors (TPS, CLT, IAT, MAP, lambda).
2. Check trigger and ignition timing (7.2).
3. Starting (cranking) and warm-up.
4. Idle.
5. VE table at part load, then full load.
6. Optimise ignition advance (dyno).
7. Transitions: acceleration enrichment, overrun fuel cut-off.
8. Comfort functions: fan, A/C, lambda control.

7.2 Checking ignition timing with a timing light

This check is mandatory after every installation.

1. Start the engine and let it warm up.
2. **Ignition › Ignition hardware**: *Timing Mode* = **Fixed**, *Fixed Timing* = **10°**.
3. Connect the timing light to cylinder 1 and watch the TDC mark.
4. If the light does not show 10°, adjust **Setup › Trigger** *Trigger Angle Advance* in small steps until the mark shows 10°.
5. Set *Timing Mode* back to **Dynamic**, Burn.

7.3 Tuning the VE table

- Engine at operating temperature, lambda control off (otherwise it hides the error).
- At steady operating points compare actual lambda with target lambda. New VE value = old VE value × actual lambda / target lambda.
- With TunerStudio Ultra, **VE Analyze Live** does this calculation automatically from the readings.
- Smooth neighbouring cells; the table should have no steps.

7.4 Data logging

- Logging via laptop (F2) or to microSD.
- Analysis in MegaLogViewer: lambda vs. target lambda, knock count, injector duty, voltage.
- Always include the **.msq and log** with support requests.

8 CAN module with OLED display

This chapter describes the firmware of the CAN module, version 1.3.1 (November 2026). The version running on your module is shown on the start screen of the OLED display and on the update page in the Wi-Fi.

8.1 Tasks

The CAN module (OLED module with its own CAN interface) works independently of the engine control:

- **Display:** engine data on the OLED display and in the Wi-Fi dashboard.
- **Vehicle CAN:** generates the messages of the original DME so that rev counter, temperature gauge, warning lights, consumption display and ASC/DSC work.
- **A/C compressor:** switches the compressor on request from the air conditioning, evaluating the pressure switch.
- **Torque intervention:** evaluates torque requests from ASC/DSC and passes them on to the engine control.
- **CAN diagnostics:** switchable termination resistor and error counters.
- **Configuration and update** via Wi-Fi, without programming skills and without cables.

The module reads **only the rusEFI broadcast** of the uaEFI. If the CAN module fails, the engine keeps running; only displays and vehicle functions via CAN are missing.

On the PECU M52 the CAN bus is also on the vehicle connector (X1-86 CAN High, X1-85 CAN Low) and thus connected to the vehicle CAN, if the vehicle has one (e.g. E39, E36 from approx. 1997).

The CAN module is powered from the sensor supply of the uaEFI. It therefore only works with the **ignition on**, not with USB power alone.

8.2 Firmware functions

Function	Description	Setting
OLED display	7 pages with engine, vehicle and CAN data, start screen, OK screen, error pop-ups	BOOT button (8.4)
Status LED	flash code for operating state and faults	– (8.5)
Wi-Fi hotspot	name PECU-xxxx, password changeable, can be hidden	settings page › Wi-Fi (8.6)
Dashboard	engine values, torque, vehicle CAN, status, memory	192.168.4.1
Settings page	all parameters, effective immediately, kept during updates	192.168.4.1/settings (8.7)
CAN page	termination resistor, measuring guide, error counters	192.168.4.1/can (8.8)
Vehicle profile BMW E46/E39/E38/E53/Z3	messages 0x316, 0x329, 0x545, substitute 0x153; reads 0x153 (ASC/DSC)	settings page › General (8.9)
A/C compressor	switches the compressor via its own output at the vehicle connector	settings page › A/C compressor (8.12)
Torque model	estimate of the engine torque from the cylinder air mass	settings page › torque model (8.10)
Torque intervention	ignition retard and soft spark cut via `pecu_io.lua`	Lua in TunerStudio (8.10)
Warning lights	MIL, cruise control, EML, fuel cap, overheating, charge warning, oil pressure	settings page › lamps
Multilingual	German, English, French, Spanish for web interface and OLED	settings page › General
Firmware update	via Wi-Fi with encrypted and signed .pecu files, locked while the engine is running	192.168.4.1/update (8.11)
Monitoring	watchdog restarts the module if the firmware hangs; detection of duplicate CAN IDs	–

8.3 Requirements in TunerStudio

The settings from chap. 6.8 must be set: broadcast on, base address 512, period 20 ms, *CAN dash type* = None. Torque intervention and lamps additionally need the Lua script `pecu_io.lua` (chap. 8.10).

8.4 OLED display

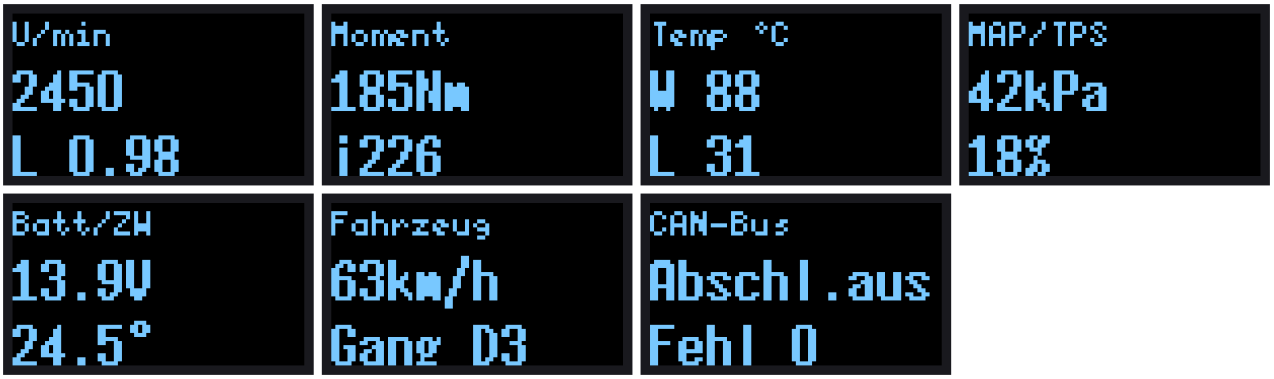
After switching on, the display shows the k-data logo for 2 s, “PECU CAN” with the firmware version for 1.5 s and the Wi-Fi name, password and IP address for 4 s. Then a large **“OK”** appears as long as everything is fine. Pressing the **BOOT** button skips the start screen; the first press after the OK screen switches to the rpm page. The CAN bus is already working normally during this time.

The display shows German texts at the factory. Select English on the settings page (chap. 8.7); the pictures in this chapter show the German texts.



Start screen: logo, version, Wi-Fi data, OK screen

The **BOOT** button on the module pages through seven pages:



OLED pages (example values)

Page	Title (German)	Line 1	Line 2
1	U/min	engine speed	lambda (L)
2	Moment	estimated crankshaft torque in Nm	indicated torque (i)
3	Temp °C	coolant (W)	intake air (L)
4	MAP/TPS	manifold pressure in kPa	throttle in %
5	Batt/ZW	system voltage	ignition advance
6	Fahrzeug	speed from ASC/DSC	gear, if the vehicle reports it via CAN
7	CAN-Bus	termination on/off	CAN errors since start

Symbols in the title line

Symbol	Meaning
MIL	check engine light active (fault in the uaEFI)
!	a fault is present; the error text is shown for 1.2 s every 5 s
ID!	ID conflict: *CAN dash type* in TunerStudio is not set to None

Pop-ups

Display	Meaning	Remedy
“Fehler / MCP2515 / SPI?”	CAN controller does not respond	send the unit for service (hardware fault)
“CAN / warte auf / rusEFI”	no data from the uaEFI	switch on broadcast in TunerStudio, check base address 512
“Fehler / CAN / Bus-Off”	CAN bus disturbed	check wiring, termination (8.8), bit rate; the controller restarts by itself
“WLAN unsichtb. / PECU-xxxx / Passwort”	reminder when the Wi-Fi is hidden (8.6), for 1.2 s every 5 s	–



Symbols in the title line and pop-ups

A button press hides an error text immediately and shows the next page.

8.5 Status LED of the CAN module

LED	Meaning
steady on	everything OK
2 × flash, pause	no rusEFI data
3 × flash	CAN controller does not respond
4 × flash	CAN bus-off
5 × flash	ID conflict (*CAN dash type* ≠ None)

8.6 Wi-Fi and dashboard

1. Switch on the ignition.
2. Look for the Wi-Fi **PECU-xxxx** with a smartphone or laptop (xxxx = last four digits of the device ID). Factory password: **kdatapecu**.
3. Open **http://192.168.4.1** in the browser.

The dashboard shows engine values, the estimated torque, data from the vehicle CAN (speed, brake, gear, interventions), the status of the module, the CAN errors, the termination and the free memory. All values are available in machine-readable form at **http://192.168.4.1/data.json**.

> **Important:** Change the Wi-Fi password during commissioning (settings page, group Wi-Fi, at least 8 characters). With the default password anyone within range can change the settings of the module.

Wi-Fi hidden: If this setting is on, the hotspot stays active but no longer appears in the Wi-Fi list. Connect via “Add hidden network” with name **PECU-xxxx** and password. So that name and password are not lost, the OLED display briefly shows both every 5 s.

Password forgotten (recovery via USB): If the Wi-Fi password is lost and cannot be read on the small OLED display, the module can also be configured without Wi-Fi. Switch the ignition off, remove the housing lid, connect the PC with a USB cable to the USB socket of the CAN module and start the program **PECU Konfigurator** (Windows, on the k-data download page). It finds the module by itself and shows dashboard, settings page and update page as in the Wi-Fi. Set a new Wi-Fi password there, switch off *Wi-Fi hidden* or reset everything with **factory settings** (password afterwards `kdatapecu` again). Then unplug the USB cable and refit the lid.

8.7 Settings page

http://192.168.4.1/settings. Changes take effect immediately and are kept during firmware updates. **Factory settings** resets everything (including the Wi-Fi password to `kdatapecu`).

Group	Setting	Factory setting	Explanation
General	Language	German	Deutsch, English, Français, Español for web interface and OLED
	Vehicle profile	BMW E46/E39/E38/E53/Z3	protocol of the original DME; “none” for VAG
	rusEFI base ID	200 (hex)	must match TunerStudio (512 decimal)
Messages	0x316 / 0x329 / 0x545	on	can be switched off individually, e.g. on vehicles without cluster CAN
	DSC lamp off (substitute 0x153)	off	switch on **only** if no ASC/DSC unit is fitted
Engine	MD_NORM	D9 (400 Nm)	reference torque in the torque messages (S54: DF)
	OBD_STEUER engine stopped / running	80 / 86	status values in 0x329
	engine running from / idle below	500 / 1000 rpm	status bits for the instrument cluster
	report ASC intervention	on	requires `pecu_io.lua`
Torque model	source, air mass for 400 Nm, offset, friction	cylinder air mass, 700 mg, −24 Nm, 20 Nm + 5 Nm/1000 rpm	estimate of the engine torque (8.10)
Pedal	send pedal, source, kickdown	on, TPS, 98 %	pedal value for ASC/DSC; PPS with drive-by-wire
	air pressure	1013 hPa	
Lamps	overheating / charge warning / oil pressure	115 °C / 12.2 V / off	thresholds for the warning lights
	oil temperature = coolant	off	for vehicles without oil temperature sensor
	consumption factor	25 steps/ml	**calibrate against the on-board computer**
A/C compressor	switch A/C compressor via the module	off	compressor runs on request, pressure OK and engine running (8.12)
	request	CAN 0x615 (BMW E46)	On the PECU M52 select **Eingang** (input, X1-16). CAN 0x615 applies to the BMW E46 only.
	request active at	12 V	only for request via the input
	pressure switch	not present	not present / pressure OK at 12 V / pressure OK at 0 V
	minimum rpm	500 rpm	compressor only with the engine running
CAN bus	CAN termination 120 Ω	on	measure in case of faults (8.8)
Wi-Fi	password	kdatapecu	at least 8 characters

Group	Setting	Factory setting	Explanation
	Wi-Fi hidden	off	name is not broadcast, hotspot stays active

The names on the settings page depend on the selected language and may differ slightly from this table.

8.8 CAN termination and error counters

A CAN bus needs a 120 Ω termination resistor at each end, together 60 Ω between CAN High and CAN Low. If the original DME is removed, one termination may be missing; if only one device is connected to X4, usually both are missing. Every PECU board has its own 120 Ω termination, which the CAN module switches by a setting. It is on at the factory, because the PECU usually replaces a control unit at the end of the bus.

Setting (dashboard › CAN bus or http://192.168.4.1/can):

1. Switch the termination **off**, ignition off, wait a few minutes until all control units are asleep.
2. Measure the resistance between CAN High and CAN Low at the PECU connector with a multimeter.

Reading	Meaning	Setting
≈ 60 Ω	correctly terminated	off
≈ 120 Ω	one termination missing	**on**
≤ 40 Ω	too many terminations	off, remove another one
very high / open	line interrupted or no other termination	check the wiring

Error counters: The CAN page, the OLED page “CAN-Bus” and the dashboard show the CAN errors since start (transmission errors, buffer overflows, send errors, bus-off, warning and passive level, error counters REC/TEC). With the engine running, all values should stay at 0 or rise only very rarely. If they keep rising, the bus is incorrectly terminated or disturbed.

8.9 Vehicle profile BMW E46/E39/E38/E53/Z3

The module sends the messages of the Siemens MS42/MS43 every 10 ms:

Message	Content
0x316 DME1	engine speed, engine torques, status bits (terminal 15, ASC, gear change possible)
0x329 DME2	coolant temperature, air pressure, pedal, idle, brake, kickdown, further status values multiplexed
0x545 DME4	warning lights (MIL, cruise control, EML, fuel cap, overheating, charge warning, oil pressure), consumption, oil temperature
0x153 (substitute)	only on request, if no ASC/DSC is fitted: suppresses the DSC warning light

It reads 0x153 (ASC/DSC: speed, brake, torque intervention).

8.10 Torque model, torque intervention and Lua script

ASC/DSC expects the current engine torque from the engine control and requests a torque reduction in case of wheel slip.

- **Torque estimate:** The module calculates the torque from the cylinder air mass of the uaEFI (indicated torque minus friction). Plausibility check: A stock M52B28 should show about 280 Nm at the crankshaft at full load, an M52B25 about 245 Nm, an M52B20 about 190 Nm.
- **Intervention:** If ASC/DSC requests less torque, the module calculates the reduction share and sends it to the uaEFI. There, `pecu_io.lua` first retards the ignition by up to 30° and beyond that softly cuts individual sparks (never two in a row). An intervention ends after 1.25 s at the latest.

Including the Lua script

1. Obtain `pecu_io.lua` from k-data and copy its content.
2. TunerStudio: **Advanced › Lua › Lua Script Settings** (or the Lua script editor), paste the content.
3. Burn and switch the ignition off/on.

The script also transfers warning lights (MIL, cruise control, EML, fuel cap) from the uaEFI to the instrument cluster.

8.11 Firmware update of the CAN module

k-data provides updates as a file **`pecu-can-<version>-update.pecu`**. These files are encrypted and signed; the module only accepts files with a valid k-data signature. With a faulty file the previous firmware remains active.

1. **Engine off**, ignition on. (The update is locked while the engine is running.)
2. Connect to the Wi-Fi PECU-xxxx, open **http://192.168.4.1/update**.
3. Select the .pecu file, start **Update** and wait until the module restarts (approx. 30 s). Do not switch off the ignition during the update.
4. Check the new version number on the OLED start screen or in the dashboard.

The settings are kept. The changes in each version are listed in the change log that k-data publishes with every version.

8.12 A/C compressor

Function: The CAN module switches the A/C compressor when the air conditioning requests it, the pressure switch enables it and the engine is running.

Factory setting: off. The compressor stays off until the function is switched on.

Setting (settings page › A/C compressor):

1. Switch on *switch A/C compressor via the module*.
2. Choose *request*: On the PECU M52 select **Eingang** (input, X1-16). CAN 0x615 applies to the BMW E46 only.
3. For a request via the input: *request active at* 12 V or 0 V. Watch the indicator “A/C request” in the dashboard and press the A/C button; the indicator must follow.
4. *Pressure switch*: On the PECU M52 the signal at X1-16 already includes the pressure switch; select *Druckschalter* = nicht vorhanden (not present) (chapter 3.17).
5. Only change *minimum rpm* (factory 500 rpm) if the compressor should not run during cranking.

The dashboard shows “A/C request”, “A/C pressure OK” and “A/C compressor”. The compressor only runs when all conditions are met and the uaEFI sends data. If the CAN module fails, the compressor stays off.

Technology: request and pressure switch act via transistor stages on two inputs of the CAN controller; the output is a low-side semiconductor output, switches to ground and is designed for a relay coil. Vehicle connector pins: chap. 3.17.

> **Note:** The idle increase with the A/C on is set in the uaEFI (**Setup › Air Conditioning**, *A/C Idle RPM*). For this the uaEFI needs the information that the compressor is running; this is not set up in the base calibration.

9 Diagnostics and troubleshooting

9.1 Procedure

1. Look at the error messages in TunerStudio (warning indicators, error codes).
2. Check sensor readings with the ignition on for plausibility (CLT ≈ ambient temperature with a cold engine, MAP ≈ 95–102 kPa, TPS 0 %, VBatt > 12 V).
3. Check actuators individually with **Controller › Bench test**.
4. Record and analyse a log.

9.2 Troubleshooting table

Symptom	Possible cause	Remedy
No connection to TunerStudio	wrong COM port, another program uses the port, USB cable	select the port again, close rusEFI Console, try another cable
TunerStudio reports a wrong firmware signature	.ini does not match the firmware	project properties: let TunerStudio detect the .ini again (chap. 5.2)
Engine turns, no rpm in TunerStudio	crankshaft sensor, trigger setting changed	check sensor/connector, restore the trigger settings of the base calibration
Rpm present, no spark	spark off, ignition coil supply, main relay	switch *Spark* on, bench test coil, check main relay and fuses
Spark present, does not start	fuel pump, injectors, cranking fuel, ignition timing	bench test pump/injectors, measure fuel pressure, cranking fuel, timing light (7.2)
Starts and stalls	idle valve, after-start enrichment, air leak	increase idle position, after-start enrichment, look for air leaks
Lambda shows nothing / a fixed value	sensor not connected, CAN O2 not enabled, engine not running	chap. 3.7 and 6.7
Idle hunts	control parameters too aggressive, VE wrong at idle	first tune open loop to be stable, then PID; use closed-loop ignition idle timing
Instrument cluster: rev counter/temperature dead	CAN module receives no data	check OLED/LED (8.4/8.5), broadcast settings (6.8)
CAN error counters rise, cluster flickers	termination resistor missing or doubled	measure the resistance, set the CAN termination (8.8)
Wi-Fi PECU-xxxx not visible	ignition off, or “Wi-Fi hidden” on	ignition on; read name and password from the OLED display and connect as a hidden network (8.6)
Wi-Fi password forgotten	–	change the setting from a connected device, otherwise have k-data reset the module
Update is rejected	no .pecu file, wrong signature or engine running	use the current file from k-data, engine off
uaEFI LED D103 lights red	serious firmware error	read the error message in TunerStudio (3.16)
OLED “ID!”	*CAN dash type* ≠ None	set to None, Burn
DSC light on without a DSC unit	substitute 0x153 off	settings page: switch on “DSC lamp off”

9.3 Back to the base calibration

If things are unclear: **File › Open Tune**, load the supplied base calibration (.msq), Burn, ignition off/on. Save your own changes first.

10 Maintenance, warranty, support

- The PECU is maintenance-free. Keep the connectors dry.
- The wideband sensor is a wear part. Leaded fuel, oil in the exhaust and short trips shorten its life.
- Warranty according to the terms and conditions of k-data. Damage caused by reverse polarity, overvoltage, water and improper intervention is excluded.
- **Support:** k-data.org. Please include the serial number or type plate, firmware version, .msq file and a log.
- **Disposal:** electronic waste, not household waste (WEEE).

Appendix A – Pinout of the uaEFI module

Source: rusEFI project, uaEFI connector description. The PECU carrier board makes the connection to the vehicle; this table is for troubleshooting and extensions.

Connector A (supply, H-bridges)

Pin	Function
A1 / A5	H-bridge 1 (DC1− / DC1+)
A2 / A6	H-bridge 2 (DC2− / DC2+)
A3, A4	power ground
A7	ignition / battery voltage
A8	+12 V from the main relay

Connector B (outputs)

Pin	Function	Pin	Function
B1–B6	injection 6 … 1	B10	ignition 6
B7	LS1 / VVT1 (diode)	B11	ignition 4
B8	LS_HOT2 fan relay	B12	ignition 3
B9	LS_HOT1 main relay	B13	ignition 5
B16	LS4 / fuel pump (diode)	B14	ignition 2
B17	LS3 / injector 7 (diode)	B15	ignition 1
B18	LS2 / VVT2 / idle / injector 8 (diode)		

Connector C (sensors, trigger)

Pin	Function	Pin	Function
C1, C2	+5 V sensor supply	C11–C13	sensor ground
C3	AUX2	C14	TPS2
C4	PPS2	C15	AUX3 / fuel pressure
C5	HALL1 / camshaft 1	C16 / C17	VR2+ / VR2−
C6	HALL2 / camshaft 2	C18 / C19	VR1+ / VR1−
C7	HALL3 / VSS	C10 / C20	EGT+ / EGT−
C8	power ground / VR shield	C9	BUTTON3

Connector D (sensors, CAN)

Pin	Function	Pin	Function
D1	AUX1	D9	external MAP
D2	BUTTON1	D10	BUTTON2 / A/C request
D3, D4	+5 V sensor supply	D11, D12	sensor ground
D5	FLEX / digital input	D13	TPS1
D6	PPS1	D14	knock sensor
D7 / D8	CAN High / CAN Low	D15 / D16	IAT / CLT

Connector E (Bosch LSU 4.9)

Pin	Function	LSU pin	Wire colour
E1	heater + 12 V	4	grey
E2	trim resistor (RCal)	5	green
E3	heater –	3	white
E4	Vs (Un)	6	black
E5	Ip, pump current	1	red
E6	Vs/Ip (Vm)	2	yellow

Position in the connector: see chap. 3.7.

Appendix B – Vehicle connector X1 (PECU M52)

88-pin connector like the original DME Siemens MS41, pin numbers according to BMW numbering. Pins not connected on the carrier board are marked as *not used* (removed functions of the original DME: chapter 3.19). Details of each signal are in the chapter given. The table is read directly from the board layout when the manual is generated.

X1	Signal	Type	uaEFI	Ch.	X1	Signal	Type	uaEFI	Ch.
1	Ignition coil cyl. 2	Z	[B13]	3.4	45	*not used*			
2	Ignition coil cyl. 4	Z	[B10]	3.4	46	*not used*			
3	Ignition coil cyl. 6	Z	[B11]	3.4	47	*not used*			
4	Ground	M	GND	3.1	48	+5 V sensor supply	V	+5 V	3.6
5	Injector cyl. 2	A	[B2]	3.3	49	Ignition on (terminal 15)	E	[A7]	3.1
6	Injector cyl. 1	A	[B6]	3.3	50	*not used*			
7	Ground	M	GND	3.1	51	*not used*			
8	Analogue input AUX1 (air mass meter)	E	[D1]	3.9	52	*not used*			
9	*not used*				53	Idle actuator, winding 1	A	[B18][1]	3.11
10	Coolant temperature	E	[D16]	3.5	54	*not used*			
11	*not used*				55	Ground	M	GND	3.1
12	Throttle position sensor	E	[D13]	3.6	56	Ground	M	GND	3.1
13	*not used*				57	Knock sensor	E	[D14]	3.8
14	Intake air temperature	E	[D15]	3.5	58	Sensor ground	M	GNDA	3.1
15	Vehicle speed signal	E	[C7]	3.9	59	*not used*			3.8
16	A/C request	E	CAN module	3.17	60	*not used*			
17	*not used*				61	Ground	M	GND	3.1
18	*not used*				62	*not used*			
19	*not used*			3.17	63	Sensor ground	M	GNDA	3.1
20	*not used*				64	Camshaft sensor (Hall)	E	[C6]	3.2
21	Vanos solenoid valve	A	[B7]	3.10	65	+5 V sensor supply	V	+5 V	3.6
22	Injector cyl. 3	A	[B4]	3.3	66	*not used*			
23	Injector cyl. 6	A	[B3]	3.3	67	Sensor ground	M	GNDA	3.1
24	Injector cyl. 4	A	[B1]	3.3	68	Tank venting (EVAP)	M	R343	3.18
25	Ground	M	GND	3.1	69	Fuel pump relay	A	[B16]	3.10
26	*not used*				70	Sensor ground	M	GNDA	3.1
27	Idle actuator, winding 2	A	[B18][1]	3.11	71	Sensor ground	M	GNDA	3.1
28	Sensor ground	M	GNDA	3.1	72	Sensor ground	M	GNDA	3.1
29	Ignition coil cyl. 1	Z	[B15]	3.4	73	Main relay	A	[B9]	3.1
30	Ignition coil cyl. 3	Z	[B12]	3.4	74	A/C compressor relay	A	CAN module	3.17
31	Ignition coil cyl. 5	Z	[B14]	3.4	75	*not used*			
32	Ground	M	GND	3.1	76	*not used*			
33	Injector cyl. 5	A	[B5]	3.3	77	*not used*			
34	Ground	M	GND	3.1	78	*not used*			
35	*not used*				79	Ground	M	GND	3.1
36	Rev counter	A	[B17]	3.10	80	*not used*			
37	*not used*				81	*not used*			
38	Ground	M	GND	3.1	82	*not used*			
39	Sensor ground	M	GNDA	3.1	83	Crankshaft sensor (Hall)	E	[C5]	3.2
40	Sensor ground	M	GNDA	3.1	84	*not used*			
41	Ground	M	GND	3.1	85	CAN Low	B	[D8]	3.14
42	Sensor ground	M	GNDA	3.1	86	CAN High	B	[D7]	3.14
43	Sensor ground	M	GNDA	3.1	87	+12 V from main relay	V	[A8]	3.1
44	+5 V sensor supply	V	+5 V	3.6	88	*not used*			

Type: E = Input · A = Output, switches to ground · Z = Ignition output (ignition driver) · B = CAN bus · V = Supply · M = Ground

[1] Via the carrier board: one uaEFI output drives both windings of the idle actuator (chapter 3.11). R343 = fixed bridge to ground (chapter 3.18). The cylinder numbers follow BMW numbering (cylinder 1 at the front). The camshaft sensor at X1-43/64/65 is assigned differently from the MS41 (chapter 3.2).

Appendix C – Glossary

Term	Explanation
Alpha-N	load detection via throttle angle and engine speed
Burn	permanently saving the settings in the control unit
CLT / IAT	coolant / intake air temperature
DME	Digital Motor Electronics, BMW's name for the engine control unit
Dwell	charging time of the ignition coil
IGBT	power transistor for the ignition coil
Lambda	air-fuel ratio; 1.0 = stoichiometric, < 1 rich, > 1 lean
MAP	manifold absolute pressure
.msq	TunerStudio calibration file
TDC	top dead centre
PPS / TPS	pedal / throttle position sensor
Speed Density	load detection via manifold pressure, temperature and engine speed
Trigger	signal from crankshaft and camshaft used to determine the engine position
VE	volumetric efficiency
VR sensor	inductive (variable reluctance) speed sensor
VVT / Vanos	variable camshaft timing

Appendix D – Changes to this manual

This appendix lists what has changed for you: in this manual, between the board revisions and in the firmware of the CAN module. The latest edition and firmware are available on the k-data download page.

D.1 Editions of this manual

Edition	Date	Changes
2.0	November 2026	First edition for the PECU M52. Applies to board revision R04, rusEFI firmware release_20260812 and CAN module firmware 1.3.1.

D.2 Board revisions

This manual applies to all revisions of the PECU M52. The revision is printed on the board after the product name (for example “PECU M52 R04”). The chapters describe the latest revision; where older revisions differ, this is stated in the table and at the relevant place in the text (“from …” or “up to …”).

Revision	Delivered from	Differences from the previous revision
R04	November 2026	First series revision.

D.3 Firmware of the CAN module

Your version is shown on the start screen of the display and on the update page in the Wi-Fi. All settings are kept during an update. Detailed notes on each version are in the release notes supplied with the firmware on the k-data download page.

Version	Date	Main changes
1.3.0–1.3.1	07.11.2026	no change for this board
1.2.3	03.11.2026	A/C compressor control with pressure switch
1.2.1	03.11.2026	OK screen, Wi-Fi data in the start screen, PECU Konfigurator (Windows), switchable CAN termination, hidden Wi-Fi, only signed updates, factory Wi-Fi password **kdatapecu**
1.2.0	02.11.2026	languages German, English, French, Spanish
1.1.3	02.11.2026	start screen with version, faults no longer block the display
1.1.0–1.1.2	02.11.2026	settings page in the Wi-Fi, update via Wi-Fi, engine torque, ASC/DSC intervention, warning lights
1.0.0	02.11.2026	first version: OLED, Wi-Fi dashboard, E46 messages