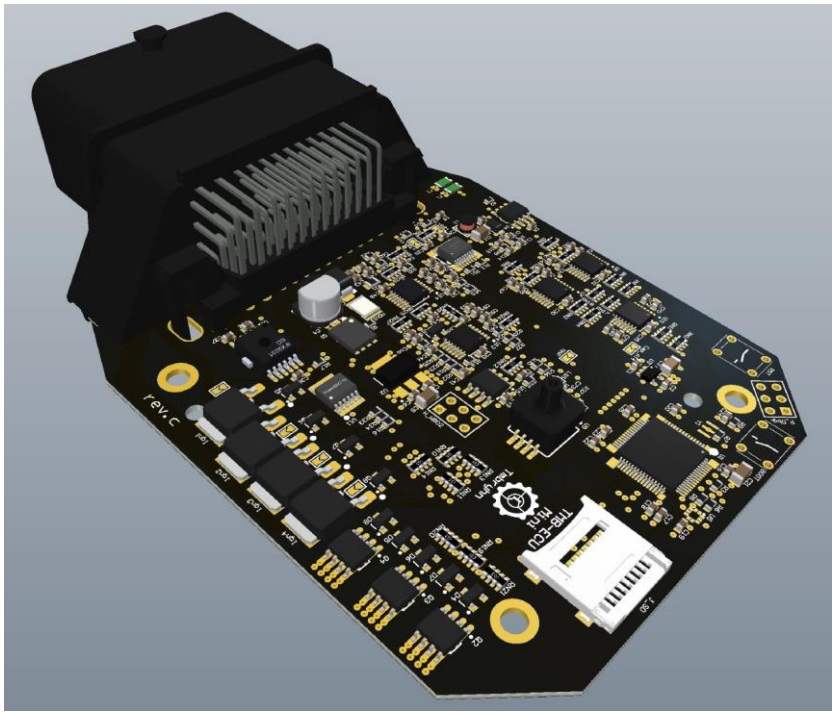
TMB ECU Mini

By

Tmbryhn engineering

Revision: c



Disclaimer of liability

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Schematics

DISCLAIMER OF LIABILITY:

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Introduction

The TMB ECU Mini is a robust platform offering a wide range of functionality suitable for typical 4-cylinder EFi implementations. The software is based on an open source platform (RusEFi) with a steadily growing user and developer community, resulting in continuous improvement and a growing list of features.

Some of the key hardware features includes direct USB communication, integrated wideband controller, DBW capability, knock sensor input, internal SD card logging, 4x passive/logic coil drivers, up to 5x injector drivers, integrated 4 bar MAP sensor and multile spare analog inputs for expansion beyond basic fuel/ignition control.

The result is a more or less all-inclusive affordable EMS that delivers functionality for a wide variety of smaller engine setups – allowing for a typical 4-cylinder engine running features like fully sequential fuel delivery, direct spark, turbo w. boost control, ETB and advanced knock control.

The ECU package includes the following items:

- TMB ECU Mini
- Shielded USB cable
- Bosch LSU 4.9 Wideband oxygen sensor + connector & weld-in bung
- Pre-terminated flying lead + spare pins (optional)
- Relay holder; main pwr & fuel pump (optional)

Specifications & Features

Specification

Voltage range	7.0 - 30.0
Min temp. °C	-40
Max temp. °C	85
Injector Pulse Width resolution (ms)	0.01
Spark resolution (crankshaft°)	0.1
Cylinder quantity	1-8

Hardware

Inputs		
WBO2	1x	Integrated Wideband controller for Bosch LSU4.9
Trigger; Crank & Cam	2x VR / 2x Hall	https://github.com/rusefi/rusefi/wiki/All-Supported-Triggers#universal
Analog, 0-5V	10x	Pressure, Position etc.
Analog, "Temp" / Digital	4x	Internal 2.7k Pullup. 2-wire temp. sensor or digital input (Active GND)
MAP/BARO	1x	Integrated 400kPa (4 bar / 58 PSI) absolute pressure sensor
Knock	1x	Compatible with most Wideband & Narrowband knock sensors

Outputs		
Ignition	4x	4x Passive / 4x Logic
General purpose "Low-side" (Active GND)	5x	High-Z injectors, Idle, Boost, VVT, relays etc.
General purpose "High-side" (Active 12V)	2x	Relays, tachometer signal, lamps & LEDs etc.
Drive By Wire / Motor control	1x	H-bridge

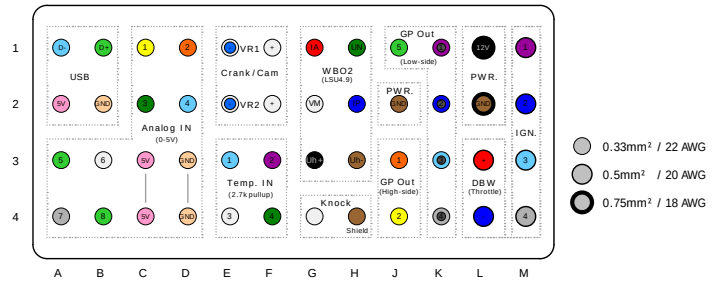
Connection	
USB	Tuner Studio, MSDroid, ShadowDash
Internal SD card	Automatic datalogging, Megalogviewer format (.mlg)

Software

RusEFi firmware	https://rusefi.com/
TunerStudio by EFi Analytics	https://www.tunerstudio.com/index.php
Quick tune / VE analyzer Live	Autotune Fuel VE table
Speed density	MAP-based fuel/ignition
Alpha-N	TPS-based fuel/ignition
16x16 Fuel VE, Ignition timing and AFR target maps	
Drive By Wire / ETB	Simplified Auto calibration. Pedal vs. Throttle vs. RPM map
Boost control	Closed / Open loop
Batch/fully sequential fuel. Wasted/Direct spark (COP)	4 cylinders (sequential injection & COP) / 8 cylinders (batch injection & wasted spark)
Acceleration enichment	Simple/Advanced "X-Tau" strategies
Idle control	DBW or IAC, Closed / Open loop
EGO control	Closed loop
VVT - Variable valve timing	Up to 2x camshafts
Knock detection & control	Individual cylinder smart DSP knock detection & ign. timing strategies
Fuel pressure monitoring	Dynamic injector flow rate compensation
Generic Press & Temp monitoring	Oil, fuel etc.
Vehicle & generic shaft speed	CAN or Digital input based. Gear detection strategy
Turbo speed	Digital input, Turbine speed monitoring.
Flex fuel	Continental/GM, 50-150Hz type
Launch control & Anti-lag	Switched or Conditional. Fuel & spark (retard & skip) tables. Adjustable ETB air bypass.
Fuel pump and Cooling fan control	Fuel priming delay, 2x conditional fan control w. hysteresis

	Name	CPU Pin	Connector Pin #	Size (AWG)	Description		Default / Note
	INPUT						
Power	**12V, ECU**		L1	18	ECU Power & GND		Main power relay "87"
	GND, ECU		J2	22			Chassis/Batt GND
	GND, PWR		L2	18			Chassis/Batt GND
Sensor	**GND**		D3, D4	22	Sensor GND return		
	5V		C3, C4	22	Sensor 5V power		
	Analog Temp 1	PA4	E3	22	Internal 2.7k pullup		CLT/CHT
	Analog Temp 2	PA2	F3	22			IAT
	Analog Temp 3	PA0	E4	22			Oil temp
	Analog Temp 4	PA1	F4	22			Optional: TPS SENT
	Analog Volt 1	PA7	C1	22	0-5V		PPS-A
	Analog Volt 2	PA5	D1	22			PPS-B
	Analog Volt 3	PC4	C2	22			TPS #1A
	Analog Volt 4	PA6	D2	22			TPS #1B
	Analog Volt 5	PC2	A3	22			Fuel press
	Analog Volt 6	PC3	B3	22			MAP (Internal jumper)
	Analog Volt 7	PC0	A4	22			TPS #1A
	Analog Volt 8	PC1	B4	22			TPS #1B
	Analog Volt 9	PB0	NA	NA			WBO2 (Internal)
	Analog Volt 10	PC5	NA	NA			Battery voltage (Internal)
WBO2	**IP**		H2	22			LSU-Pin 1
	VM		G2	22			LSU-Pin 2
	Uh-		H3	22	Heater GND (N-FET)		LSU-Pin 3
	Uh+		G3	22	Heater 12V		LSU-Pin 4
	IA		G1	22			LSU-Pin 5
	UN		H1	22			LSU-Pin 6
Crank/Cam/VSS	**VR 1+**	PB2	F1	TP	VR sensor Shielded twisted pair		Crank
	VR 1-		E1	TP			Crank
	VR 2+	PB1	F2	TP			Cam or VSS
	VR 2-		E2	TP			Cam or VSS
	Shield		H4	22			
Knock	**Channel 1**	PA3	G4	22	Sensor "+" input		
	Shield		H4	22	Shield / Sensor "-" input		

	OUTPUT						
General Purpose	**Low-side 1**	PA10	K1	22 Striped	Active GND (N-FET)		Inj #1
	Low-side 2	PB8	K2	22 Striped			Inj #2
	Low-side 3	PB5	K3	22 Striped			Inj #3
	Low-side 4	PC13	K4	22 Striped			Inj #4
	Low-side 5	PB4	J1	22			
	High-side 1	PB15	J3	22	Active 12V (P-FET)		Fuel pump relay +12V
	High-side 2	PC6	J4	22			Tachometer signal
Ignition	**Ign 1**	PC7	M1	20	Active GND (IGBT)	5V logic (Solder Jumper)	Coil, passive #1
	Ign 2	PC8	M2	20			Coil, passive #2
	Ign 3	PC9	M3	20			Coil, passive #3
	Ign 4	PA8	M4	20			Coil, passive #4
DBW	**M+**		L3	20			
	M-		L4	20			



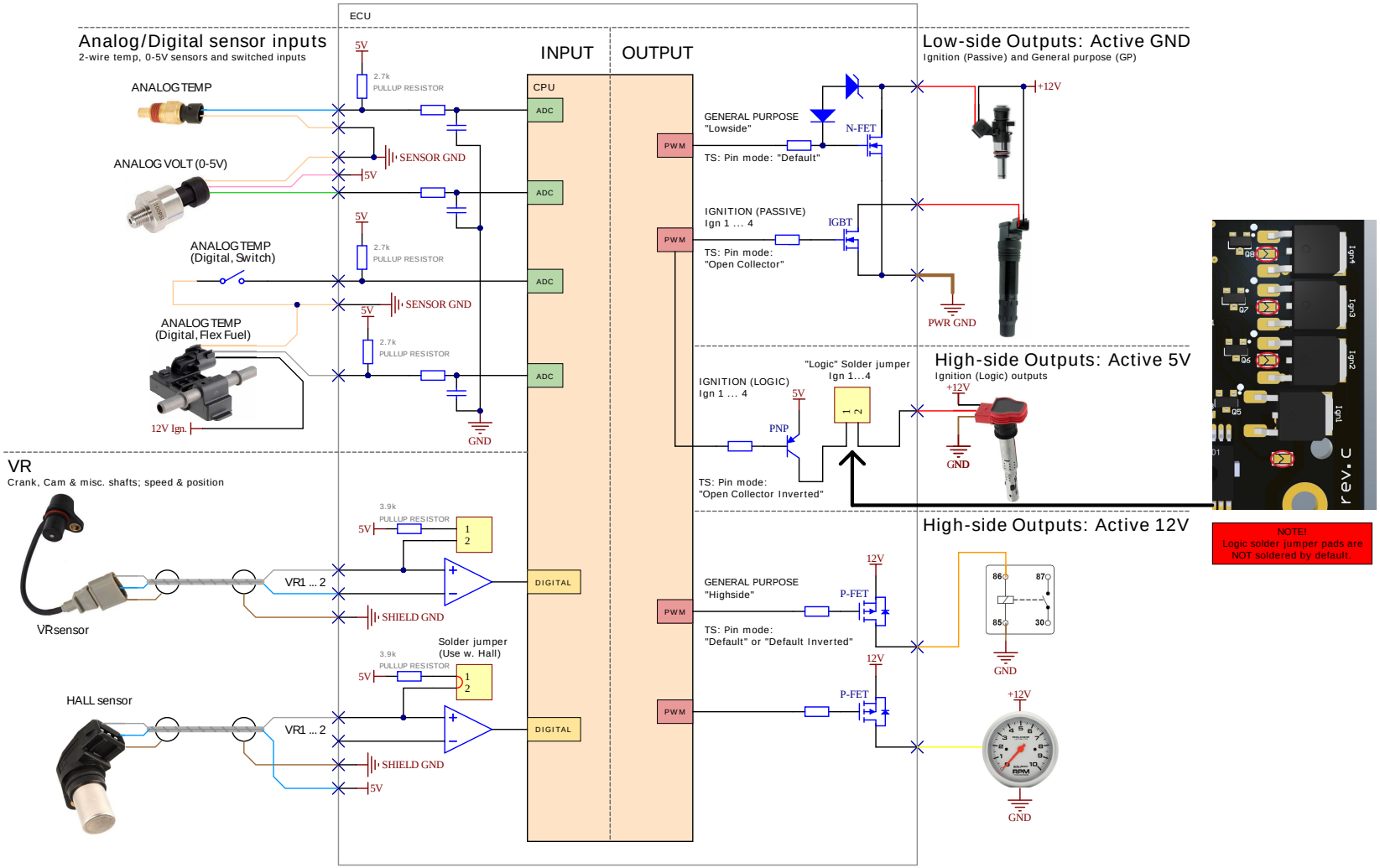
0.33mm² / 22 AWG

0.5mm² / 20 AWG

0.75mm² / 18 AWG

TMB ECU Mini wiring guide:

Input/Output general example



*ADC = ANALOG TO DIGITAL CONVERTER

*PWM = PULSE WIDTH MODULATION

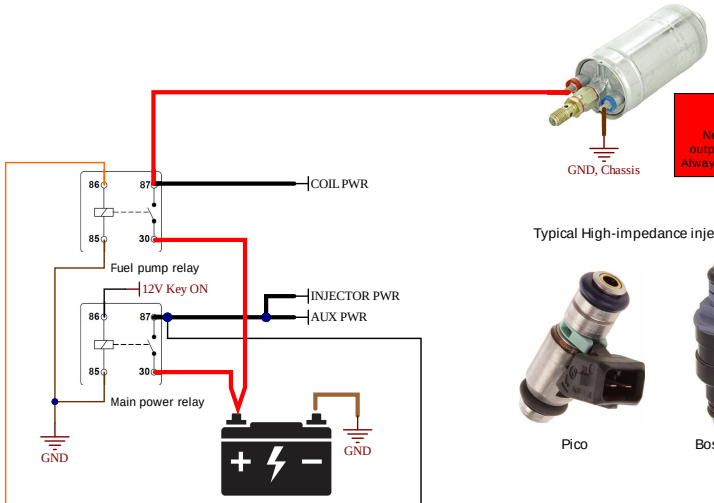
TMB ECU Mini wiring guide:
Power, Ignition/Injection & Misc.

GENERAL PURPOSE OUTPUTS:

Low-Side:
- Active GND: The load is grounded through the ECU
- Max current per channel: 5A
- 47V active voltage clamp
- Multiple loads may be connected in parallell

NOTE: Only use high-impedance injectors, typically between 8-16 Ohms

High-Side:
- Active 12V: The load is permanently grounded, and powered by the ECU
- Max current per channel: 4A
- Multiple loads may be connected in parallell



WARNING!

Never connect the pump directly to the output - This will damage the driver circuit. Always use a relay rated for at least 16 amps.

Typical High-impedance injectors:

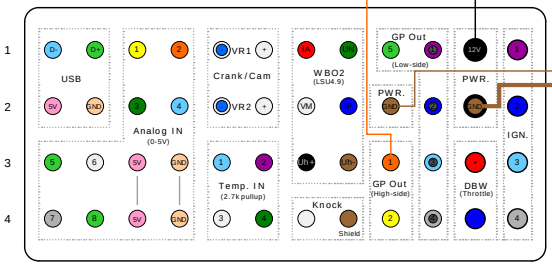
Pico | Bosch EV-1 | Bosch EV-6 | Bosch EV-14

PASSIVE COILS connections:
- Positive: Constant 12V through relay
- Negative: Passive ignition output (Active GND)

COP | Dual Channel - "Wasted spark" | Single

LOGIC/SMART COILS connections:
- Constant 12V through relay
- Constant GND connection
- Input signal: Logic ignition output (5V pulse)

COP | Dual Channel - "Wasted spark" | Quad Channel | Single



GND

0.33mm² / 22 AWG
0.5mm² / 20 AWG
0.75mm² / 18 AWG

GROUNDING GUIDELINES:

GND ..... 0.5mm² / 20 AWG or larger
PWR GND ... 1.5mm² / 16 AWG or larger

Run all GND wires individually to a common lug/terminal bolted to a clean GND point at the engine case.
Terminate w. either a high quality crimper or solder for a reliable low-resistance GND connection.

IGNITION OUTPUTS:

PASSIVE:
- Output 1 ... 4: Internal ignition amplifiers (Active GND)
- Max current per channel: 17A
- TunerStudio setting: "Ignition Pin Mode" = "Open Collector"

LOGIC:
- Output 1 ... 4: 5V pulse (internal solder jumper)
- For coils w. built-in ignitor or external ignition amplifier.
- Max continuous current: 100mA
- TunerStudio setting: "Ignition Pin Mode" = "Open Collector Inverted"

WARNING!

Setting the "Ignition Pin Mode" incorrectly will destroy the coils and/or the ignition outputs! Always disconnect the 12V power supplying injectors, coils and miscalaneous loads whenever loading firmware or setting up your project for the first time.

TunerStudio CONFIG:

1. Set firing order: "Base Engine Settings" -> "Firing Order".

2. Set "Trigger" -> "Trigger type":
NOTE: "Sequential" injection & "Individual Coils" may only be enabled if Crank+Cam trigger or Camshaft primary trigger is implemented.

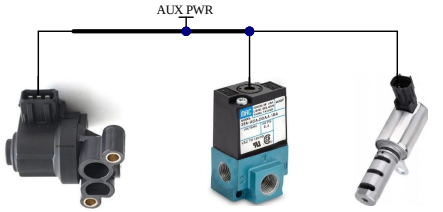
Spark:
-> "Single Coil": Traditional distributor setup
-> "Individual Coils": One coil per cylinder running direct spark
-> "Wasted Spark": Each channel is wired to a pair of cylinders @ TDC simultaneously
(Individual coil setups running wasted spark: Activate "Individually wired Wasted Spark")
-> "Two Distributors": Traditional distributor setup w. two spark plugs per cylinder

Fuel:
-> "Simultaneous": All injectors fire simultaneously
-> "Batched": Injectors are wiried in pairs between cylinders at TDC simultaneously.
-> "Sequential": Individually wired injectors fire on a per-cylinder basis in firing order

3. Define which outputs are wired to the respective coils & injectors:
- "Fuel" -> "Injection hardware"
- "Ignition" -> "Ignition settings"

NOTE: Injection and Ignition output pins are driven according to the defined firing order.
Thus, the list of pins (1 ... n) are sequenced in the firing order.

	Wasted Spark / Batch Inj.			Direct Spark / Sequential Inj.			
No. of cyl.	4	6	8	4	5	6	8
Ign/Inj Pin # (720°)	1	1	1	1	1	1	1
	2	2	2	2	2	2	2
	1	3	3	3	3	3	3
	2	1	4	4	4	4	4
		2	1		5	5	5
		3	2			6	6
			3				7
			4				8



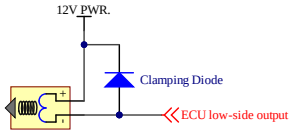
Typical 3-wire IAC | Boost control valve | VVT control valve

2/3 wire IAC:
Tuner Studio: "Idle" -> "Idle Hardware":
- 3-wire = "Double Solenoid Mode"
- Inverted output: See "Idle Solenoid output(s) Mode"

Boost and VVT control valves:
Polarity is not critical for either type.

MAC valves frequency: 15-30 Hz

Consult OEM manufacturer datasheet for correct PWM frequency or adjust till you attain a stable and responsive cam position.



"Fly-back" clamping diodes on Low-side outputs:

For inductive loads with high inductance ratings such as relays, idle- and VVT valves, a "fly-back diode" should be fitted between the output pin and the 12V supply.

DO NOT use "Fly-back" diodes on outputs used for injectors!

TMB ECU Mini wiring guide:

Sensor Input: Crank/Cam, Analog, Digital and Knock

Similar to most electronic control systems, an Engine Management System acquires key information by reading a set of sensors in order to perform accurate calculations essential for eg. fuel delivery, spark timing and idle control.

The sensor inputs can be divided into two fundamental categories with a set of typical sub-categories:

Digital:
- Crankshaft/Camshaft speed & position
- Switched/Pulsed, timed or triggered events

Analog:
- Temperature
- Pressure
- Relative position
- Knock sensing

CRANK / CAM SENSOR INPUTS - "VR":

The ECU processor tracks the pulses generated by the crank & cam sensors to calculat e engine speed, position and phase. For a basic wasted spark & semi-sequential/batch injection configuration, a crank trigger system such as a 36-1 or 60-2 is sufficient fo r crankshaft speed and position tracking.
To run direct spark or fully sequential fuel delivery or utilize VVT control, a dedicated cam sensor for engine phase and camshaft position tracking is required.

TunerStudio CONFIG:
"Base Engine" -> "Trigger".
VR sensors: Configure "Only rising edge" = "True"
Use the "Composite logger" to verify correct funtion of the speed/position sensor inputs.

VR & Hall sensors explained:
https://www.linkedin.com/pulse/inductive-hall-effect-rpm-sensors-explained-kiril-mucevski

Supported trigger patterns:
https://github.com/rusefi/rusefi/wiki/All-Supported-Triggers#universal

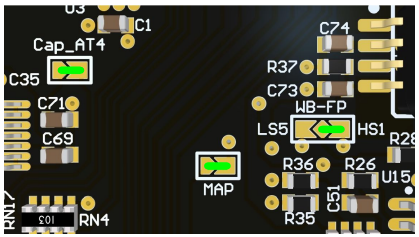
ANALOG SENSOR INPUTS:

All Analog Volt inputs are generic and can each be mapped to the desired function in TunerStudio.

Analog Volt, "0-5V":
Used for sensors such as TPS, pressure, additional AFR and typical 3-wire sensors that outputs 0-5V signals.
*AV6: Allocated by default to the internal MAP sensor through a pre-soldered jumper.
*AV9: Hardwired to the internal WBO2 controller
*AV10: Hardwired to the 12V input for battery voltage monitoring

Integrated 4 Bar absoulte pressure sensors (calibration - "MPXH6400"), AV6:
Usually used to monitor manifold pressure, but may also be used to monitor/log values such as eg. barometric pressure, exhaust back pressure or crank case pressure.

Analog Temp:
Dedicated for 2-wire temperature sensors such as Coolant, Intake and Oil temp.
All "Temp" inputs have internal 2.7k pullup resistors.
All temp inputs can be used as "Active GND" digital inputs.
*AT4: Used as dedicated digital TPS input signal for SENT based ETBs. Note solder jumper below.

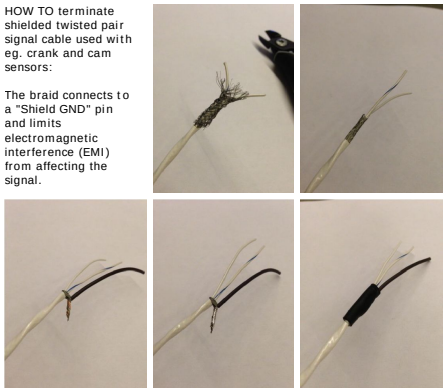


Solder jumpers
GREEN = DEFAULT SETUP

- "MAP": Internal MAP sensor: AV6
- "WB-FP": Fuel pump control signal: LS5 or HS1
- "Cap_AT4": AT4 R/C filter capacitor. De-solder for TPS SENT usage.

HOW TO terminate shielded twisted pair signal cable used with eg. crank and cam sensors:

The braid connects to a "Shield GND" pin and limits electromagnetic interference (EMI) from affecting the signal.



VR Sensor:

Typically used as crank position sensors. Passive & inductive; no power supply required

2 or 3 wires:
- VR+
- VR-
- Cable shield (optional)

HALL Sensor:

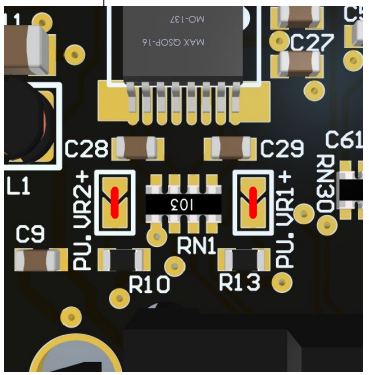
Typically used as cam or distributor sensors

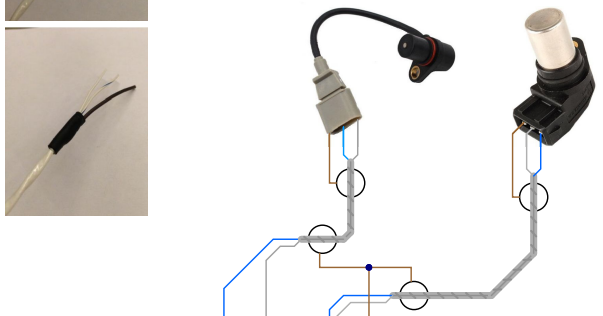
3 wires:
- Sensor power (5V or 12 V)
- Output (Typically Active GND)
- Sensor GND

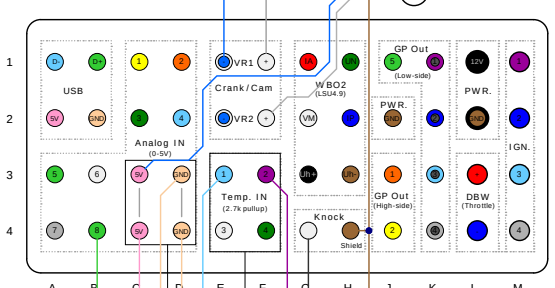
Hall sensors & "VR" inputs:

Connect as shown in diagram and solder corresponding jumper pads: "PU.VR1+" or "PU.VR2+".

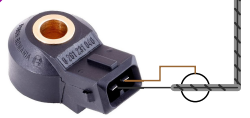
VR+ Pullup jumper pads are NOT soldered by default.







- 0.33mm² / 22 AWG
- 0.5mm² / 20 AWG
- 0.75mm² / 18 AWG



KNOCK:

The ECU has a Digital Signal Processed knock sensor input channel used fo r smart engine knock detection through a wide variety of "donut" style wideband or smallband sensors typically found on most factory EFi equipped vehicles.

Tuner Studio: "Controller" -> "Software Knock"

Knock setup guide: https://github.com/rusefi/rusefi/wiki/knock-sensing

TPS
Throttle position sensor

NOTE: TPS polarity is not critical.

Config: "Sensors" -> "TPS"
- Analog input
- Min/Max

IAT
Intake air temp.

CLT
Coolant temp.

Sensor GND & 5V:

- All "Sensor GND" and "5V" pins are internally connected in the ECU.
- All sensors should be grounded at a dedicated "Sensor GND" return point.

NOTE: DO NOT ground any sensors at the engine block or chassis as this may result in erratic signal behaviour or ground offsets.

DIGITAL SENSOR INPUTS:

All "Temp" inputs are equpped with 2.7k 5V pullup resistors and can thus be used as generic "Active GND" digital inputs. The digital inputs can be wired directly to eg. switches, flex fuel sensors or open-collector devices such as Hall or optical sensors.

Used eg. for activation or triggered events such as:

- Launch control
- Camshaft position: Engine phase tracking & VVT control
- Vehicle Speed Sensing
- Flex fuel: Fuel temp and ethanol/gasoline ratio

TMB ECU Mini wiring guide:
WBO2 & DBW

TMB ECU Pro is equipped with an integrated wideband O2 controller for use with the Bosch LSU4.9 O2 sensor.
All Genuine Bosch sensors are calibrated individually during production - hence the controller does not require free-air calibration.

In order to maximize sensor lifespan and reliability in accordance with Boschs guidelines, the control logic features a smart heater strategy applying a gentle heater ramp-up whenever the ECU detects a cold sensor, and assures that the sensor is never heated unless the engine is running (Active by Fuel Pump logic state).

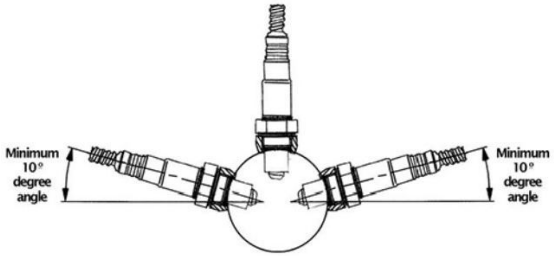
The integrated wideband controller uses the same transfer function as the Innovate LC1/LC2 controllers:
0-5V = 7.4 - 22.4 AFR = 0.5 - 1.5 Lambda

WBO2 sensor INSTALLATION GUIDELINE:

Accumulation of condensation combined with rappid changes in temperature may lead to cracks in the ceramic sensor element and permanent damage.

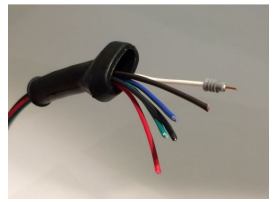
Please follow these guidelines when mounting the sensor to limit accumulated moisture whenever the vehicle is parked:

Bosch LSU4.9 wideband O2 sensor

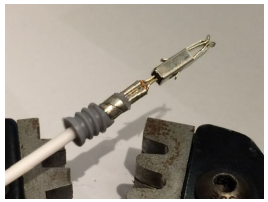


1. Typical termination equipment

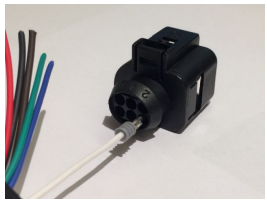
2: Connector, terminals, wire seals and grommet.



3: Feed wires through grommet and strip 3.5 - 4mm of insulation.



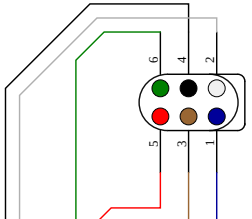
4: Proper crimp. Make sure the terminal retains the seal as hown.



5: Insert the pin from the rear.
A "click" is heard when the primary lock is engaged.

6: After all terminals are inserted and locked, push the pink secondary lock into place from the left side.

7: Finish the termination job by fixing the grommet into place.



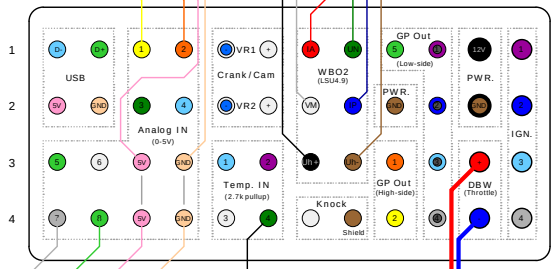
The ECU incorporates a H-bridge output capable of uni-directional operation of electric motors found in eg. ETBs (Electronic Throttle Bodies) and supports the following features:

- Simple calibration of pedal & TPS along with TB PID auto-tuning for easy and quick setup

- Redundant PPS/TPS-sensor implementation for OEM safety standard.

- Comprehensive 3D map defining the relationship between pedal input vs. throttle output as a function of RPM, allowing the user to either set limits or customized curves for increased driveability or improved throttle response.

DBW setup guide:
https://github.com/rusefi/rusefi/wiki/Electronic-Throttle-Body-Configuration-Guide



0.33mm² / 22 AWG
0.5mm² / 20 AWG
0.75mm² / 18 AWG

Dedicated SENT TPS input:
Use Analog Temp #4
(pin F4)