ECUMASTER PNP ECU SERIES

Application Note

MINI COOPER R53 V1.0

Revision 1.0

Contents

1. Copyright and trademarks

2. Safety precautions

- The ECUMASTER BLACK PNP ECU series is designed for motorsport applications only and cannot be used on public roads!
- Incorrect tuning with the ECUMASTER EMU BLACK PNP ECU can cause serious engine damage!
- Never modify the device's settings while the vehicle is moving as it may cause an accident!
- ECUMaster assumes no responsibility for damage caused by incorrect installation and/or tuning of the device!
- To ensure proper use of the ECUMASTER EMU BLACK PNP ECU and to prevent risk of damage to your vehicle, you must read these instructions and understand them thoroughly before attempting to install this unit.
- Modification of the tables and parameters should be performed only by people who understand the operation of the device and operation of modern fuel injection and ignition systems.
- Never short-circuit the wires of the engine's wiring loom or the outputs of the ECUMASTER EMU BLACK PNP ECU.
- All modifications to the engine's wiring loom must be performed with the negative terminal of the battery disconnected.
- It is critical that all connections in the wiring loom are properly insulated.
- The device must be disconnected before performing any welding on the vehicle!

3. Introduction

The EMU BLACK PNP ECU series was created to simplify the connection of the EMU BLACK ECU to popular cars. The ECU has a preload base map for an unmodified stock car which is a very good starting point for tuning the engine. In chapter 10 there is table with connector descriptions and assigned EMU BLACK function. The unused outputs and inputs are available on the pig tail connectors. For more details, please refer to chapter 11 and 12.

4. ECU Features

The list below summarizes all EMU BLACK PNP ECU features for the Mini Cooper R53

- Precise fuel control based on Speed Density strategy
- Advanced ignition angle control
- Real time tuning
- Wideband oxygen sensor support (LSU 4.2 or LSU 4.9)
- Knock control
- Drive by wire support with auto-calibration feature
- Fuel auto-tune function
- Support of OEM CAN stream
- Sport functions like traction control, boost control, rev matching, gear cut, etc.
- Safety features like oil pressure cut, stuck throttle detection, lambda guard and more
- Easy and intuitive software

5. Installation

1. Disconnect the negative terminal of the battery (located in the car trunk)
2. The ECU is located under the bonnet (the ECU mounting box is marked red)

3. Remove the ECU box cover (1) and disconnect ECU connectors (2),(3)

4. Remove the OEM ECU
5. Insert the USB cable and bend the pig tail harness and place PnP ECU in the ECU box

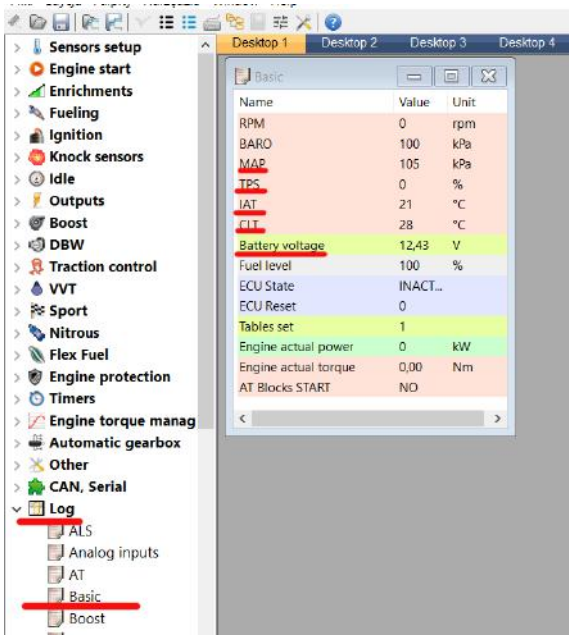
6. Connect the OEM ECU connectors and modify cover to allow the pig tail harness go out
7. Connect the negative battery terminal

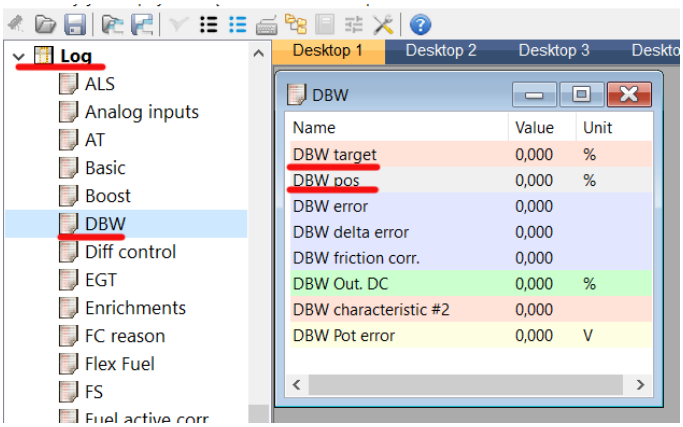
6. First start

1. Connect the USB cable to the laptop
2. Start Ecumaster EMU Black client (www.ecumaster.com/products/emu-black/)
3. Turn ignition on

Now the ECU should connect to the client software (the connection status on the left bottom corner of application should turn green and change to 'Connected'). If there is no connection, please check if the USB cable is properly inserted. The ECU is provided with a loaded base map for standard Mini cooper R53.

Open log window group basic and check the following channels (marked red) display proper values. The coolant temperature sensor (CLT) and intake air temperature (IAT) depends on the temperature of the coolant and temperature under the bonnet. The battery voltage should be about 12V (depends on the battery condition). TPS should be 0 and MAP should be equal to the actual barometric pressure. If all of the sensor readings are correct the electronic throttle should be checked.





Press the throttle pedal. The ***DBW pos*** *value* should follow the ***DBW target*** value. We strongly recommend to use automatic DBW calibration tool to set up the electronic throttle calibration parameters to the car throttle (see the DBW calibration chapter).

If all of the above checks are ok, you can start the engine. The provided base map was created using OEM Mini Cooper R53, however due to the different wear of the engines the fuel dose (lambda vs lambda target) should be checked especially on the full engine load (see the tuning fuel dose and wide band oxygen sensor chapters).

In the case the engine is modified (smaller pulley, different injectors, etc.) the base map should be adjusted. Using the car without adjustment, especially on the high load may lead to engine damage.

7. Wide band oxygen sensor

The EMU BLACK PnP ECU is equipped with wideband oxygen sensor control that is capable to support Bosch LSU 4.2 and Bosch LSU 4.9 sensor.

By default, the ECU is set up to use the OEM narrow band oxygen sensor. All signals required to connect a wideband sensor are available in the Deutsch connector with the black harness.

Bosch LSU 4.2

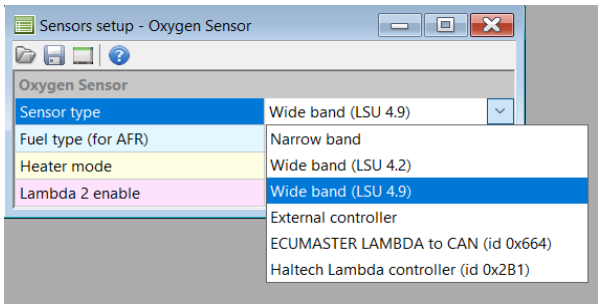
ECU Deutsch Connector Black	Description	LSU 4.2 Connector
3	WBO Heater	4
4	WBO Ip	6
5	WBO Vs	1
6	WBO Rcal	2
7	WBO Vgnd	5
11	+12V	3

Bosch LSU 4.9

ECU Deutsch Connector Black	Description	LSU 4.9 Connector
3	WBO Heater	3
4	WBO Ip	1
5	WBO Vs	6
6	WBO Rcal	5
7	WBO Vgnd	2
11	+12V	4

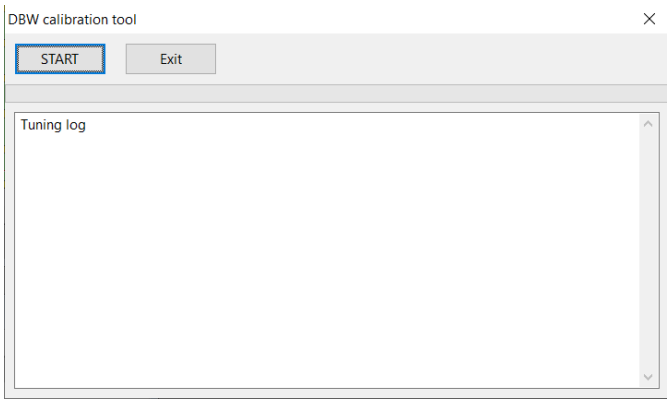
Remember to disconnect OEM lambda sensor before connecting wideband oxygen sensor!

To select appropriate oxygen sensor, open the **Sensor setup / Oxygen sensor**



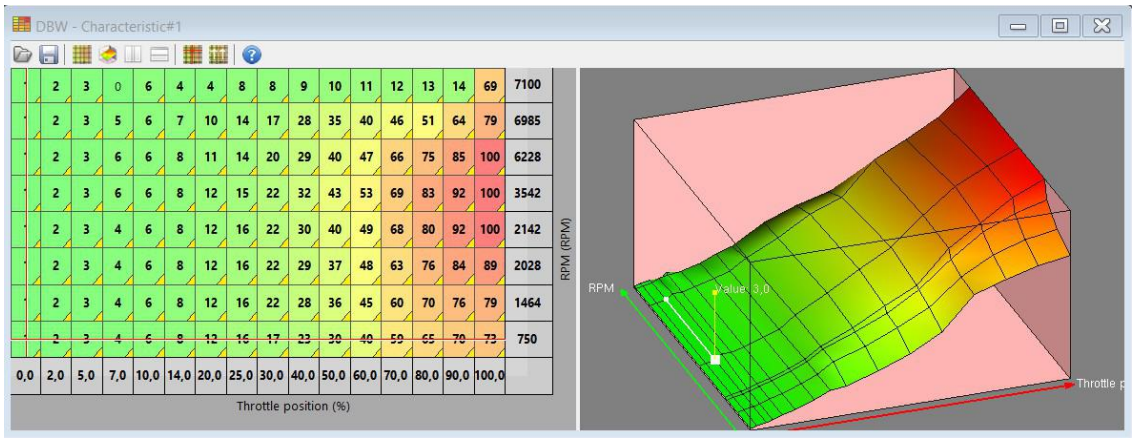
To check the oxygen sensor, start the engine, wait when the sensor heats up, and observe logging channel ***Lambda***

8. Drive by wire (DBW)

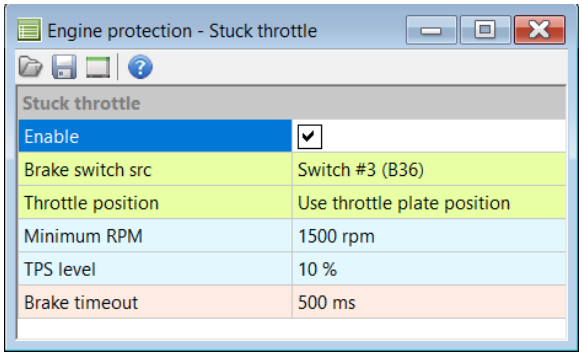


The engine is equipped with the electronic throttle. We strongly recommend to use electronic throttle calibration tool before first running. It takes about 5 minutes, and adjusts all parameters to fit the particular car throttle. From the application menu select option Tools/DBW Calibration tool. Do not forget to press F2 after the calibration, to save new settings in the device flash memory. It is also important to check if the throttle follows the throttle target request (***DBW pos*** vs ***DBW target*** log channels).

To change how the pedal position, influences the throttle position the table DBW/DBW Characteristic can be adjusted.



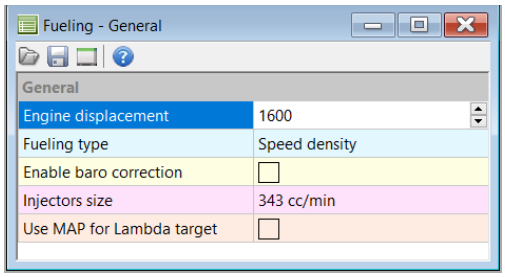
There is also a safety mechanism ***Engine protection/ Stuck throttle.*** If any malfunction of the throttle appears and the driver presses the brake pedal, the engine will cut fuel until the rpms reach Minimum RPM, which prevents the engine from stalling.



9. Basic tuning

9.1 Fuel dose

The main engine configuration is located in ***Fueling / General***

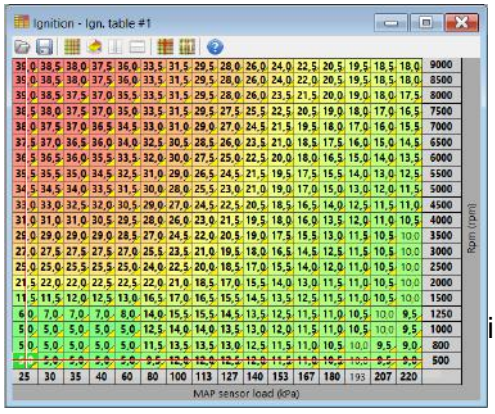


If the car has different injectors to OEM installed, injector size should be adjusted. Also when other injector types are used the dead time calibration table should be adjusted (***Fueling/ Injectors/Injectors cal.***).

The volumetric efficiency table defines the ratio of the mass density of the air-fuel mixture drawn into the cylinder at atmospheric pressure for given Load/RPM points. The table can be found in ***Fueling/Fuel tables/VE table.*** In connection to the Lambda target table it is the base parameter for calculating fuel dose. First step in tuning fuel is setting Lambda target table for desired values. The next step is to tune VE table so that the lambda value for the whole table matches the target. EMU Black has a feature for autotune VE table based on log values. The detailed procedure is described in EMU BLACK Client software help.

9.2 Ignition advance

The trigger system is already configured in the base map loaded into device. The main ignition advance table can be found in *Ignition/Ign. Table #1.* The positive values mean ignition angle before TDC, the negative values mean ignition angle after TDC. Too much ignition advance can destroy the engine by causing knocking or detonation. Ignition angle advance table is the key table in aspect of efficiency of the engine, and influences the engine torque.

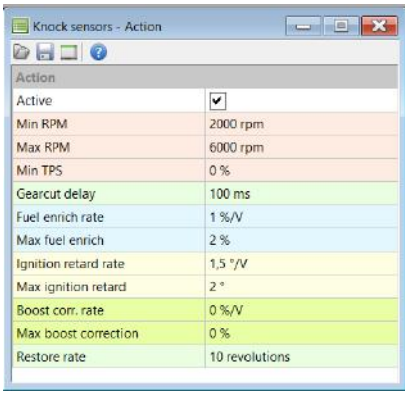


There is also a table called Coil dwell time (**Ignition/Coils/Coil dwell time**), that defines how long is the ignition coil turns on before the spark. In general, the longer the time, the more spark energy, however if the coil dwell time is too long, there is no greater spark energy and the coil gets hot.

9.3 Knock sensing

The EMU Black supports knock sensors, and when the knocking occurs, the engine protection action can be performed (ignition retard, fuel dose increase). The EMU continuously samples knock sensor signal (in so called knock window), filters it for engine characteristic knock frequency and integrate the signal voltage. The output is presented in *Knock Sensor Value* channel. This value is compared with the *Engine noise table* **(Knock sensors/Engine noise)** and the value *Knock level* is calculated.

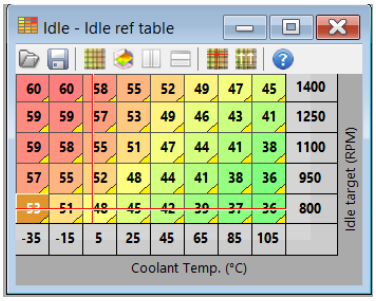
Knock Level = Engine Noise – Knock Sensor Value



If the *Knock level* value is greater than 0, the knocking occurs. The higher Knock level then the more severe the knock is. If the engine internals were changed the engine noise value could require adjustment.

When the knock occurs then the action takes place. You can define the action parameters in ***Knock sensors/Action*** window.

9.4 Idle control



To adjust the idle RPM there are several important tables. The first table is ***Idle / Idle ref table.*** This table defines how much the throttle opened (the percent of DBW idle range) for given engine temperature and idle target. The more the throttle is opened the more air enters the engine and the higher is the engine revolution.

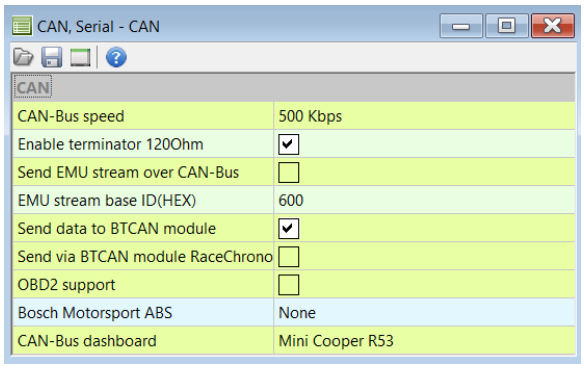
The idle target is defined in the table ***Idle/Idle target RPM***.

This tables defines the engine rpm when on idle as a function of engine coolant temperature.

In addition to air control the idle RPM is controlled in closed loop using **Idle / Ignition control** strategy. Depending on idle target and current idle, this strategy adjusts ignition advance to increase / decrease RPM. The more the ignition advances the higher engine RPM.

9.5 Can Bus

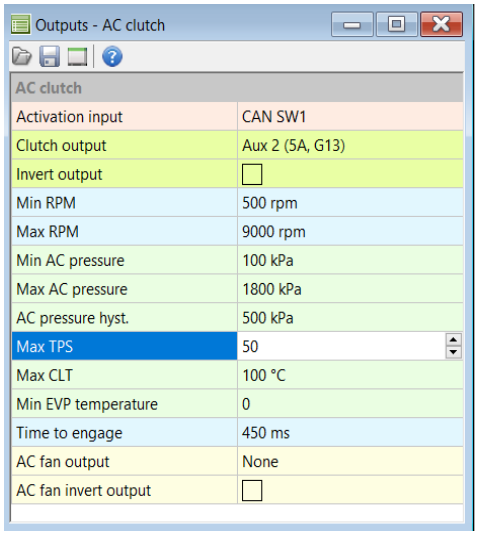
The EMU Black supports Mini R53 CAN BUS powertrain stream. It is set in CAN,Serial/CAN in CAN BUS dashboard. To connect other CAN BUS based devices like displays, power management, the CANL and CANH data lines are available on the pig tail connector (see chapter 12)



9.6 Air condition

Mini Cooper R53 is equipped with AC pressure sensor, that provides the ECU information about current pressure in the AC system. When the AC is requested by the AC switch, the ECU must engage the AC compressor clutch when the AC pressure is outside working range.

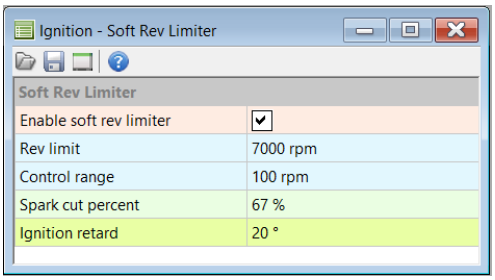
The parameters for AC system are defined in **Outputs/AC clutch**. The AC switch is connected to the *CAN Switch #1* input (it is read from CAN BUS). The AC pressure sensor is connected to the *Analog input #4*, and it is calibrated in **Sensor Setup/Pressure/AC pressure cal.** When the AC pressure is under 100kPa, the AC clutch will be never engaged due to the lack of gas in the installation. If the pressure is higher than 1800kPa, the clutch is turned off to prevent system against overpressure. If the TPS position is greater than 50%, the clutch is also disengaged to provide maximum power to the wheels.



9.7 Revolution limiter

There are two rev limiters in EMU Black. One is based on fuel cut (Hard rev limiter) and its parameters are defined in ***Fueling/Fuel Cut.*** If the revolutions are higher than the RPM Limit, the fuel is cut.

The second rev limiter, called *soft rev limiter* can be defined in ***Ignition/ Soft rev limiter.*** This allows a soft limiter based on ignition retard and spark cut. If the car is equipped with a catalytic converter, using any spark cut strategy can lead to its damage!



There is also a 3rd mechanism involved in revolution limiting. When the RPM is near desired RPM limit the throttle starts to close. It is defined in the following region of throttle characteristic table.

10. Function assignment

The table below shows the assignment of the inputs / outputs to EMU device

EMU Black input	Function
Analog #1	MAP sensor
Analog #2	DBW position plausibility check sensor
Analog #3	DBW position sensor
Analog #4	AC pressure sensor
Analog #5	Pedal position plausibility check sensor
Analog #6	Clutch pedal sensor
Switch #3	Brake pedal switch
TPS	Pedal position sensor
CLT	Coolant temperature sensor
IAT	Intake air temperature sensor
KS #1 Input	Knock sensor
Primary trigger input	Crank position sensor
CAM #1 input	Camshaft position sensor
CAN Switch #1	AC switch
AUX #1	Fuel pump relay
AUX #2	AC clutch relay
AUX #3	Coolant fan relay
AUX #4	Main relay
AUX #5	Power steering fan relay
Injector #1	Injector 1
Injector #2	Injector 2
Injector #3	Injector 3
Injector #4	Injector 4
H-Bridge 1A	DBW Motor
H-Bridge 1B	DBW Motor
Ignition output #1	Coil #1
Ignition output #2	Coil #2

11. Spare inputs / outputs

The following outputs are free of use and are available on the pig tail connectors:

- H-Bridge 2 A and 2 B
- WBO Sensor (heater, IP, VS, Vgnd, Rcal)
- INJ 5, 6
- AUX 6
- CANL, CANH
- RS232 Tx, Rx
- +5V

The following inputs are free of use and are available on the pig tail connector:

- Mux switch 2
- Mux switch 3
- Flex Fuel input
- EGT1
- EGT2

12. Pig tail connectors

The unused EMU Black inputs/outputs and WBO inputs are present on the pig tail connectors.

The black harness connector

Terminal	Function
1	H-Bridge 2 B
2	H-Bridge 2 A
3	WBO Heater
4	WBO Ip
5	WBO Vs
6	WBO Rcal

Terminal	Function
7	WBO VGnd
8	AUX 6
9	INJ 5
10	INJ 6
11	Battery +12V
12	Power ground

The grey harness connector

Terminal	Function
1	CAN H
2	CAN L
3	RS232 Tx
4	RS232 Rx
5	Flex Fuel input
6	EGT 2

Terminal	Function
7	EGT 1
8	MUX SW2
9	MUX SW1
10	Ignition +12V
11	+5V
12	Analog ground

13. Revision history

16.06.2020 Ver 1.0

- Initial version