USER MANUAL

Lotus Elise 2ZZ PNP ECU

Document version: 2.0
Software version: 2.169 or later
Published on: 29 July 2024

ECUMASTER

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 Function assignment *(on page 19)* 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 Spare inputs / outputs *(on page 21)*.

4. ECU features

The list below summarizes all EMU Black PNP ECU features for the Lotus 2ZZ engine

- 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, launch control, boost control, gear cut, etc.
- Safety features like oil pressure cut, stuck throttle detection, lambda guard and more
- Easy and intuitive software

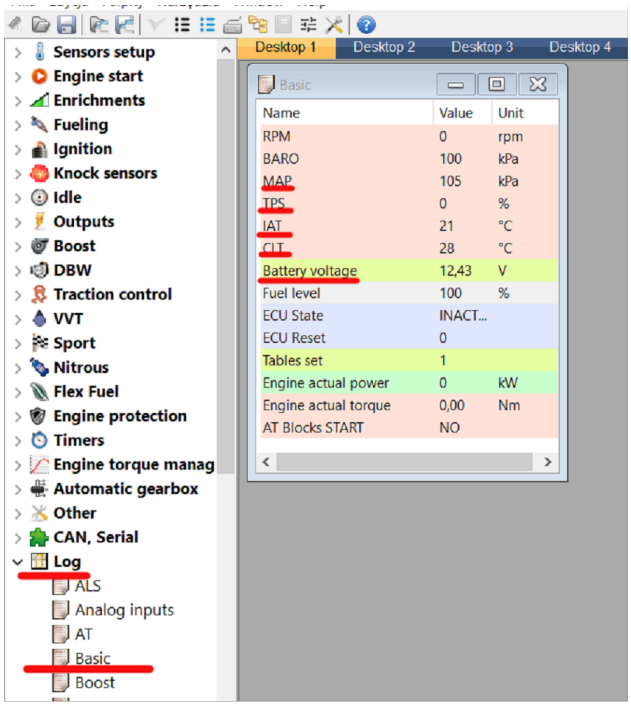
5. Installation

1. Disconnect the negative terminal of the battery (located in the car trunk)
2. The ECU is located in the engine bay behind the passenger's head
3. Disconnect the ECU connecters and remove the OEM ECU
4. Connect the EMU Black PNP ECU to the OEM connectors and USB cable
5. Connect the vacuum hose to the EMU Black PNP ECU nipple. In the NA variants the nipple is located near the throttle body, blanked with the rubber cap. Supercharged versions require a nipple to be installed. We suggest to install it in the aluminium bend before the supercharger.
6. In the NA engine version, the MAF is used for reading intake air temperature. On supercharged Exige versions the intake air temperature is read from the TMAP installed in exit of the intercooler. In case of supercharged Exige, the MAF connector **has to be disconnected**, otherwise the intake temperature readings will not be correct.
7. Connect the negative battery terminal

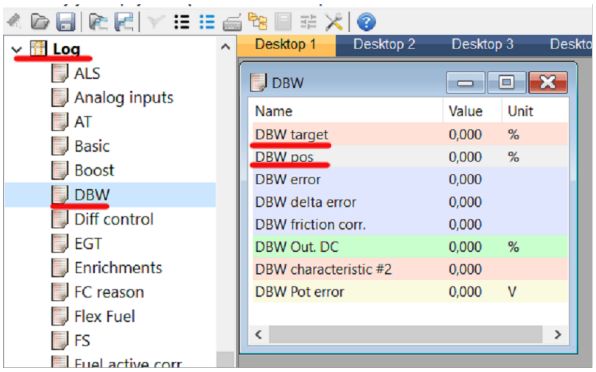
6. First start

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 Lotus 2ZZ engine.



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 12 V (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 Lotus car, however due to the different engines wear rates the fuel dose (*lambda* vs *lambda target*) should be checked especially on the full engine load (see the tuning fuel dose and wideband oxygen sensor chapters).

In the case the engine is modified (turbocharged, smaller supercharger 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 on the OEM Lotus connector on unused terminals.

In the case of Lotus 2ZZ PNP ECU we provide additional terminals required to connect wideband oxygen sensor to unused ECU terminals. Three of the wires are shared with the OEM sensor (+12

V, Vs and Heater control). You can splice the wires. Do not forget to disconnect the OEM narrow band oxygen sensor.

Bosch LSU 4.2

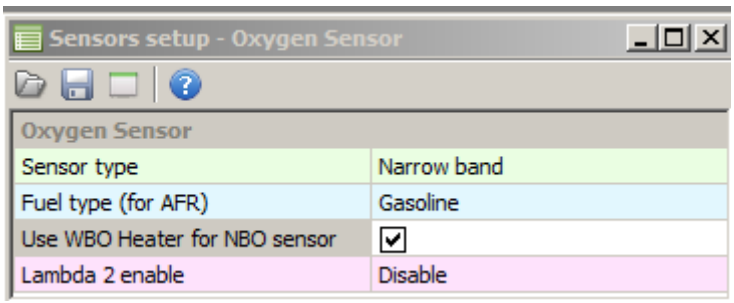
ECU Terminals	Description	LSU 4.2 connector
3K	WBO Heater	4
4E	WBO Ip	6
3A	WBO Vs	1
3D	WBO Rcal	2
4F	WBO Vgnd	5
3G	+12 V	3

Bosch LSU 4.9

ECU Terminals	Description	LSU 4.9 connector
3K	WBO Heater	3
4E	WBO Ip	1
3A	WBO Vs	6
3D	WBO Rcal	5
4F	WBO Vgnd	2
3G	+12 V	4

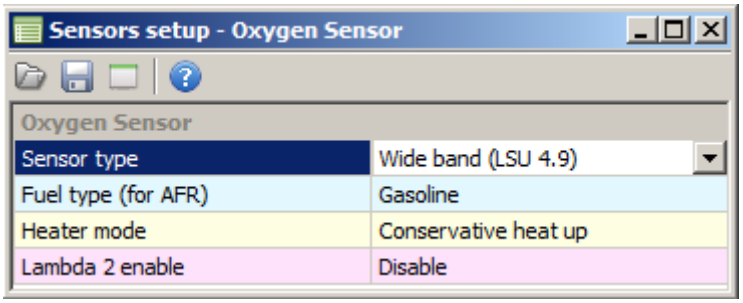
Remember to disconnect OEM lambda sensor before connecting wideband oxygen sensor!

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



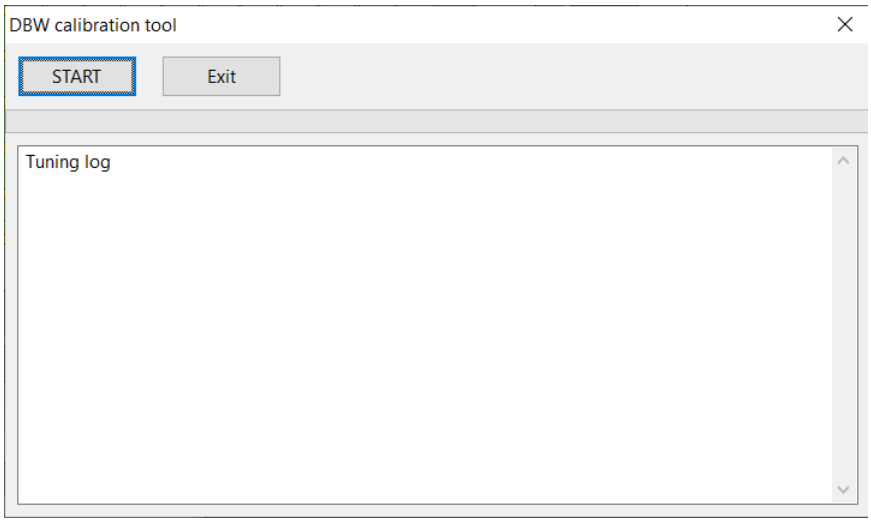
If the standard narrow band oxygen sensor is used, option *Use WBO heater for NBO sensor* must be enabled.

If LSU 4.2 or LSU 4.9 is selected, we strongly recommend to use Conservative heat up *Heater Mode.*



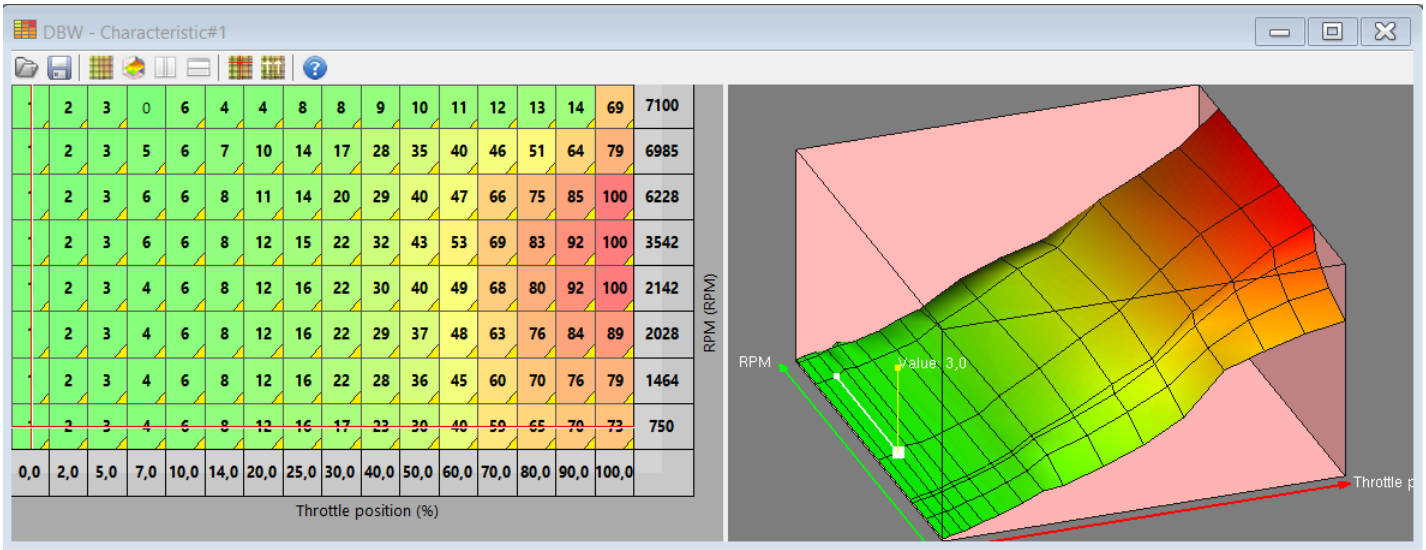
To check the oxygen sensor, start the engine, wait when the sensor heats up, and observe logging channel *Lambda*.

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).

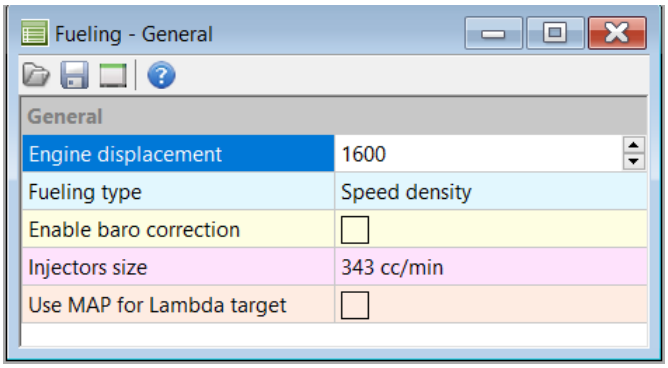
To change how the pedal position, influences the throttle position the table DBW / DBW Characteristic can be adjusted.



9. Basic tuning

9.1. Fuel dose

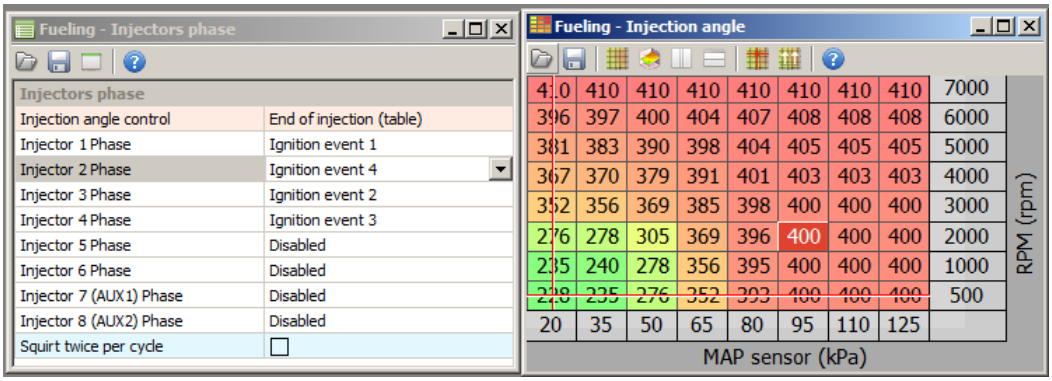
The main engine configuration is located in ***Fueling / General***



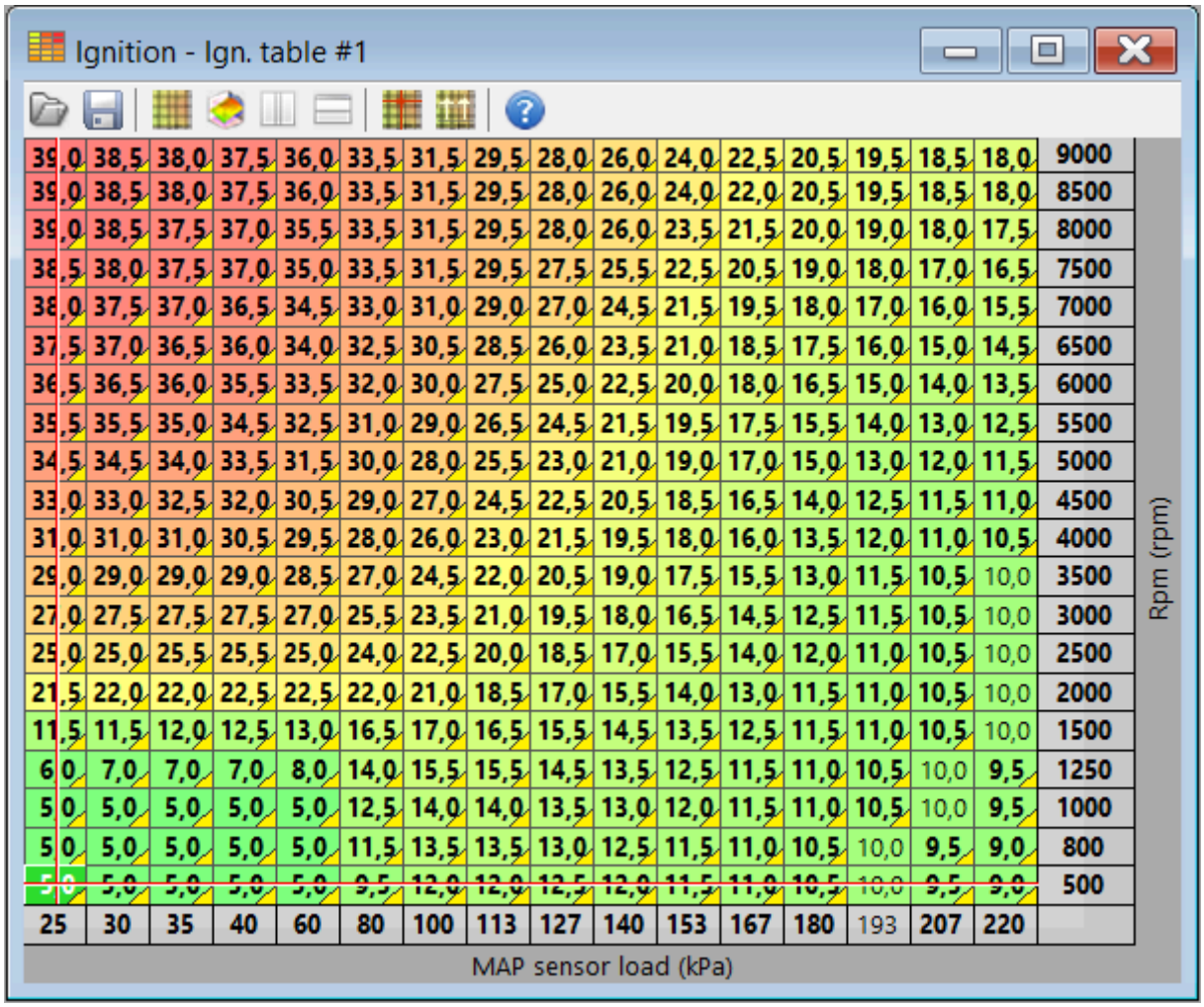
If the car has different injectors to OEM installed, injector size should be adjusted. Also, when other injector types are used the dead time calibration table should be adjusted (***Fueling / Injectors / Injectors cal.***).

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.

To adjust the injection angle, you need to use ***Fueling / Injectors / Injection angle*** table. Make sure that *Injection angle control* in ***Injectors phase*** window is set to *End of injection*.



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. Tables / Ign. Table #1***. The positive values mean ignition angle before TDC, the negative values mean ignition angle after TDC. Too much ignition

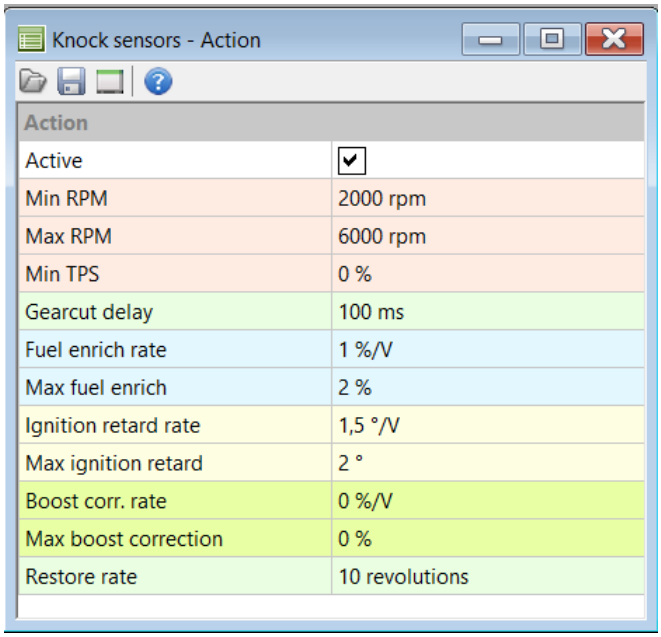
advance can destroy the engine by causing knocking or detonation. Ignition angle advance table is the key table in aspect of efficiency of the engine, and influences the engine torque.

There is also table called Coil dwell time (***Ignition / Coils / Coil dwell time***), that defines how long is the ignition coil turn 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 = Knock Sensor Value – Engine Noise

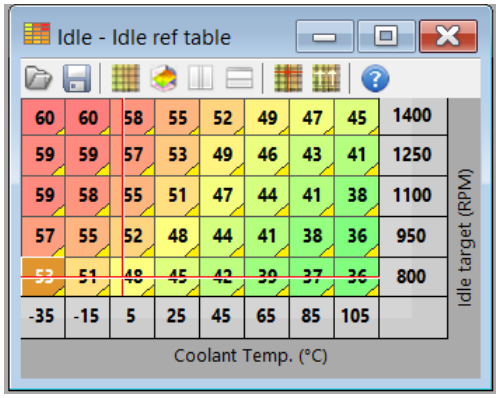


If the *Knock level* value is greater than 0, the knocking occurs. The higher *Knock level* then the more severe the knock is. If the engine internals were changed the engine noise value could require adjustment.

When the knock occurs then the action takes place. You can define the action parameters in ***Knock sensors / Action*** window. Due to possible engine modifications, camshafts wear, etc. the base map doesn't define knock sensor parameters nor engine noise table. For more information about

knock sensor setup please press F1 or press ? icon on the knock sensor parameters window in EMU Black client software.

9.4. Idle control



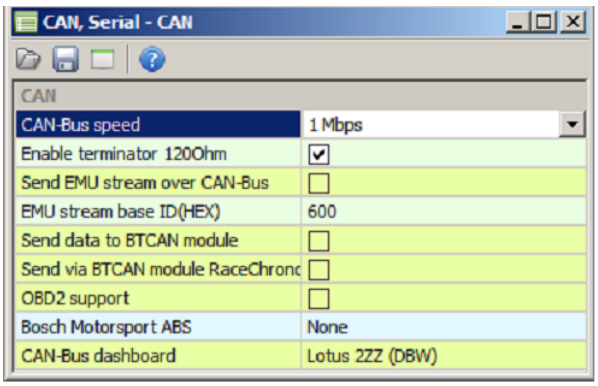
To adjust the idle RPM there are several important tables. The first table is ***Idle / Idle ref table***. This table defines how much the throttle opened (the percent of DBW idle range) for given engine temperature and idle target. The more the throttle is opened the more air enters the engine and the 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 Lotus S2/S3 CAN bus powertrain stream. It is set in *CAN,Serial / CAN bas* a CAN bus dashboard. There are 3 options available:

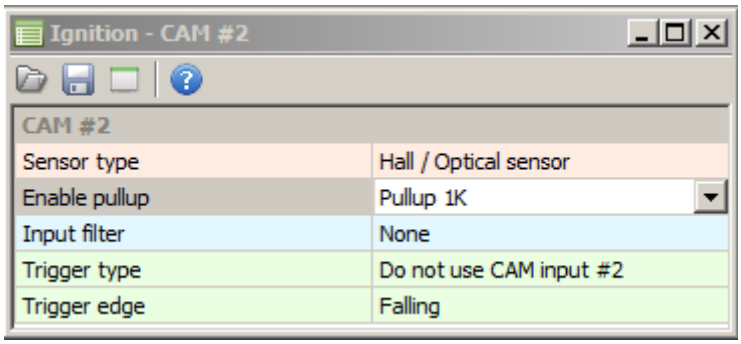
- Lotus 2ZZ (DBW) for the cars equipped in electronic throttle
- Lotus 2ZZ (Cable throttle) for the cars equipped in cable throttle
- Lotus S3 2ZZ, for S3 cars equipped in 2ZZ engines

The following data is sent over the CAN bus:

- Check engine light
- Oil pressure lamp
- Shift light (setup EMU Black shift light to get it work ***Sport / Shift light***)
- Coolant temperature gauge
- Vehicle speed
- RPM
- Fuel level (the calibration of fuel level is available in ***Sensors setup / Other sensors / Fuel level cal.***)

There was a series of 2ZZ equipped cars with the CAN bus speed 500 kbps instead of 1 Mbps. In such case the CAN bus speed should be changed from 1 Mbps to 500 Kps

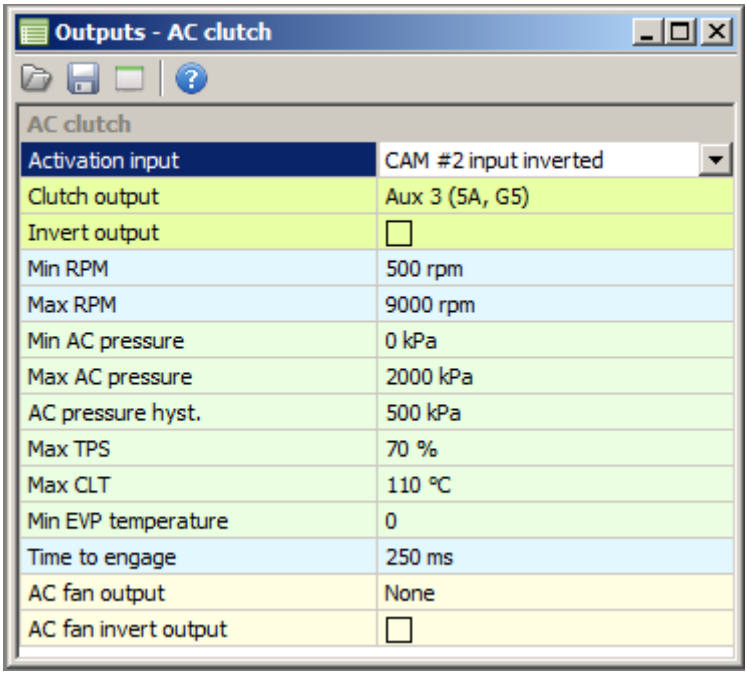
9.6. Air conditioning



The AC clutch in 2ZZ equipped cars is controlled by the user switch and a series connected trinary switch that opens if the AC gas pressure is too low or too high. This trinary switch controls the AC clutch engagement. The AC clutch request is connected to the CAM#2 input of PNP ECU.

Due to the fact the AC clutch request switch to ground, the ***CAM#2 Switch*** input is On when the AC clutch is not required and Off when the AC clutch is requested.

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.

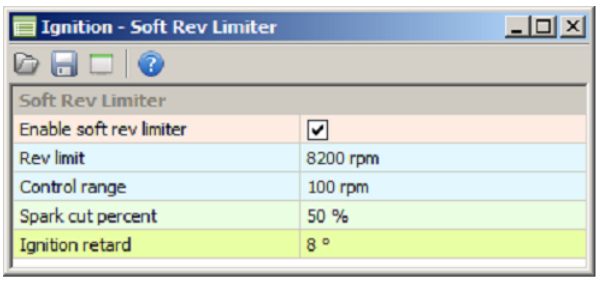


The parameters for AC system are defined in ***Outputs / AC clutch***. The activation input is CAM#2 switch inverted, and the AC compressor relay is connected to the AUX3.

To turn on the coolant fan when the AC is active, the option Turn On when AC active must be set in ***Outputs / Coolant fan*** setup.

9.7. Rev limiter

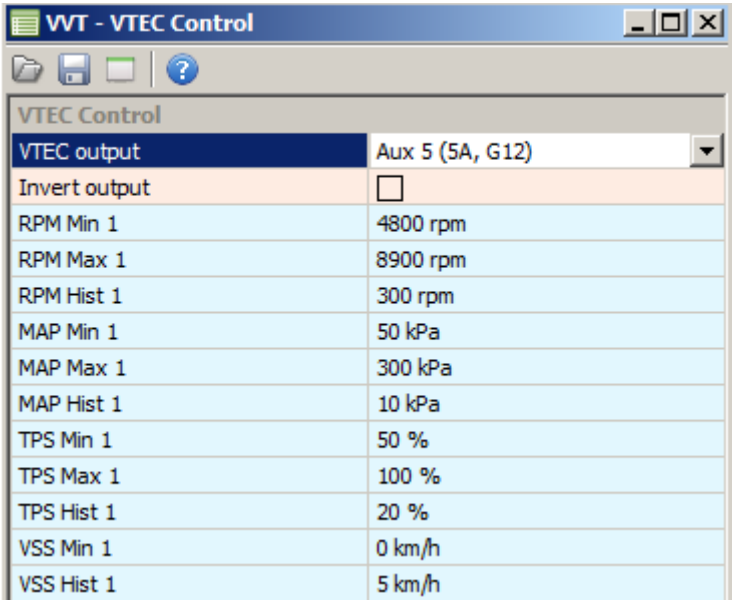
There are two rev limiters in EMU Black. One is based on fuel cut (Hard rev limiter) and its parameters are defined in ***Fueling / Fuel Cut***. If the revolutions are higher than RPM Limit, the fuel is cut.



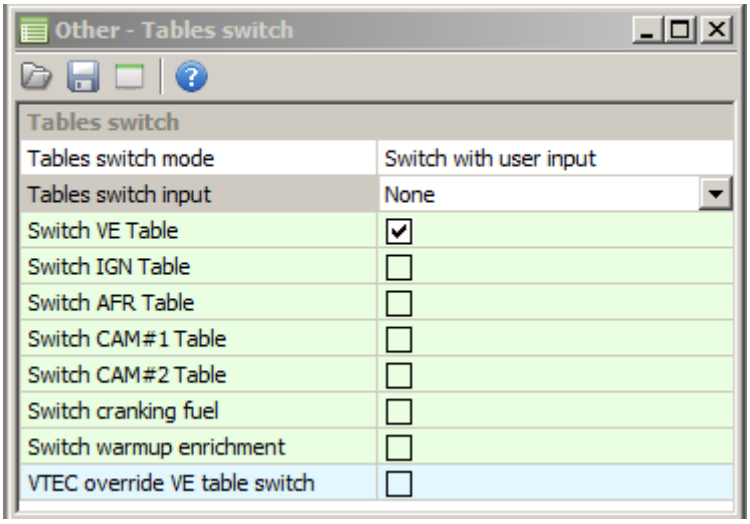
The second rev limiter, called *soft rev limiter* can be defined in ***Ignition / Soft rev limiter***. This allows soft limiter based on ignition retard and spark cut.

> **Warning:**
> If the car is equipped with a catalytic converter, using any spark cut strategy can lead to its damage!

9.8. Variable Valves Lift



The 2ZZ Engine is equipped with the VVL mechanism. It is controlled in an On / Off manner.

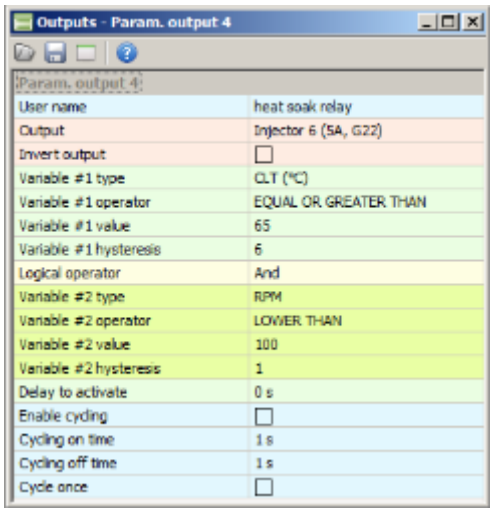


To control the variable valve lift the EMU VTEC strategy is used. It defines the region of RPM, MAP, TPS and VSS where the VVL should be on. The VVL control solenoid is connected to the AUX5 output. When VVL is active the VE table switch from VE table #1 to VE table #2. This behaviour is defined in ***Other / Tables switch***.

9.9. Variable Valves Timing

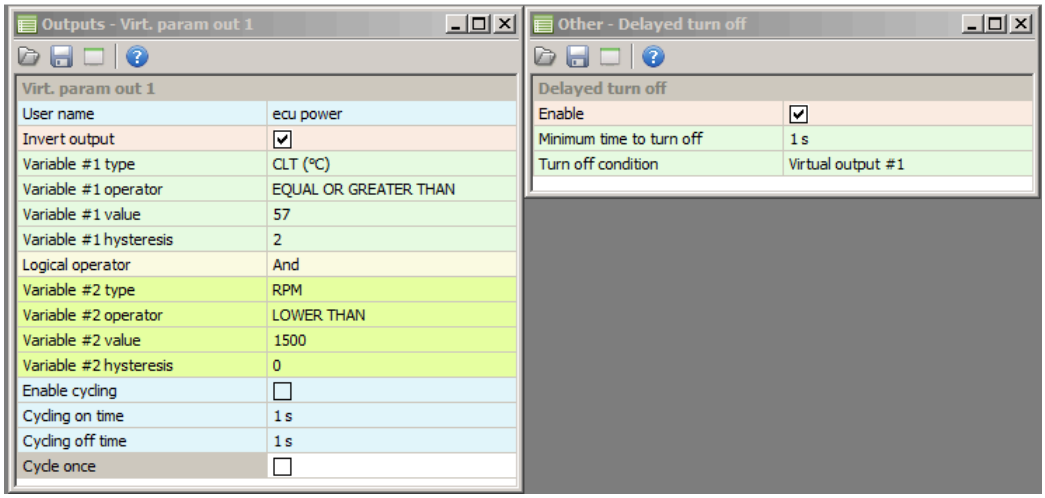
In addition to the VVL mechanism, the variable valve timing is present on the intake camshaft. The control solenoid is connected to the AUX 6 output, and the camshaft advance is defined in VVT / CAM1 angle #1 table. It is worth to note that changing the CAM advance, changes the volumetric efficiency of the engine for given region, and the VE table should be adjusted.

9.10. Heat soak pump



The 2ZZ engine is equipped with a heat soak water pump. The EMU Black use ***Outputs / Parametric / Param. output 4*** to control this pump. When the coolant temperature is over 65˚C the heat soak pump starts to work.

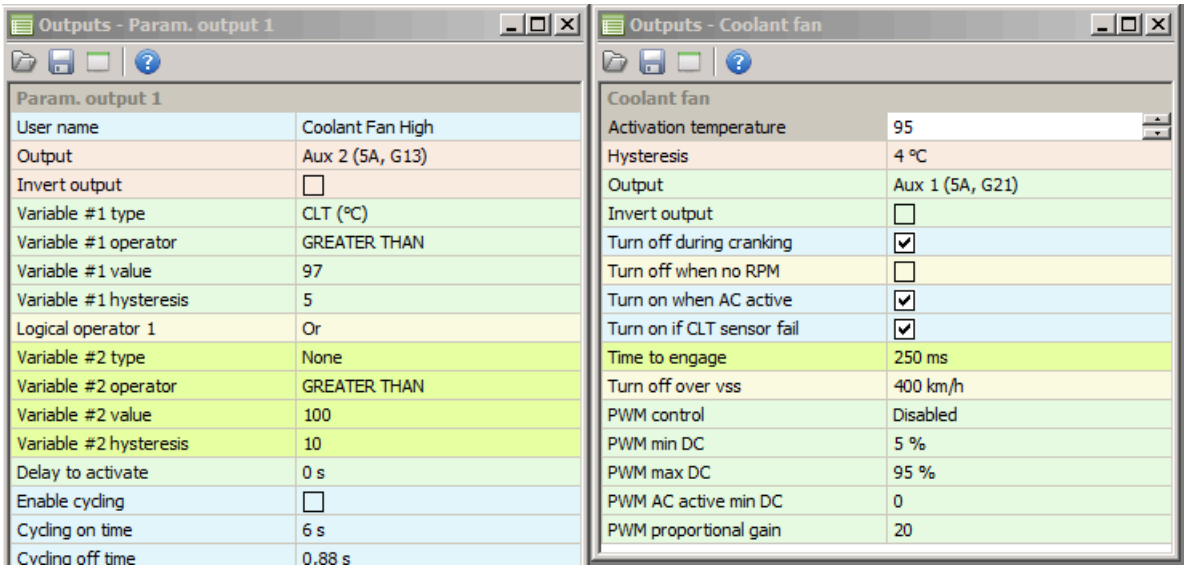
In addition to this the ECU keep powering the pump even if the ignition is off but the coolant temperature is equal or higher than 57 ˚C. Two mechanisms are involved: ***Other / Delayed turn off*** and ***Outputs / Parametric / Virtual output #1*** which defines the condition for delayed turn off.



9.11. Coolant fans

The 2ZZ engine has a coolant fan with the two working speeds slow and fast. The slow speed is managed by ***Outputs / Coolant fan*** strategy.

The fast speed is controlled by ***Outputs / Parametric / Param. output 1***



9.12. Vehicle speed

Vehicle speed is read directly from the digital signal sent via the ABS module. EMU Black is not capable to read 4 vehicle speeds from digital inputs (only via CAN bus). The speed is read from the front right wheel.

9.13. Traction control

Lotus cars are equipped with a Traction control button. This button can be used for activation of traction control or for activation of other ECU function (eg. second set of tables). Due to the fact that in this application ECU is not able to read 4-wheel speeds only the RPM based traction control strategy can be used (it senses RPM delta and based on it can reduce engine torque by cut spark or fuel).

To use Speed Based traction control, the Ecumaster Wheels speed to CAN module can be used to send information about wheel speeds via CAN. More information about traction control configuration can be found in EMU Black software help.

9.14. Oil pressure sensor

The factory oil pressure sensor (switch) is connected to the ***Switch #2*** and assigned to oil pressure sensor. It allows the control of oil pressure light on the dashboard.

9.15. Starter relay

The starter relay provides the electric current to the starter motor. It must be enabled prior to cranking. It is controlled using ***Outputs / Parametric / Param. output 3***. When the RPM is lower than 1000 RPM it is possible to engage the starter.

9.16. MAP Sensor

The PNP ECU uses a built in 400 kPa MAP sensor and the vacuum hose must be connected to the nipple on the ECU.

10. Function assignment

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

EMU Black input	Function
Analog #1	DBW position sensor
Analog #2	Fuel level
Analog #3	Traction control switch for version different than 08My
Analog #4	DBW position sensor plausibility check sensor

EMU Black input	Function
Analog #5	Pedal position plausibility check sensor
Analog #6	Traction control 08My version
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
CAM #2 input	AC Request (Inverted)
Switch #1	Oil pressure switch VVL
Switch #2	Oil pressure switch
Switch #3	AC fan request
AUX #1	Radiator low speed
AUX #2	Radiator high speed
AUX #3	AC compressor relay
AUX #4	Main relay
AUX #5	VVL
AUX #6	VVTi
Injector #1	Injector 1
Injector #2	Injector 2
Injector #3	Injector 3
Injector #4	Injector 4
Injector #5	Fuel pump relay
Injector #6	Heat soak pump
H-Bridge 1A	DBW Motor
H-Bridge 1B	DBW Motor
H-Bridge 2A	TC warning light
H-Bridge 2B	Starter relay
Ignition output #1	Coil #1

EMU Black input	Function
Ignition output #2	Coil #2
Ignition output #3	Coil #3
Ignition output #4	Coil #4
CANL, CANH	CAN Bus
WBO heater	WBO heater
VSS Input	Right front wheel speed

11. Spare inputs / outputs

Some of the unused inputs / outputs of EMU Black are available on the unused ECU terminals.

ECU Terminal	Function
1G	EGT Input #1
2C	RS232 Tx
3C	RS232 Rx
3D	WBO RCal
3F	EGT Input #2
4E	WBO Ip
4F	WBO VGnd
3A	Knock Sensor input #2
3L	Flex Fuel Input

12. Revision history

Version	Date	Changes
1.0	2021.05.28	First version of the document
2.0	2024.07.29	New Ecumaster standard layout applied