ZENIT
D I E S E L

Programming and operations guide for gas injection system for diesel engines

Manual for ECU MK-2012

Radom 2012

1. General information

Fuel supply with LPG or CNG for the engines with self ignition can be carried out using various methods. Radical solution is to adapt this engine to run on only one type of fuel, by switching the way (operational mode) of operations from the self-ignition to the external ignition (from the spark plug). This is both a labour consuming and expensive solution based on the conversion of the type of fuel.

Nowadays, the most common solution is the introduction of dual fuel power, which means simultaneously supplying the engine with diesel fuel and gas. This power unit is working based on a diesel engine, whereas the ignition of gas-air mixture comes from the spark of burning diesel fuel. This means that the use of LPG or CNG fuel in diesel engines is regarded as a admixture.

In the case of constant loads of diesel engine, the amount of gas supplied may be greater than 50% (e.g. while supplying power to the generators). Under conditions of variable loads (which appears with the car engines), the average percentage of the fuel gas rate can be up to 30% for LPG, and 50% for CNG. Obtaining such a mixture is possible only within certain engine loads. Practically, you can expect 20-25% share of LPG in the burned mixture, while at the same time reducing at the share of diesel.

Reducing the consumption of diesel fuel and replacing it with gas gives tangible economic benefits - about 15% of the amount spent for fuel can be saved (for LPG, CNG – 30%). The possibility of obtaining greater benefits is limited by necessity of the proper selection of two types of fuel in the way to obtain cost reduction maintain proper engine performance and maintain its operating life.

Using the admixture in the fuel, creates a situation in which the working pressure in the cylinder increases. This gives a significant increase of the forces acting on the piston in working stroke. The result is an increase in torque by approximately 20% and the power of the engine by about 12 - 15%. These values depend on the proportion of fuel consumed. Thanks to that we obtain an additional benefit of dual fuel power, which is the possibility of limiting the amount of given diesel fuel without limiting the engine power.

General Assembly recommendation: when adjusting the system, you should pay attention to the proper proportions of both fuels in the burned mixture. Too much gas given may cause engine knocking (detonation, spark knock, pinging). Too weak mixture produces an excessive increase of the temperature of exhaust gas.

Final Note: *definition used in the manual to determine the gas supply, switching to gas, working on gas, etc. should be understood as a mental shortcut and it refers to the supply of dual fuel – gas and diesel fuel. Shortcut "TPS" used in the description refers to the sensor of the accelerator pedal, called APS, PPS.*

2. The basic features and functions of the control unit of ZENIT Diesel

ZENIT Diesel is a programmable controller dedicated gas injection engine powered by diesel fuel. The basic functions allow implementation of the following strategies:

- Interference with the original power supply, that is dosing diesel fuel in order to reduce the quantity.
- Two independent, fully programmable emulators dedicated to collaborate with a linear signals in the range of 0-5 V.
- controlling a specific number of gas injectors (2-8) which are feeding gas to the engine.
- The leading of gas into the air intake system at any point before the turbine inlet valve.
- Cooperation with the diesel fuel injection control system via the OBD connection.
- Implementation of the control of the combusted mixture using the knock sensor and EGT thermocouple.
- The possibility of a simple and clear calibration of the mixture based on the current amount of fuel consumed.

The control unit (ECU) is designed to work with a 12 V supply voltage (in this case use the version of the ECU marked MK-2012/12 / ....) and a 24 V power supply (in this case use the version of the ECU marked MK-2012/24/..... In the second case the converter 24/12 V is placed on the ECU mainboard. The standard version of the ECU ZENIT Diesel is marked as: MK-2012/12/2- 12 V power supply and operation of dual gas injectors.

The calibration program and regulatory maps are dedicated to cooperate with a specific type of injector - Hana 2001. Therefore, the information given in the referring to the average combustion of the fuel gas is based on the characteristics of the specific type of injectors. The accuracy of the calculations is expected at 5%.
There is a possibility of using other types than Hana of injectors interchangeably.

3. Installation

To be used efficiently, ZENIT Diesel system needs certain hardware components or other software resources to be present on a computer.
A minimum installation requires – the operating system Windows XP SP1 and the following programs on your computer:

1. Microsoft .NET Framework 4

2. Windows Installer 3.1

3. Windows XP Service Pack 2

In the absence of these components in the system, they will be installed automatically while installing ZENIT Diesel
After the installation of subsidiary programs, the next step is to install ZENIT Diesel software. The software will be installed automatically.

4. Connection with ECU

Standard USB interfaces of the company AGC, used in all previous systems - Zenit, Zenit PRO, Zenit Compact or RS232 used in Zenit system – are indispensable to connect with ECU.

To establish a connection between the PC and the ECU, the ignition has to be on.

The message that appears in the middle of the panel signals the connection process with ECU. After establishing the connection, the bar informing about an active connection will be displayed in the window "STATUS" (indictor turns green).

The program can be started for the menu "READINGS".

If you can't connect with the control panel, go to the bookmark, "OTHER" in order to set up the connection - we recommend using "Auto" setting. A detailed description of the port settings can be found in the part –"OTHER".

5. READINGS

The window graphically shows the current values of the parameters of the engine.
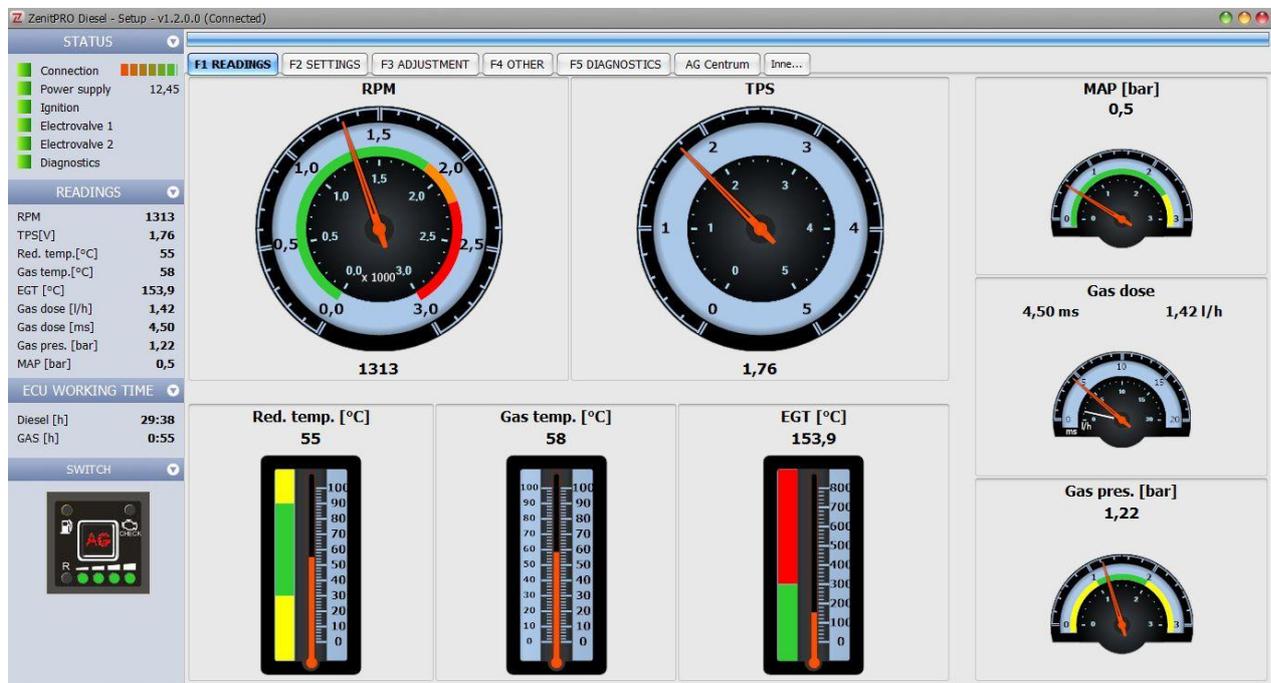
5.1. Status - a window informing about the status of the unit. When there is no power all of the lights are red. If you activate the item, it turns to green, e.g. when there is a voltage across the coil multivalve, the light "Electrovalve 1" is green.

**5.2. Readings** – show current values of each parameters of the engine given below:
- rotation speed- RPM.
- position of gas pedal – TPS,
- the pressure in the intake manifold – MAP.
- Reducer Temperature - Red. temp.[°C]
- Gas Temperature - Gas temp.[°C]
- Exhaust temperature – EGT
- gas dose– actual time of opening the gas injector - Gas dose [ms]
- average gas dose – average amount of burnet gas In liters per hour - Gas dose [l/h]

5.3. ECU WORKING TIME – work time given in hours on chosen fuel type.

5.4. Switch - Switch panel displays the selected state of the system. Using the switch (switching) is possible from the level of the configurator.

6. "Settings" tab

This tab is used to determine the operating conditions of the gas system. From here it is also possible to set up appropriate reading parameters of the working engine.
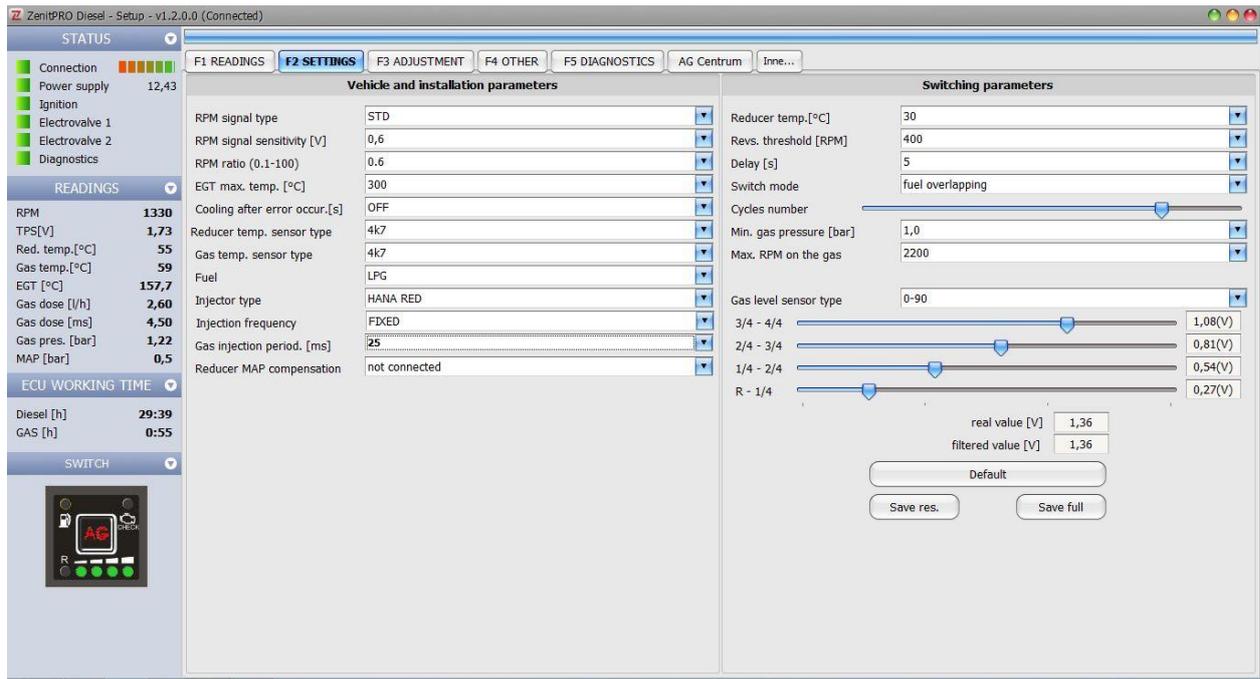
6.1. Vehicle and installation parameters

- RPM signal type:
- **'STD'** – choose it for the standard signal connections such as the tachometer RPM.
- **'ADV'** - choose when You want to use the RPM signal from the inductive sensor with normal characteristics.
-**'ADV DW'**- choose when You want to use the RPM signal from the inductive sensor with the reverse characteristics.
Note: When using a signal from an inductive sensor (options 'ADV' and 'DW ADV') it is recommended to use an additional conditioner in order to eliminate the disturbance during reading.

 - RPM signal sensitivity - specifies the minimum voltage that will be read by the driver. A low value means an increased sensitivity of the reading, a large value means that the circuit interference is being filtrated and the sensitivity of the reading is low.

- RPM ratio – allows the user to read the engine speed in accordance with the actual values (indicated by the tachometer). Ratios lower than 1 increase the readings, greater than 1 – decrease them.

- **EGT max. temp. -** (EGT – Exhaust Gas Temperature) allows to determine the limit of the exhaust gas temperature above which the system will automatically switch to power on Diesel fuel.

- **Cooling after error occur.-** when the specified temperature of the exhaust system will be reached, the system will automatically switch to Diesel fuel, and after a specified time will return to gas. If the exhaust gas temperature remains high, the countdown in order to cool down will restart (that means work on Diesel fuel).

- **Reducer temp. sensor type -** a standard value of the sensors resistance for the system Zenit Pro Diesel is 4.7 kΩ.

- **Gas temperature sensor type -** allows you to choose the correct type of the gas sensor. For the standard installation Zenit Diesel - the sensor is 4.7 ohms.

- **Fuel -** the choice of gas used - LPG / CNG Fuel type

- **Injector type** - the type of the gas injectors used in the system.

- **Injection frequency –** while selecting the type "fixed", the injector opens with a fixed frequency regardless of the engine speed (recommended for engines operating at low speed and / or high gas demand).

   While selecting the option "variable", the frequency of injection varies from the engine speed (recommended for engines operating at higher speeds and / or low gas demand)

- **Gas injection period** - in the case of selecting the injection frequency 'constant' it is necessary to specify the time interval between subsequent injections of gas. As a standard the injection period - 30 ms.

- **Reducer map compensation** – the option used to obtain the correct reading of the gas pressure in the system:

- **'Not Connected'**- select this option when the vacuum nozzle on the reducer (pressure compensation) is not connected to the engine intake manifold.

- **'Connected'**- select this option when the vacuum nozzle on the reducer is combined with the engine intake manifold.

Note: While installing to the engine without the turbocharger always choose the option 'Not Connected' no matter how do you connect the vacuum nozzle.

6.2. Switching parameters

   The tab allows you to select parameters needed for the change-over from power on Diesel fuel to the gas supply.

- **Reducer temperature** - after reaching the minimum temperature, the system will automatically switch to gas.

   The limit for the reducer temperature while operating on gas is 10 ° C - if during driving on LPG the temperature falls below this value, it will return to power on diesel fuel, indicated as "emergency".

- **Revs. threshold –** the engine speed above which the system will switch on the gas. Switching occurs with the automatic time acceleration of fuels imposition.

- **Delay –** delay time of switching to the dual-fuel after reaching the rest of switching parameters

- Switch mode - tab contains options that allow a smooth and stable fuel switching. If you change the power from ON to LPG there is a delay in the supply of gas which may be associated with disturbances in the engine:

- **'Fuel overlapping'** – during switching for some time ('cycles') both fuels are served at the same time. For example, for the switching from ON to gas - as a first the gas injectors are opened and then the ON limiting emulators are switched on.

- **'Smooth'** - when switching from one fuel other takes place at the same time:

1. Progressively reducing the amount of one fuel

2. Progressively increasing the amount of the second fuel.

Each change of the type of power is the principle of gradual changes in the proportion of the two fuels.

It is recommended to use the switching option - 'Smooth'

- Cycles number - for the option **'Fuel overlapping'** it is required to specify the time in which the fuel is supplied simultaneously. It corresponds to the number of gas injector opening cycles before the ON dose reduction.

- Min. gas pressure - the pressure under which the system will automatically switch to power on Diesel fuel with the standard audible signals (no gas)

It is recommended to maintain the minimum pressure of 0.6 bar less than a working pressure.

Note: The value of the gas pressure given in the program is the value of the differential pressure (between the gas pressure prevailing at the output of the regulator and the air pressure at the input of the regulator nozzle compensation). In order to receive correct readings, select the connected or not connected 'Reducer map compensation'.

- Max. RPM on the gas- with diesel engines, it is necessary to limit the maximum engine speed. It is recommended that the introduction of the maximum RPM speed should be adequated to the engine speed limiter working on Diesel fuel. After exceeding this value, the system will automatically switch to power on Diesel fuel.
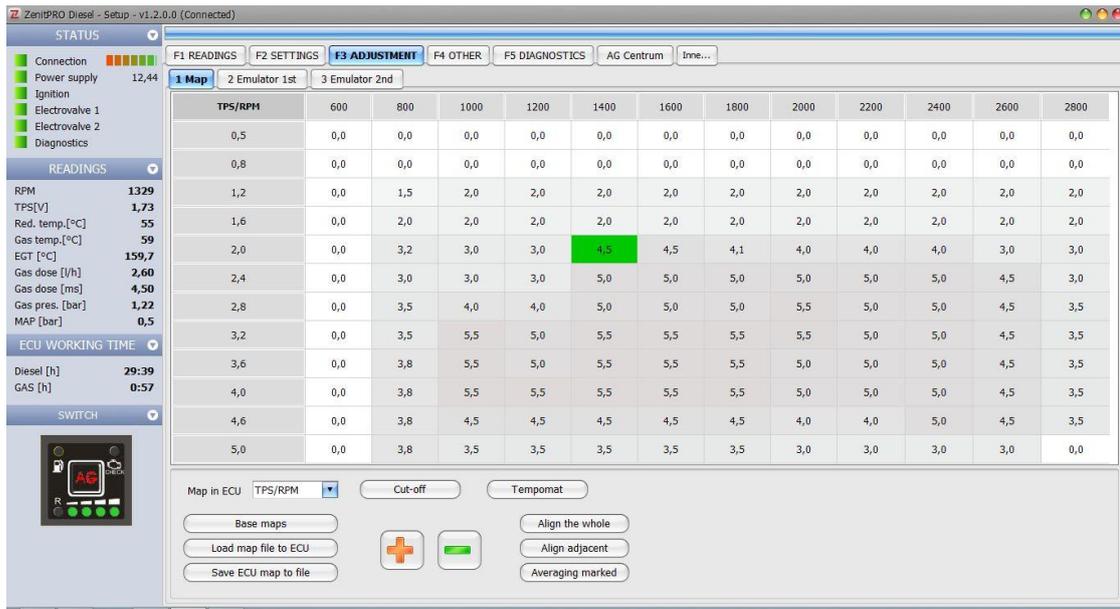
- Gas level sensor type – allows the user to select and calibrate the gas level sensor used in the vehicle.

- Real value - is the actual value of the voltage on the gas level sensor.

- Filtered value - is the average value of the voltage on the sensor, illustrated on the switch LEDs.

7. "ADJUSTMENT" tab

The regulatory map is used to determine the dose of used gas. In order to determine the basic gas injector opening times, use the base maps – button "Base Map". Depending on the engine type and the amount of gas you can use the maps, 'HEVY TRUCK 'or 'VAN'.

ZenitPRO Diesel - Setup - v1.2.0.0 (Connected)

F1 READINGS | F2 SETTINGS | **F3 ADJUSTMENT** | F4 OTHER | F5 DIAGNOSTICS | AG Centrum | Inne...

1 Map | 2 Emulator 1st | 3 Emulator 2nd

STATUS

Connection
Power supply 12,44
Ignition
Electrovalve 1
Electrovalve 2
Diagnostics

READINGS

RPM	1329
TPS[V]	1,73
Red. temp.[°C]	55
Gas temp.[°C]	59
EGT [°C]	159,7
Gas dose [l/h]	2,60
Gas dose [ms]	4,50
Gas pres. [bar]	1,22
MAP [bar]	0,5

ECU WORKING TIME

Diesel [h]	29:39
GAS [h]	0:57

SWITCH

TPS/RPM	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800
0,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
1,2	0,0	1,5	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0
1,6	0,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0
2,0	0,0	3,2	3,0	3,0	4,5	4,5	4,1	4,0	4,0	4,0	3,0	3,0
2,4	0,0	3,0	3,0	3,0	5,0	5,0	5,0	5,0	5,0	5,0	4,5	3,0
2,8	0,0	3,5	4,0	4,0	5,0	5,0	5,0	5,5	5,0	5,0	4,5	3,5
3,2	0,0	3,5	5,5	5,0	5,5	5,5	5,5	5,5	5,0	5,0	4,5	3,5
3,6	0,0	3,8	5,5	5,0	5,5	5,5	5,5	5,0	5,0	5,0	4,5	3,5
4,0	0,0	3,8	5,5	5,5	5,5	5,5	5,5	5,0	5,0	5,0	4,5	3,5
4,6	0,0	3,8	4,5	4,5	4,5	4,5	4,5	4,0	4,0	5,0	4,5	3,5
5,0	0,0	3,8	3,5	3,5	3,5	3,5	3,5	3,0	3,0	3,0	3,0	0,0

Map in ECU [TPS/RPM] | Cut-off | Tempomat

Base maps | Align the whole
Load map file to ECU | Align adjacent
Save ECU map to file | Averaging marked

To configure the emulation of the signals from the sensors of the system Diesel fuel (Diesel fuel dose limits), use tabs 'EMULATOR 1' and 'EMULATOR 2'.

7.1. Base Maps

In the case of maps HEVY TRUCK it is presupposed that the average dose capable to obtain a gas combustion in an amount of about 10 liters per hour, at engine speeds from 1200 to 1500 RPM. The standard accepted frequency of injectors opening – "Fixed".

For "VAN" maps gas doses are set at the level of 4 liters per hour. The adopted frequency of injector opening – "Variable ".

- TPS / RPM – the regulatory map based on values from accelerator pedal position sensor readings in a function of the RPM. Depending on the type of selected maps (TRUCK or VAN) automatically selects the appropriate RPM range and the TPS. Moreover, the appropriate opening type for the gas injector is automatically assigned, that is for the map type "TRUCK" - fixed frequency, for the map type "VAN" – on variable frequency.

Fixed frequency means the constant time interval between the gas injector opening, independent of the engine speed. Standard interval is 30 ms.
Variable frequency means that the injector opening is synchronized with the engine revolutions. This means that for higher speed the gas is supplied more frequently.

- MAP / RPM – the regulatory map based on the indications of the air pressure sensor in the intake manifold in a position function of the accelerator pedal. The system uses the MAP - the sensor supplied in Zenit Diesel installation kit.
This map type is recommended to use when driving with the cruise control. The signal from the TPS is not taken into consideration in the settings of the map.

- MAP / TPS – the regulatory map based on the indications of the air pressure sensor in the intake manifold as a function of the position of the accelerator pedal.

General notes:
All of values on the map can be customized. It is possible to correct the range of RPM and TPS values within given intervals in order to adapt them to the individual vehicle. It is possible to edit the map points from the keyboard (direct change of the value on the selected windows) as well as through the panel which is modeling larger areas of the map.

"Cut Off" - In order to limit the amount of fuel burned, the ON driver performs certain strategies. Firstly, it is used to disconnect the injection (the fuel supply to the engine) during the engine braking. In practice it happens whenever the accelerator pedal moves from the load range to the idle range (when changing gear, accessing to the junction, downhill drive etc.) In the case of LPG activation, this function allows you to cut off the gas injectors in the situation when there is no need for the fuel supply. In this way we can increase the LPG efficiency and reduce the emissions of HC.
    The function 'Cut Off' is based on the sensor of the accelerator pedal (TPS). The strategy of removing the injectors is based on the TPS changes.
1. 'Mode' - allows you to adjust the function to a particular signal TPS. By default, the function is inactive – TPS 'Off'.
2. 'TPS Threshold'- in this section must specify the voltage on the accelerator pedal in order to get information about the transition to the idle state. By default, a typical operating range for the sensor (0 - 5 V). When the TPS voltage falls below a certain threshold (e.g., 1.2 V), the controller turns off the gas injectors. The increase in the voltage on the TPS sensor (moving above the threshold (while speeding up)) will automatically open the injectors according to the injection map.

3. 'Delay' - in order to avoid an uncontrolled switching of the 'Cut Off' function (related to the disturbances in the voltage readings), the ECU Zenit Diesel activates the injectors disconnection after a specified period of time. This means that after reaching the 'TPS Threshold' the injectors will be closed only after a specified time delay.

"Cruise control" - This feature allows you to determine the dose of gas while driving at a constant speed using the cruise control. It is a specific type of engine because the signal from the accelerator pedal position indicates the right status for the idle, and the vehicle is moving at normal speed. In this case, the use of TPS / RPM map is not possible. The activated function 'Cruise control' allows you to determine the dose of gas regardless of the base map. It is based on the value of the pressure in the air intake manifold and the TPS indications and RPM value.

1. 'Mode' - allows you to enable the cruise control function.

2. 'TPS threshold' - as in the case of function 'Cut Off' that is the voltage of the TPS signal below which the option 'Cruise Control' will be activated (that means switching to gas dosing in accordance to an additional map. In practice, each deacceleration on gas pedal will cause the decline in the value of the voltage to the idle value. For ECU Zenit Diesel it is important to determine the voltage (threshold) below which we have a situation with idle running.

3. 'MAP threshold' - rely the gas dosing on the pressure sensor MAP requires the determination of the value - what we consider to be 'load running' and which value corresponds to 'idling'. For proper operation of 'Cruise control' function you should clearly define the limit between those two working states. The function will activate only in the higher pressure values (usually above 1.3 bar)

4. 'RPM threshold "- the value of the engine speed above which the function 'Cruise control' will be activated

5. 'Delay' - the time from the moment of the changing the voltage on the TPS ('loosing' gas pedal) to the moment of activation function. The time delay helps to stabilize all engine operating parameters (pressure, RPM, TPS) and attach the individual map only when all the conditions will be fulfilled. Please note that in case of an active 'cut off' function it is realized as a first one, the activation of the cruise control is carried out as a second one.

6. 'Cruise control Map' - is a table which allows to determine of the gas dose as a function of the manifold pressure value (MAP). While activating the function 'Cruise control' the system will automatically switch to control the injection of gas from the base map on the cruise control map.

"Align the whole" – The entire map is automatically recalculated by the system. You should select the desired area (e.g. one field) on the map to then after the **"aligning"** all values will be matched to it. The principle is that the base field (fields) are regarded as the greatest values, so the remaining part of the map is leveled to "down".

"Align adjacent"- when you select the area (one or more fields) and enable the function, the correction of the values in the adjacent fields is follows (changes are applicable only for directly adjacent fields). The Alignment is done also in the case of adjustment of the whole map.

"Averaging marked"- this feature allows the user to average the values found in the fields of the selected area. Averaging is to determine **a single value for all selected fields.** This value is the arithmetic mean.

Note! The values in the map windows represent the opening time for gas injector in milliseconds. To obtain a rapid correction (changes can be done while using the function "+" and "-"), these values are automatically averaged to 0.5 ms. It is possible to select any opening time for gas injector thanks to the accurate correction.

Note! Appearing in the left window ("Readings") information about the dose of gas represents the current map readings that is set injector opening time. The average gas dose corresponds to the type of the gas injector HANA (red, green, black, blue).

7.2 „ EMULATOR 1" , „EMULATOR 2"
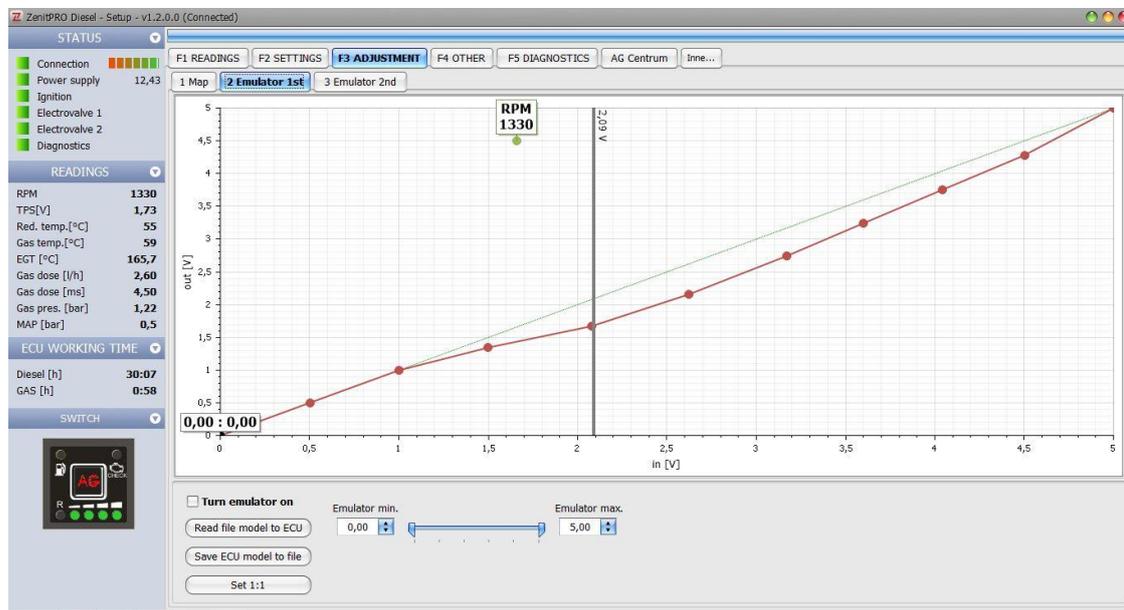
"Emulator" allow the user to modify the signal from the specific sensor of the Diesel fuel system. Emulator operates within linear signals of 0 - 5 V. This means that it is possible to change the characteristics of the sensors, such as:
- Accelerator pedal position
- Common rail fuel pressure
- Air flow sensor
- MAP sensor

The emulator allows you to change the output signal from the sensor to the Diesel fuel controller. The modification of the signal is similar to the modeling of the multiplier in the gas injection system. During the change of map points, the percentile difference between real and

emulated indication and the actual input and output voltage values are automatically displayed. The limit on the maximum change to 100% of the input value has been imposed on purpose.
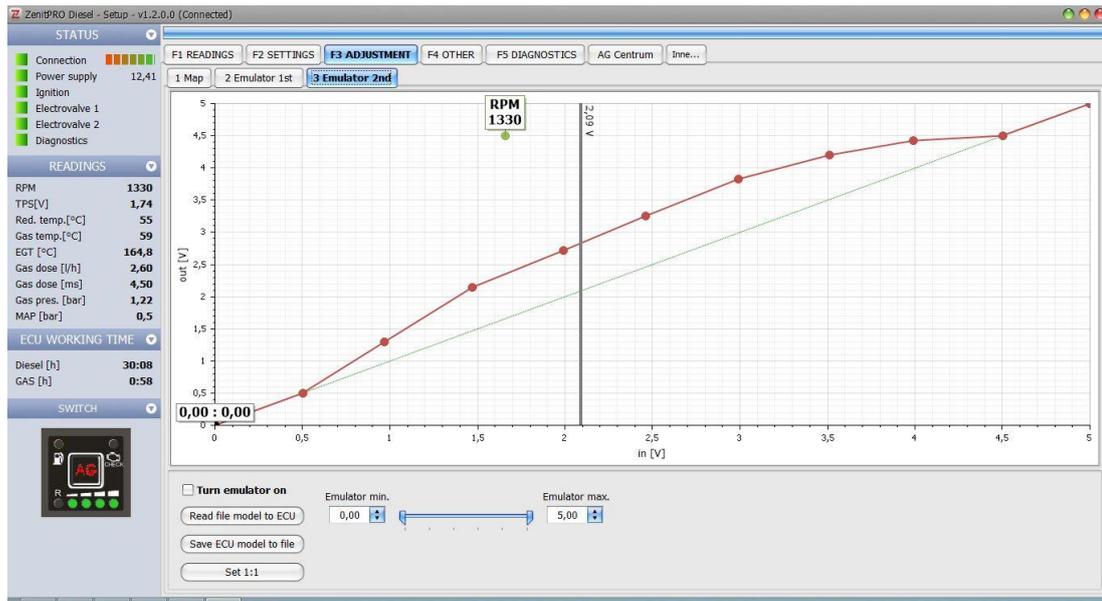
Both emulators have the same characteristics, however they work independently of each other. Using two simultaneous emulators is useful, e.g. in the case when we have two-track TPS – so a signal change for only one sensor will cause the error register. Then it becomes necessary to change the signal on the second path.

Basic working principles of the emulator.

On one axis (horizontal) there are the values of the input signal (from the sensor to the Diesel ECU) and on the other axis (vertical) there are values for the signal coming out of the emulator (to Diesel ECU). By a factor of 1:1 means there is no emulation, so the incoming and outgoing signals are the same.

To reduce the amount of Diesel fuel is necessary to provide information to the Diesel ECU about the lower demand for fuel. If you use the signal TPS, the emulation applies to the reduced readings from the sensor of the acceleration pedal position. Example of setting the sensor emulator for the sensor reduced by 10%:
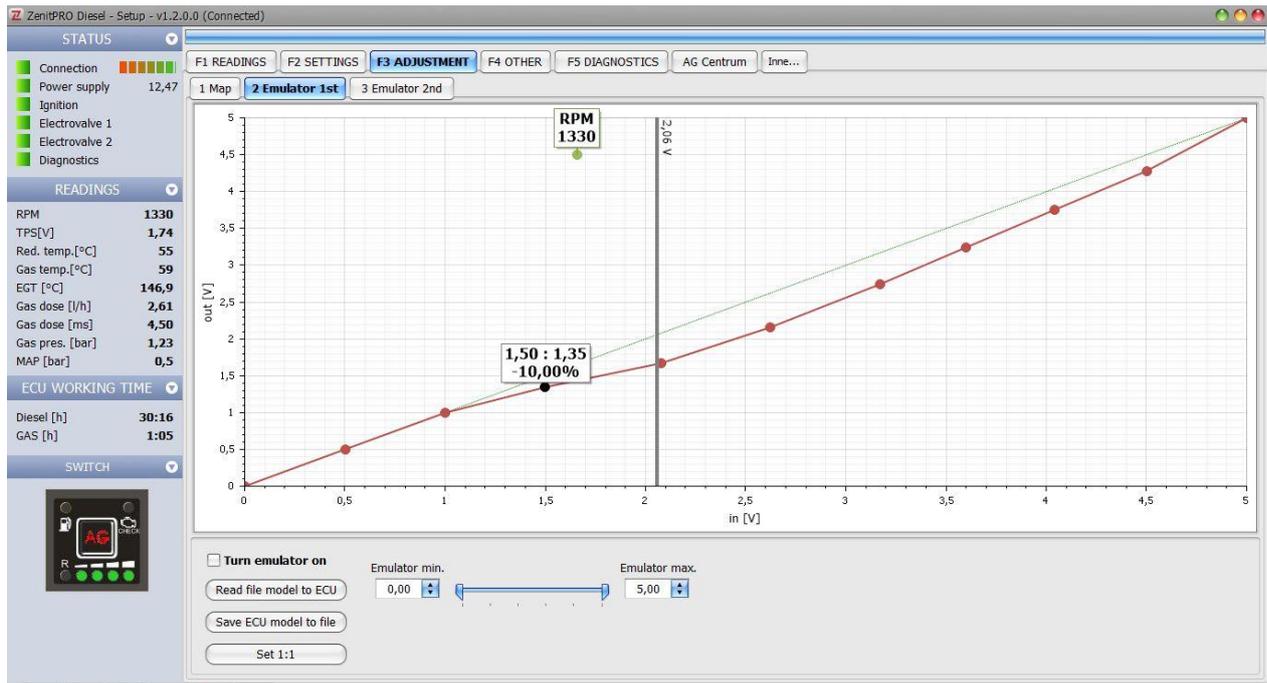
8. „OTHER" tab

8.1. ECU

This tab contains information about the control unit, such as FW version, serial no. It is possible to update the ECU firmware, software and read or write ECU configuration.
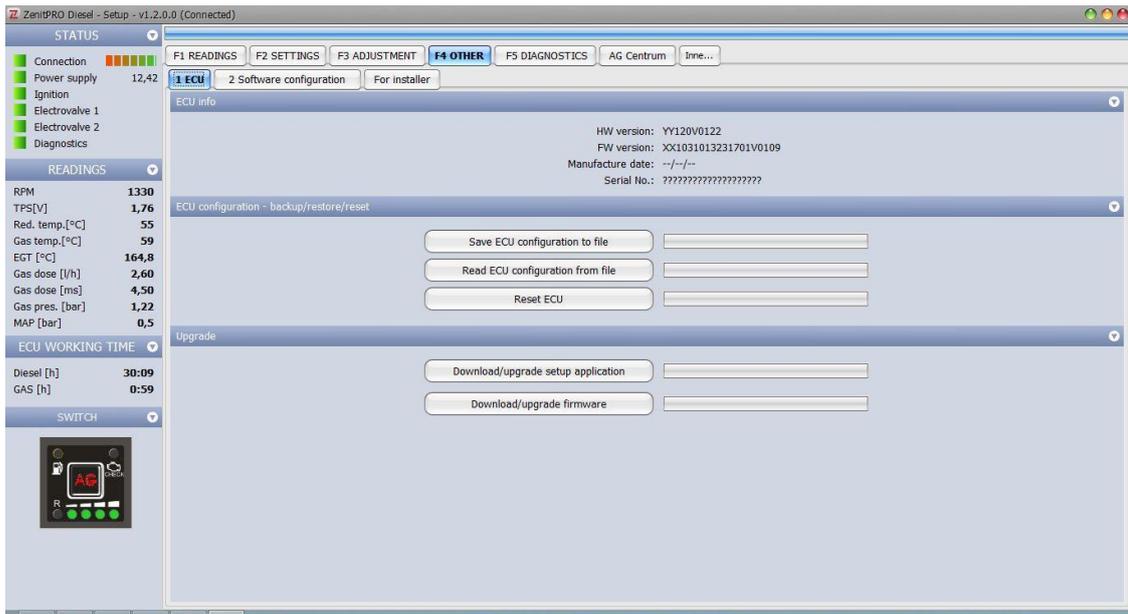
8.2. Software configuration

Automatically after running a program on your computer, ZENIT Diesel tries to establish a connection with the ECU of the vehicle. If you want to choose the type of connection click "Select port" and after that specify the number. Then the connection will be implemented only on the selected port. If you choose the type "Auto - connect" the program searches through all available ports in order to connect. Then chosen connection will be automatically assigned to a specific port. All subsequent run of the ZENIT Diesel program will be held on the same port.
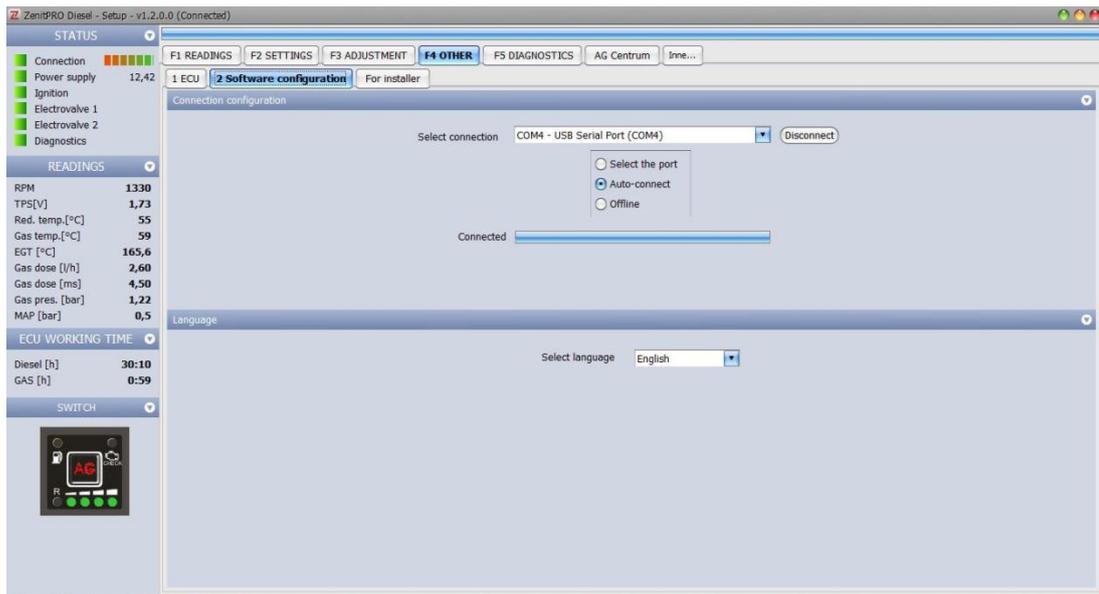
8.3. For Installer
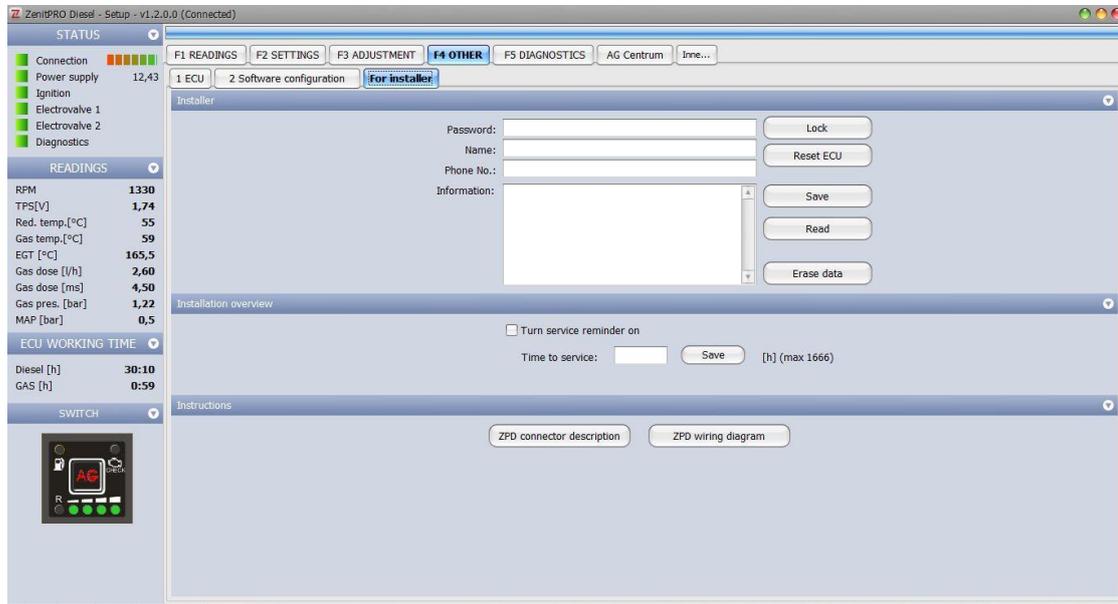
- **'Password'** – option that gives the possibility of blocking the access to the configuration. It requires entering the personal password which can contain up to 16 characters.

If you need to intervene in the configuration which is locked with the unknown password, please use the option 'Reset ECU' –the ECU will return to the default settings.

- **'Time to service'**- when activating the service option please type specified number of hours of the system operation (approximately 250 hours). The information about the service will be activated by lighting the control 'Check' on the switch panel.

- **'Instructions'**- this section contains a description of the ECU connector pins and ECU wiring diagram.

9. Diagnostics
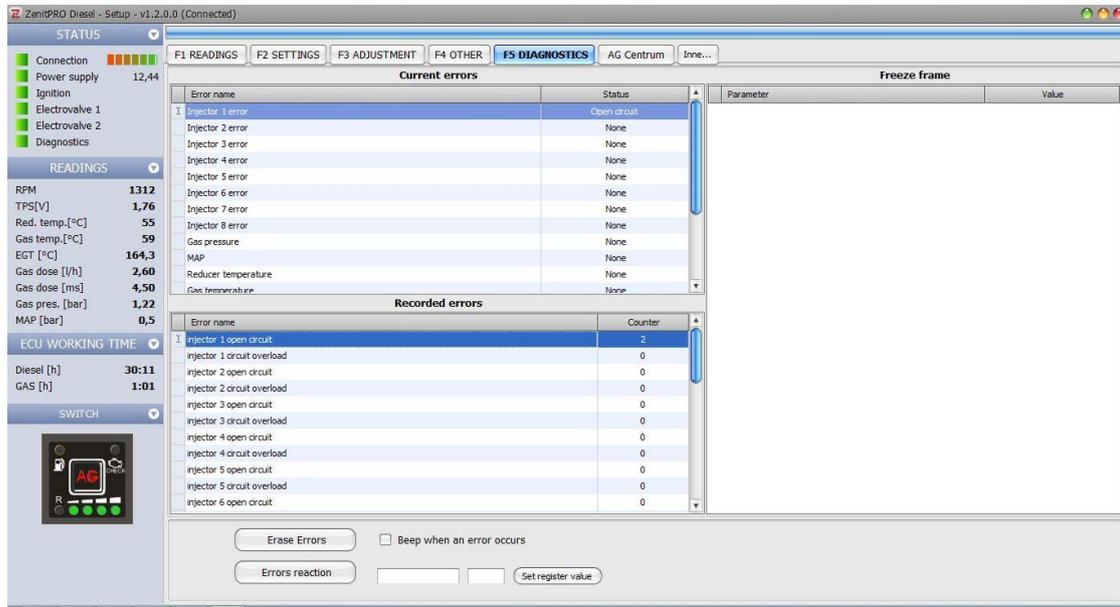
- **'Current errors'** - errors that currently exist in the system
- **'Errors recorded'** - a list of all the errors that occurred during the system operation.
- **'Errors reaction'** - this option allows to program the system diagnostics. You can also specify whether after the error occurs the system will automatically switch on the power ON or not.

If the error occurs and the system will switch on the power ON, the lights will appear on the control panel (LEDs will light up linearly to the right). It is also recommended to activate the acoustic signal.

-**'Freeze frame'** - allows you to read the engine operating conditions under which the error appeared.

10."AG CENTRUM" tab - that allows direct connection to the AGC company website

11. The description of ECU electrical pins

PIN	COLOR	DESIGNATION	FUNCTION	IN/OUT	VARIANTS
H 4	BROWN	MAP IN	PRESSURE MAP SENSOR	IN	all
J 4	WHITE	MAP IN 1		IN	all
H 1	BLACK	GND		OUT	all
H 3	RED	+ V KEY		OUT	all
K 1	BROWN	RPM 1		IN	all
K 2	BROWN-BLACK	RPM 2		IN	all
E 1	YELLOW	APS	ACCELERATOR POSITION SENSOR	IN	all
C 1	GREY	PIEZO	DIESEL INJECTOR	IN	all
M 4	RED- BLACK	+ BAT 12V	MAINFEED 12V CC	IN	/12
		+ BAT 24 V	MAINFEED 24 V CC	IN	/24
L 4	BLACK	GND	TANK LOCK-OFF	OUT	all
F 4	BLUE-BLACK	EVG 2		OUT	all
D 3	GREEN	+ V LEVEL	GAS LEVEL SENSOR	OUT	all
E 3	WHITE	LEVEL		IN	all
L 3	BLACK	GND		OUT	all
G 3	PINK	TRED	WATER TEMPERATURE	IN	all
H 1	BLACK	GND		IN	all
G 4	PINK-BLACK	TGAS	GAS TEMPERATURE	IN	all
H 1	BLACK	GND		IN	all
E 4	BLUE	EVG 1	REDUCER LOCK-OFF	OUT	all
L 3	BLACK	GND		OUT	all
M1	BLACK	GND	CHANGE –OVER SWITCH IN/OUT	OUT	all
H 2	WHITE	TX		OUT	all
G 2	GREEN	RX		IN	all
J 2	RED	+V KEY		OUT	all
M3	RED	+ V KEY IN	+ 12 V KEY	IN	/12
			+ 24 V KEY		/24
L 1	WHITE	EGT -	EXHAUST GAS TEMPERATURE	IN	all
L 2	BLACK	EGT+		IN	all
E 2	PINK-BLACK	KNOCK	KNOCK SENSOR	IN	all
J 1	BLACK	GND		IN	all
M1	BLACK	GND	INTERFACE RS-232	OUT	all

K 3	GREEN	TX LINE		OUT	all
K 4	WHITE	RX LINE		IN	all
J 3	RED	+ BAT		OUT	all
F 3	YELLOW	EMU 1 IN	EMULATOR 1	IN	all
F 1	YELLOW-BLACK	EMU 1 OUT		OUT	all
G 1	VIOLET	EMU 2 IN	EMULATOR 2	IN	all
F 2	VIOLET-BLACK	EMU 2 OUT		OUT	all
B 2	ORANGE	CAN H	OBD CAN BUS	IN	all
B 3	ORANGE-BLACK	CAN L		IN	all
D 1	GREEN	ISO H	OBD ISO BUS	IN	all
D 2	GREEN-BLACK	ISO L		IN	all
M1	BLACK	GND	INTERFACE RS-485	OUT	all
C 3	BROWN	A		OUT	all
C 2	BROWN-BLACK	B		IN	all
M2	RED	+ V KEY		OUT	all
	RED-BLACK	+ V KEY	+ 12 V KEY OUT	OUT	all
D 4	GREY	INJ 1	GAS INJECTORS COMMAND 1-4	OUT	all
C 4	YELLOW	INJ 2		OUT	
B 1	VIOLET	INJ 3		OUT	/12/4
A 1	BLUE	INJ 4		OUT	/24/4 /12/6 /24/6 /12/8 /24/8
B 4	GREEN	INJ 5	GAS INJECTORS COMMAND 5-8	OUT	/12/6
A 4	RED	INJ 6		OUT	/24/6 /12/8 /24/8
A 2	BROWN	INJ 7		OUT	/12/8
A 3	PINK	INJ 8		OUT	/24/8

12. ECU Electrical connection scheme

ZENIT PRO DIESEL
MK-2012/12/2
Schemat Elektryczny - *Electric Wiring*
strona 1 - page1

STRONA 2
SEE PAGE 2

STRONA 2
SEE PAGE 2

ŻÓŁTY
YELLOW

SZARY
GREY

CZERWONY/CZARNY
RED/BLACK

ZENIT PRO DIESEL 2 cyl. MK-2012
Schemat Elektryczny - Electric Wiring
strona 2 - page2

PRZEŁĄCZNIK
Switch

Czujnik ciśnienia i MAP
Pressure Sensor

RPM 1 — BRĄZOWY / *BROWN*

RPM 2 — BRĄZOWY/CZARNY / *BROWN/BLACK*

TPS — ŻÓŁTY / *YELLOW*

EMULATOR 1 — ŻÓŁTY (WE) - *YELLOW (IN)* / ŻÓŁTY/CZARNY (WY) - *YELLOW/BLACK (OUT)*

EMULATOR 2 — FIOLETOWY (WE) - *VIOLET (IN)* / FIOLETOWY/CZARNY (WY) - *VIOLET/BLACK (OUT)*

AKUMULATOR
Battery
12V / 24V

BEZPIECZNIK - *FUSE*

Akumulator
Battery

CZERWONY/CZARNY - *RED/BLACK*

CZARNY - *BLACK*

+12V / 24V PO KLUCZYKU
+12 / 24 *VOLTS UNDER KEY*

CZERWONY / *RED*

STRONA 1
SEE PAGE 1

WYPOSAŻENIE DODATKOWE
PODŁĄCZANE NA CZAS KALIBRACJI
(Optional Supply for calibration only)

RS-232

+12V wielozawór / zewn. urządzenia
+12V Rear Lock-off valve / additional devices

NIEBIESKI - *BLUE*

CZARNY - *BLACK*

Czujnik pełnego wskazania
Level Sensor

ZASILANIE + 12 V
ZIELONY - GREEN

SYGNAL - *SIGNAL*
BIAŁY - WHITE

MASA - GND
CZARNY - BLACK

Reduktor
Reducer

CZARNY - *BLACK*

NIEBIESKI/CZARNY - *BLUE/BLACK*

RÓŻOWY
PINK

CZARNY
BLACK

Czujnik temp. reduktora
Reducer temperature sensor

RÓŻOWY/CZARNY
PINK/BLACK

CZARNY
BLACK

BIAŁY - *WHITE*

CZARNY - *BLACK*

STRONA 1
SEE PAGE 1

Czujnik temp. gazu
Gas temp. sensor

Czujnik temperatury EGT
EGT temperature sensor

12. Installation notes

The installation of ZENIT Diesel system components should be done in accordance with applicable law. Our homologation has been done in accordance with Regulation 67.01 EKG ONZ, Regulation 110 EKG ONZ.

- Gas-injectors installation - before supplying the gas to the turbine, make sure that the air supply to the pneumatic system of the vehicle will not be mixed with gas. In this case, carry out independent air intake system to the compressor, using a separate filter.

- MAP sensor - connection output of the MAP sensor (sign, "V") should be connected to the air intake manifold and vacuum nozzle. To separate the rubber cables, use a metal tee connector ø5. The connection output marked as "G" should be connected to the gas system between the regulator and the injectors.

- EGT thermocouple - flare M 10x1 is used to fasten the thermocouples. The sensor should be located in the engine exhaust system at a distance of 40 cm behind the collector or turbine. The thermocouple temperature is 300 – 400 C for up to 700°C. The thermocouple signal cable is made in the casing in the strength up to 200°C.

Electrical connections

- Power - depending on the ECU version the power supply voltage 12 or 24 V is required. In the first case, solid power and "after key" is done by default (it's a standard). In the second case, the ECU type MK-2012/24 equipped with a voltage converter is recommended to be installed. We connect permanent power and "after key" from the ECU from the vehicle 24 V.

All components of the gas installation always work with the 12V voltage.

- RPM - when connected to a tachometer, a sensor Hall, an alternator, you should use the brown wire labeled as "RPM 1".

- TPS – independently from the emulator connection, yellow wire labeled as "TPS" must be connected. It is used primarily to determine the load on the engine for the purpose of setting up the map. In the absence of accelerator pedal position sensor, use the map MAP / RPM. For proper operation of the control panel (gas dosing) TPS signal is not necessary.

- Emulator 1 - recommended to emulate the accelerator pedal position signal.

In the case of using "Emulator 1" a yellow cable "TPS" should be connected with a yellow "Emulator 1".

- Emulator 2 - allows you to change the characteristics of any sensor on the signal 0-5 V.

Note: The cables are attached for each version of the ECU. They are designed to support specific active functions in given version. For example, if there is lack of cables to connect with the OBD, it means that the ECU does not include this option.

13. Calibration of the ZENIT Diesel installation

1. After the installation on the vehicle, verify ECU readings. The basic parameters are: the voltage, the RPM, the pressure in the intake manifold (MAP) and the ECU gas parameters (regulator temperature, gas temperature)

2. For proper operation of the system, check the basic system configuration settings (e.g. the gas pressure) and, if necessary, correct the settings.

3. Switching to gas supply is carried out automatically according to the parameters specified in the configuration. The main criterion is the regulator temperature. After reaching the right regulator temperature, the electrovalves opens. The ECU expects to the increase of the gas pressure in the system to higher value than the minimum specified. Under this condition, and the appropriate speed, the opening of the gas injectors will follow.

4. Emergency switching the power to diesel fuel (e.g. at a pressure drop of gas) takes place automatically, but the implementation process can be different. It is important that changes made using the emulators do not cause disturbances in the engine. Back to Diesel fuel "smooth" means a fully automatic sequential disconnection of the emulators and return to the "defaults". The duration of this transition is closed within about 2 seconds and involves the gradual transition to the target values. Switching with the use of "fuel overlap" is the classic solution of blending of the two fuels.

5. In accordance with the requirements, the system has the limit of the maximum engine speed when running on gas. The turnover threshold should be set according to the actual characteristics of the engine (do not suggest with the limit in the tachometer, but check practically what are the highest turnover reached by the engine while working on Diesel fuel) and then set the value of 5% lower.

6. When the engine is running on gas, the quantity of the supplied LPG or CNG fuel depends on the map settings. The values in the boxes maps define a single injector opening time of the gas in milliseconds.

7. Turning on the emulators occurs after the system switches to the gas mode (independently from opening the gas injectors). For switching off the emulation you need to use the button "Turn the emulator on".

8. During the first installation it is recommended to use the basic regulatory map. By default for the idle speed, the engine braking, and the RPM maximum is it assumed to work only on Diesel fuel.

System calibration – step 1 – driving on Diesel fuel
1. The calibration gas dosing should begin with a drive to Diesel fuel. It is necessary to verify the operating range of the engine in which it is most commonly used. It is important to determine the average RPM and the average speed. This means that the engine load conditions should be adequate to the process of normal vehicle operation. Driving on the Diesel fuel is designed to provide basic information such as:

- Average Diesel fuel consumption and the conditions under which it happens: at what engine RPM, or at which load (based on the MAP sensor readings), what is the cruising speed of the vehicle, which shows an average (or temporary) fuel consumption on the diesel dashboard display.
- the limitation of the dose of the Diesel fuel - thanks to the emulator and the possibility to verify the settings. As the base limit of 20% should be used as default. To test its effectiveness, you can use the map "zero", which is where the whole range of gas injection dose is equal to 0.00 ms. In

this case, after switching on gas, the Diesel fuel will not be supplied. Driving in this configuration will only be on Diesel fuel. When emulators are working (or emulation other than 1:1) should be observed difference in engine power. In the case of a map of the dose of gas and running on gas, you can use the option - disable emulation. The result will be a full dose of Diesel fuel and additionally with gas fuel.
- the choice of a suitable gas map. It is recommended to use a map based on the TPS indicators as a sensor with a linear, smooth tone.
- the determination at what level (%) the Diesel fuel limit will be applied.

Step 2 - Setting the gas dose
1. After selecting the appropriate map, enter the base time injection. Next, check each map window and correct columns or rows – if necessary. This is to adjust the each fields of the map to the characteristics of the sensor. The map includes voltage range from 1 to 5 V, while the majority of the sensors work in a lower extent, for example - to 4 V.

2. ZENIT Diesel allows you to get a clear and precise setting of desired quantity of gas. The average amount of fuel, while working on Diesel fuel is determined in liters per hour. The user of the vehicle can determine the fuel consumption per 100 km.
Similarly, in the case where the ZPD is also giving an instantaneous gas dose. It is a value in liters per hour, so in order to get reliable information, please refer to the speed of 100 km / h.
3. It is recommended to carry out a road test with the specific vehicle speeds to provide easy correction of the consumption of LPG.

Step 3 - Determining the gas dose
 1. The first step is to determine the dose of LPG fuel at the speed of e.g. 50 km / h. It is important to know that the amount of supplied gas will be calculated on an hour's drive. For the same settings, and the speed two times higher (100 km / h) the same amount of LPG will be consumed , but on a twice long distance. This means that you have to set the twice longer time for the injection at the speed of 100 km / h.
2. The next step is to correct the map (correct) at e.g. 75 km / h or 100 km / h. Also the indicators of the use of gas refer to the specific vehicle speed.

3.The dynamics of driving on the dual fuel should be greater than the Diesel fuel, however it is recommended to maintain the power increase on the level of 5%. Possible "surplus" of the power should be corrected by setting the emulators (limiting the oil dose). It is recommended to provide the full dose of LPG only while during the turbocharger work, which means during obtaining the highest values of the motor torque.

4. With the increase of RPM, the gas dose should not be increased if the injection frequency is set as variable ("VAN" map). For a fixed frequency ("TRUCK" map) the amount of LPG supply is

independent of the RPM, so that for low RPM you should set the low gas doses, and higher RPM – higher gas doses.

5. In order to keep the Diesel fuel injectors in full operation, you shouldn't limit too much the dose of oil at the maximum load. Too small amount of fuel is not able to properly cool the injector what may cause the damage of the diesel injector. The emulator is typically programmed to return to the default settings at max load (5 V). This configuration does not provide the right Diesel fuel savings, when the driver prefers the style of driving with the acceleration pedal pressed to the floor.