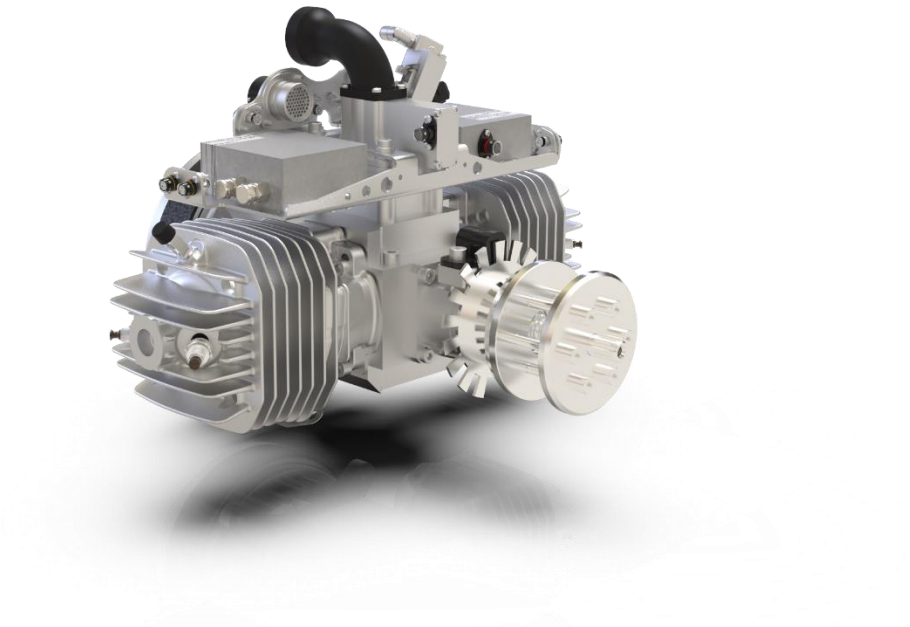
Fuel Injection and Generator

SKY POWER high performance 2-stroke HF & GAS engine and propulsion units

SP-275 (26.275.002)
25 Nov.2020 issue



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1 Change Index and Approval

The manual has a total of 51 pages
Revision 1, 27. Nov. 2020
Revision 2, 15. May 2021
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Revision 5, 24. August 2022

2 Service hotline and service address

Service hours: (German time)
Monday to Thursday from 8:00 a.m. to 4:00 p.m.
Friday 8:00 a.m. to 1:00 p.m.
Please note that our service department can only make repairs with prior appointment and service quote. Please contact us in advance to arrange an appointment.
Hotline or email:
+49 (0) 6172 – 2654258 or service@skypower.online
Mailing address:
Sky Power GmbH, Hollerstrasse 12, 61350 Bad Homburg, Germany
Spare parts
If you are ordering spare parts, please provide the part number.

- Service department telephone: +49 (0) 6047 – 3869745

3 System parts

3.1 Overview

The combustion engine system is splitted into two main parts. The first part is the fuel injection system (FIS 275). This system is responsible for combustion engine operation. The following list sums up the components of the FIS 275:

1. Engine control unit ECU 030
2. Fuel pump BP 041
3. Head temp sensors PT 405 (left and right)
4. Air temp sensor NTC 135
5. Speed sensor HS 155
6. Speed sensor wheel
7. Ignition unit HKZ 218 (left and right)
8. Throttle unit DK 022 with fuel injector
9. Exhaust temperatur sensors AGT 610 (left and right)
10. Spark plugs CMR6H
11. Equipment carrier plate GT 110 with KS551
12. Wire harness KS 557 (ECU 030)
13. Wire harness KS 558 (User supply and communication)

The second part is the hybrid system (HYS 275). This system is responsible for starter generator operation. The following list sums up the components of the HYS 275:

14. Starter generator SG 151
15. Starter generator controller SGC 352 (peak 350A/max. 75V)
16. Power Connection for SGC 352 with Fuse
17. Wire harness KS 569 (hybrid)

Figur 1 shows an overview of the complete system. The 2-stroke combustion engine is equiped with a starter generator (SG 151) on one side of the crank shaft. On top of the SP 275 there is an equipment carrier plate (GT 110) installed. This plate carries all important components for fuel injection, throttle and ignition. Figur 2 to Figur 6 show different views of the SP 275 where all important system parts are marked.

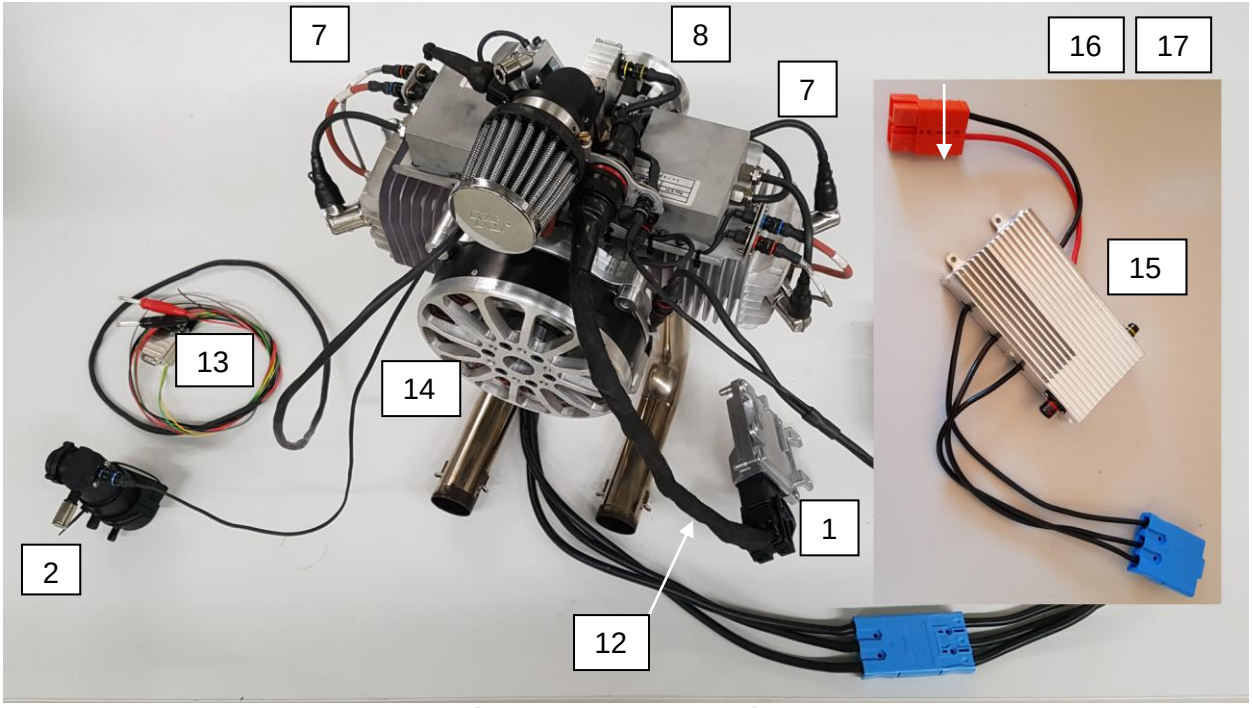


Figure 1: System overview

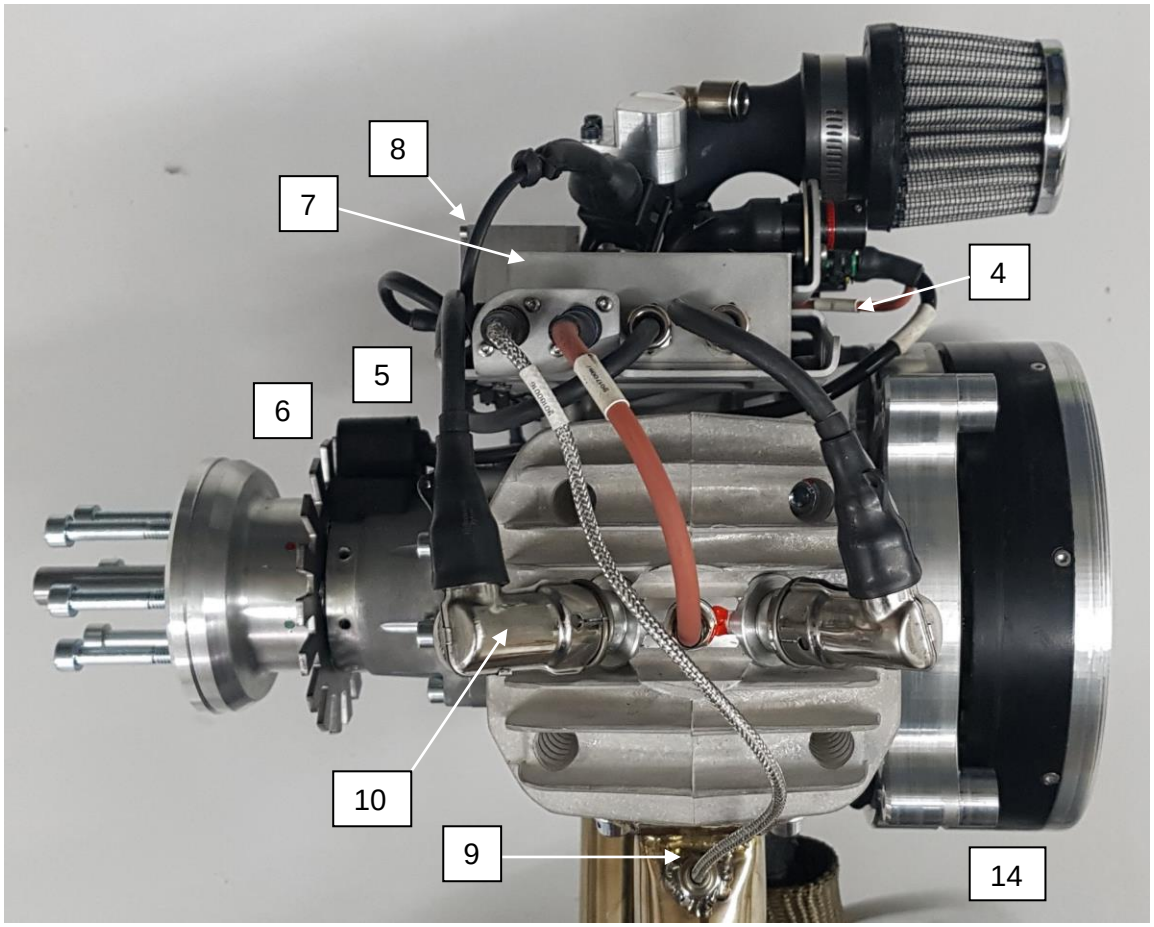


Figure 2: Left side view of SP 275 with SG 151 and FIS 275

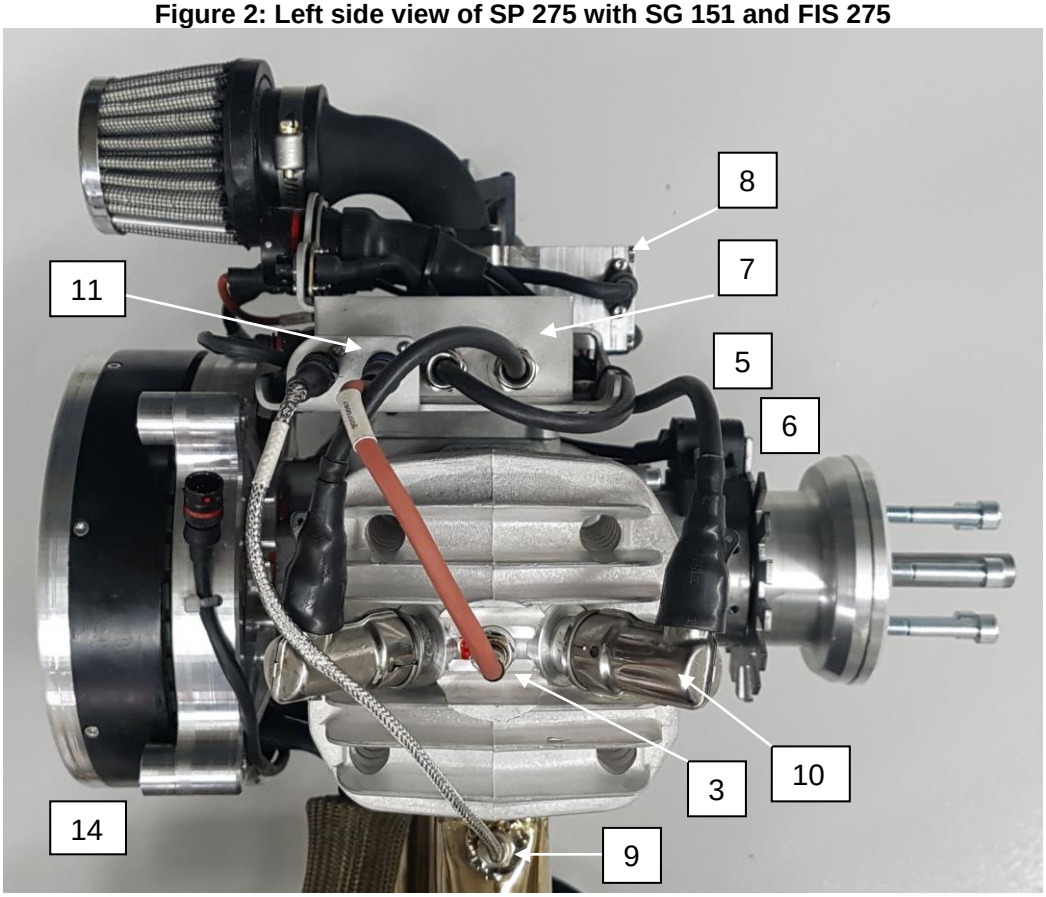


Figure 3: Right side view of SP 275 with SG 151 an FIS 275

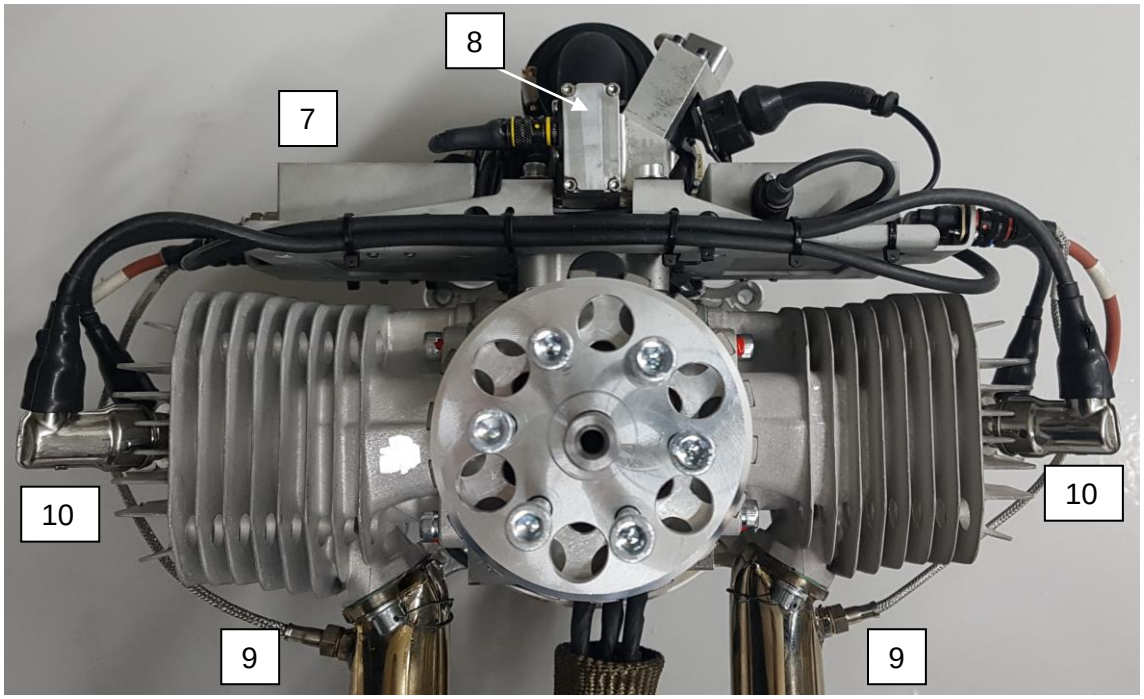


Figure 4: Front side view of SP 275 with SG 151 and FIS 275

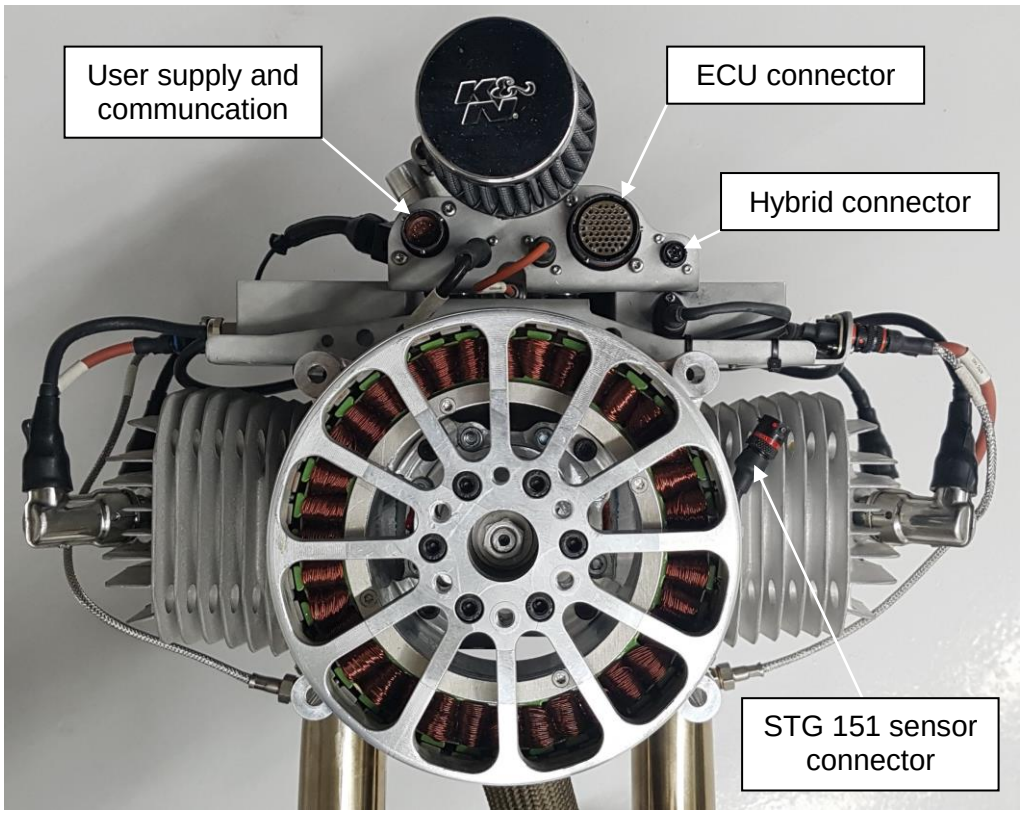


Figure 5: Back side view of SP275 with SG 151 and FIS 275

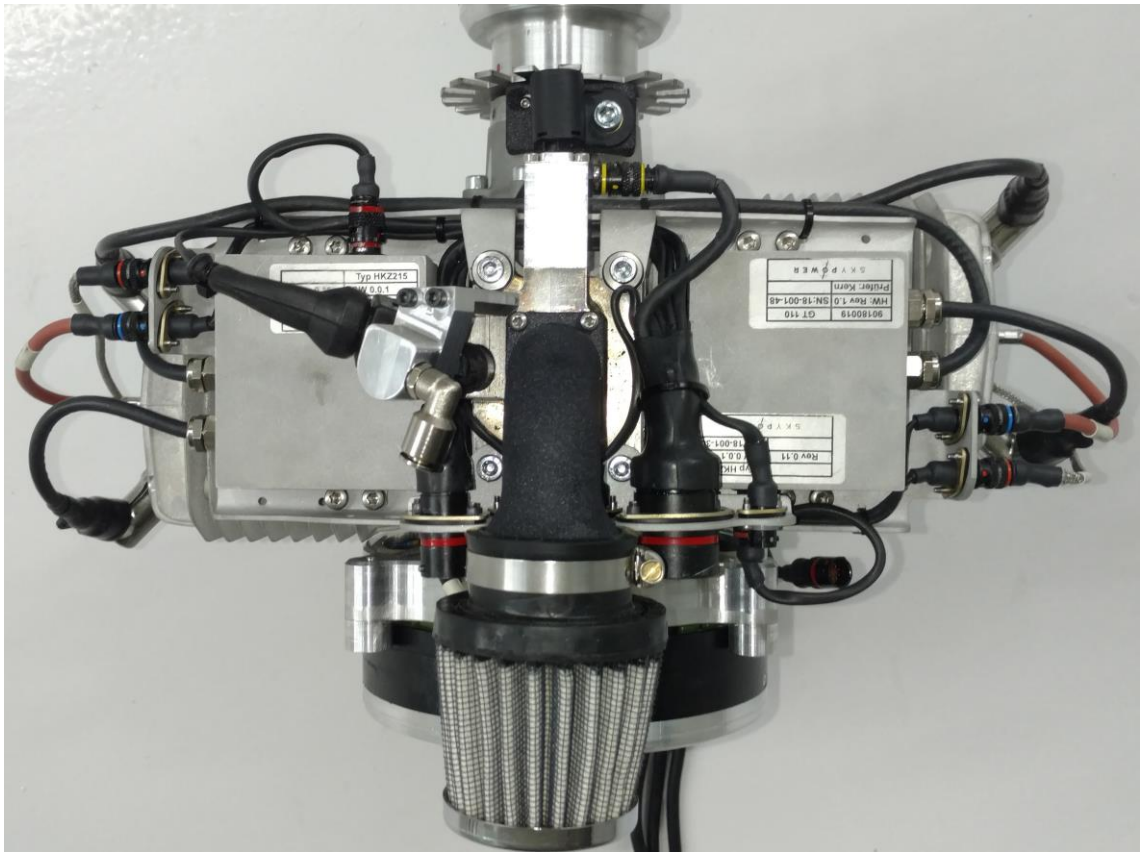


Figure 6: Top view of SP 275 with SG 151 and FIS 275

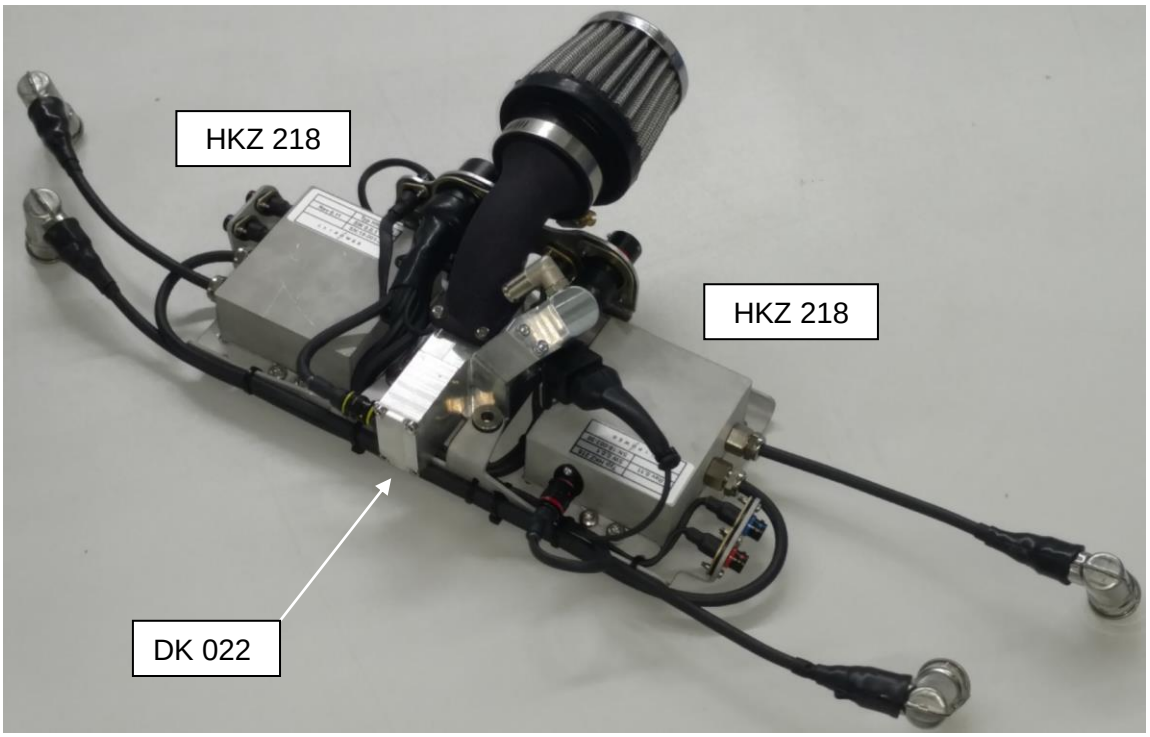


Figure 7: GT 110 with DK 022

Figur 7 shows a more detailed view of the GT 110 and DK 022. The mounting plate carries:

- Two high-voltage capacitor ignition units (HKZ 218), for redundancy each HKZ is connected to one spark plug on each cylinder

- Throttle unit (DK 022) with fuel injection valve
- Air intake socket and air filter
- Motor wire harness KS 551 with all connectors for sensors, throttle, injection, ignition units and starter generator controller

3.2 *Block diagram*

Figure 8 shows a functional block diagram of the combustion engine system. The engine control unit (ECU 030) is the main controller for the system functionality. It controls throttle position, fuel injection and triggers the ignition modules. The ECU 030 monitors the speed and temperature sensors to guarantee a save engine operation. It communicates with the starter generator controller for starting and boosting the combustion engine. Loading of the 48V-battery with the generator mode is possible as well.

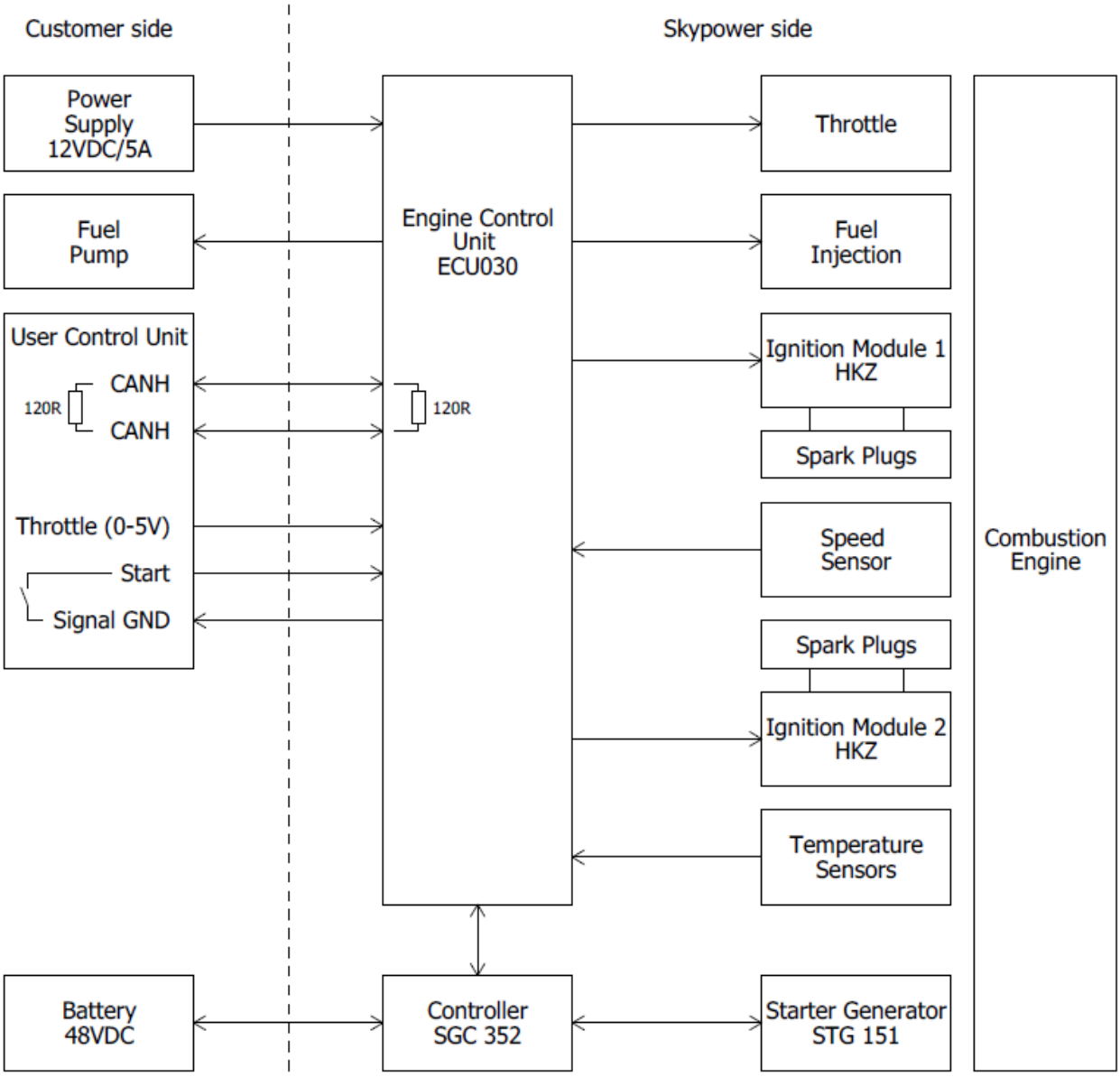


Figure 8: Block diagram of combustion engine system

The customer has to provide a 12VDC power supply with 5A continous output current (further information see section 9.1). The delivered fuel pump BP 041 has to be mounted next the fuel tank (further information see section 8).

The engine can be controlled and configured over CAN bus. The ECU 030 has an included 120Ω termination resistor. The second termination resistor has to be placed by the customer at CAN-module with the farest wire distance to the engine.

Furthermore there is the option to control the engine with an analog signal (0-5V). The engine can be started with an potential-free contact.

4 SP 275 TS

tbd

5 Intake

The SP 275 is equiped with a purpose built throttle body (DK 022) with 22mm diameter. It is controlled by the ECU030.
The injection valve and the air intake temperature sensor are mounted in the throttle body.

5.1 DK 022

tbd

5.2 Injection Valve

tbd

5.3 Air filter

tbd

6 Exhaust

The header length from cylinder to silencer is aprox. 270mm. The inner diameter of the header is 32mm.
The silencer is a resonance type silencer.

7 Fuel System

7.1 Fuel

The SP275TS is mapped for an operation with **unleaded gasoline** with **95 RON** or higher.

7.2 Lubrication oil

For the lubrication of the crank shaft and con-rods the fuel must be mixed with **Aspen 2Stroke oil** with a mix ratio **1:50** (oil to gasoline).

7.3 *Fuel pump BP 041 (90170080)*

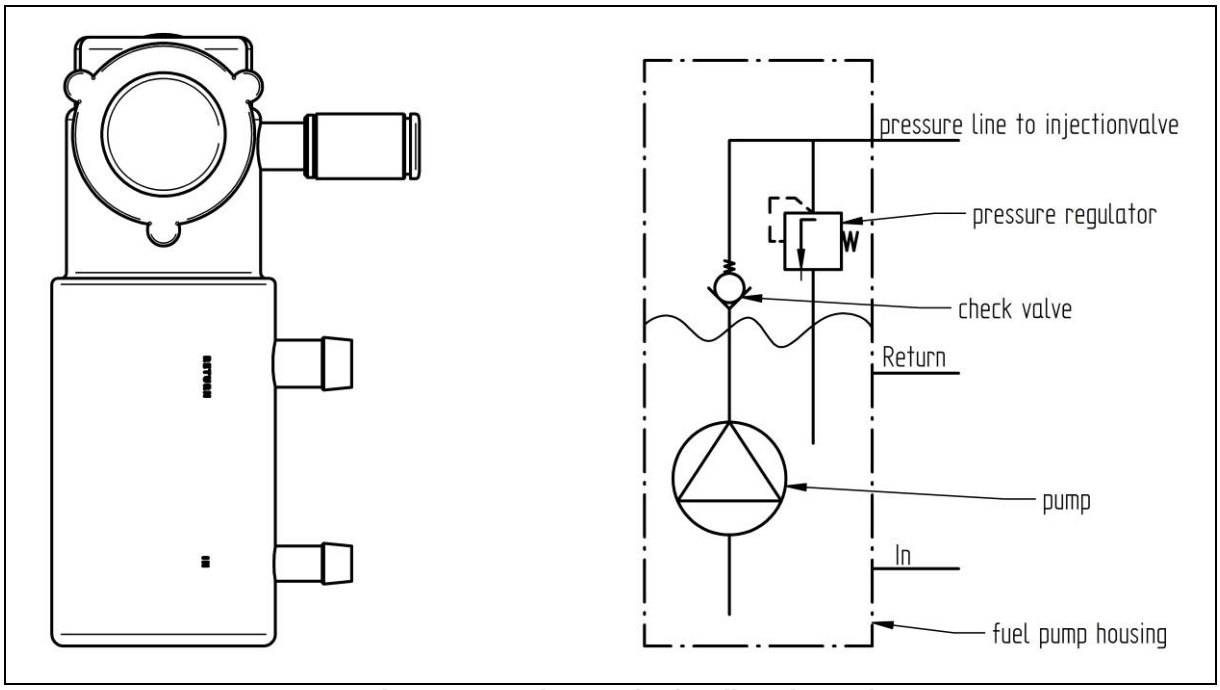


Figure 9 : Fuel pump hydraulic schematic

The BP 041 is a fuel pump with integrated pressure regulator to provide constant fuel pressure to the injection system. It can be driven directly by the ECU 030/080 without the need for an additional relay. The fuel pump has to be mounted in an upright position as shown in in the following figures. It has no self priming capabilities.

The fuel pump has three connection fittings (see also Figure 9)

1. The upper fitting is a push in fitting for 6x4mm PTFE tubes. This is the pressure side of the pump
2. The fitting in the middle is the return line to the tank. It is designed for rubber hoses with 8mm (5/16") inner diameter.
3. The lower fitting is for the fuel feed line. It is designed for rubber hoses with 6mm (1/4") inner diameter.

Parameter	Typ.	Unit	Comment
Dimension	See Figure 10	mm	
Weight	242	g	without mounting bracket (mounting bracket 15g)
Voltage	12	V	
Current	1,3	A	

Pressure	3	bar	nominal
Flow rate	25	l/h	

Table 1: BP 041 technical data

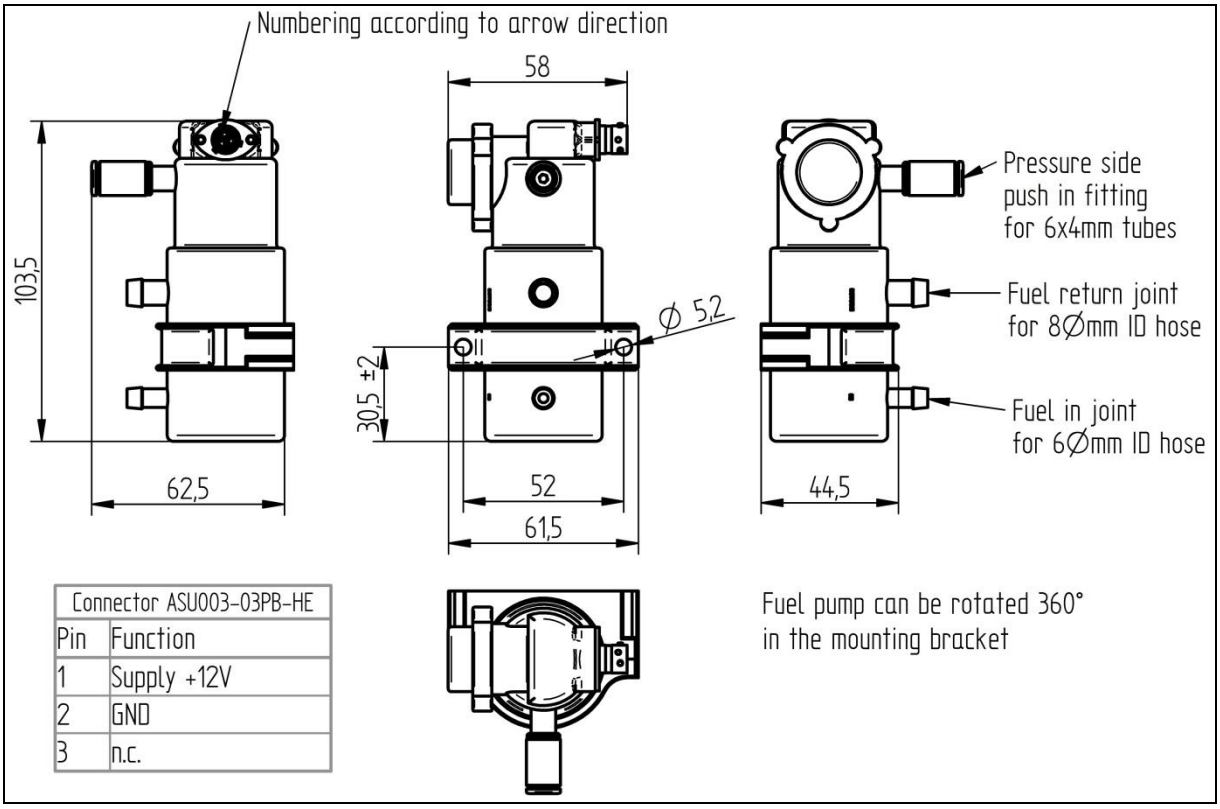


Figure 10: Drawing of fuel pump

7.4 Fuel System with pre mixed fuel

In applications where the engine is operated with pre mixed fuel (oil to fuel ratio 1:200) the fuel pump can be operated either in a single pump system (see Figure 11) or in a twin pump system with an additional pre feed pump and a catch tank (see Figure 12). As the BP 041 is not self priming it is essential that the pump is mounted in such a way that at least the “fuel in” fitting is lower than the fuel level. The fuel filter and the fuel line from the tank to the pump should also be below fuel level so that the fuel can flow by gravity to the pump. For the return line it is important that it also ends below fuel level to prevent the pump from sucking air but it may run higher than fuel level (see Figure 11).

In a twin pump fuel system (see Figure 12) the BP 041 and the catch tank can be mounted higher than the main fuel tank. In this case the pre-feed-pump constantly fills the catch-tank, excessive fuel flows back to the main tank. It is important that the pre-feed-pump has a higher flow rate than the BP 041. The mounting position of the pre-feed-pump is depending on its self-priming capabilities. For flight operation in heavy weather or with high roll and pitch movements it is expedient to implement a twin pump fuel system.

To make the first startup of the complete system easier it is necessary to bleed the fuel system by disconnecting the pressure line at the throttle body and running the fuel pump for a few seconds until fuel spills.

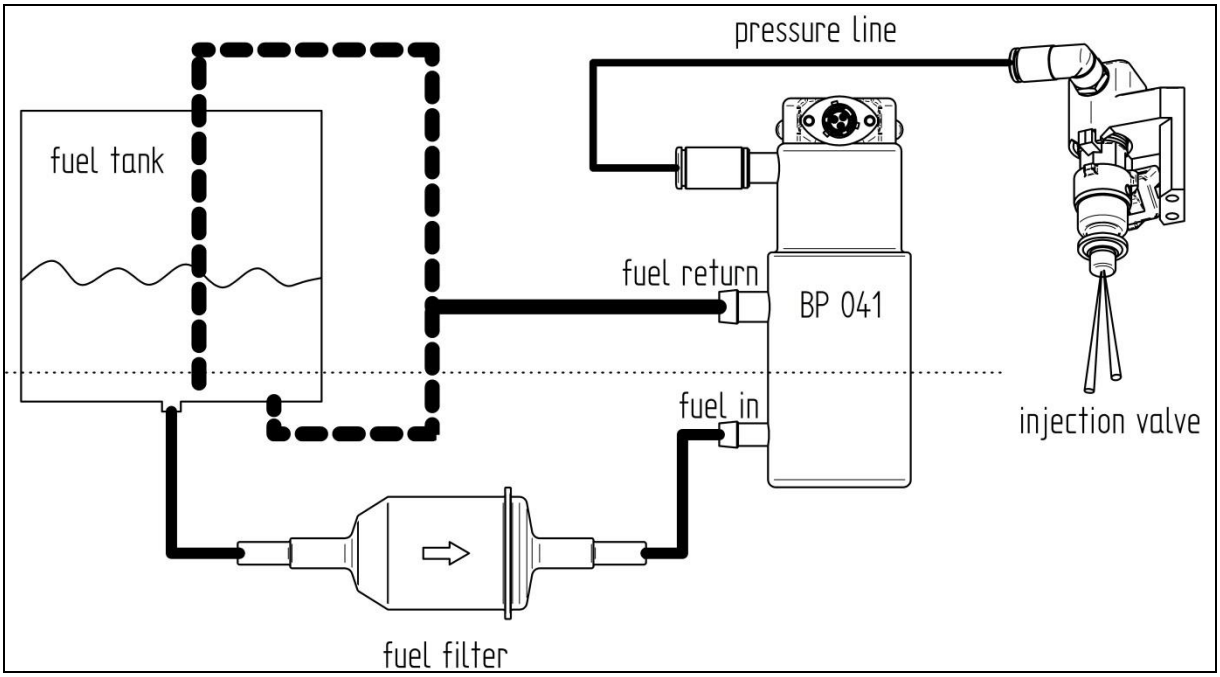


Figure 11: Fuel system

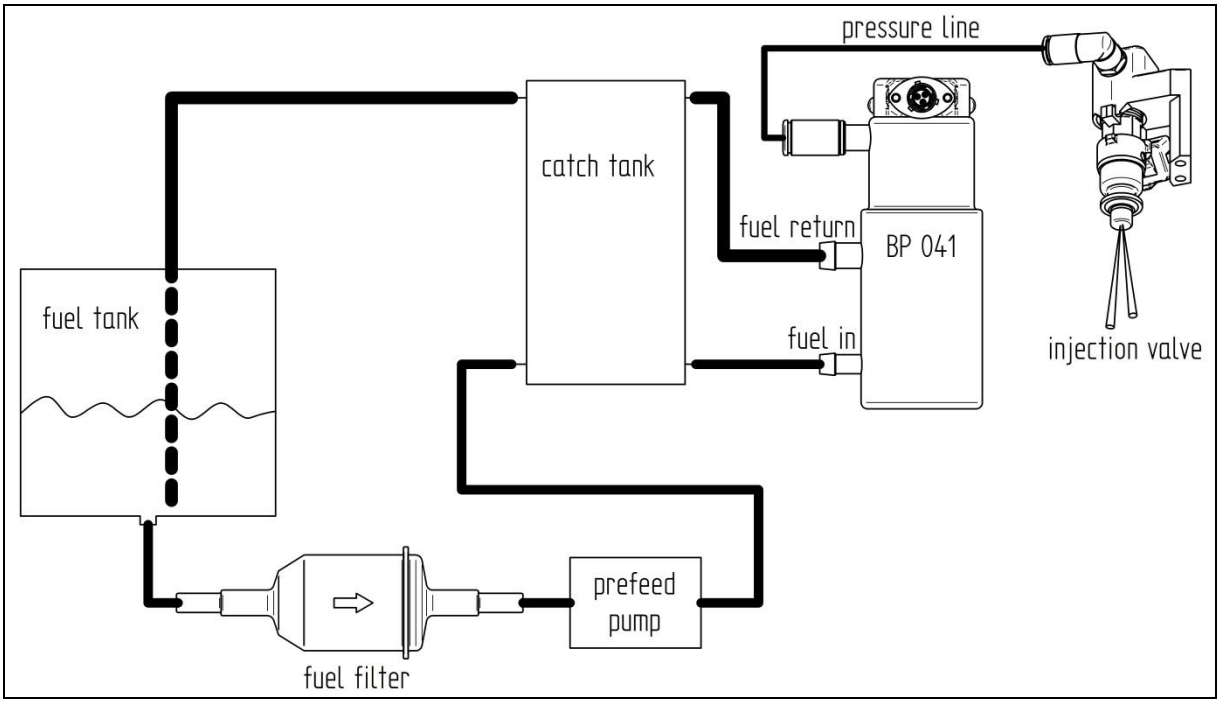


Figure 12: Fuel system with catch tank

7.5 *Fuel system with separate oil and fuel tank*

This system is optional. Additional hardware required.

For applications where no pre mixed fuel is used the fuel system includes in addition a lubrication oil reservoir, a proportioner pump and a small catch tank where fuel and oil are mixed.
There are also two options:
The first system (see Figure 13) is without a prefeed pump. In this case the fuel pump needs to be below fuel level (see also description to Figure 11). Befor first use, (and if you ran out of fuel) The system must be bleeded by opening the bleeder screw until fuel comes.During operation the proportioner pump is delivering the oil volume according to the current fuel consumption to the pre mix tank at the fuel pump.
The second option is to use a pre-feed pump. In this case the BP041 can be monted above fuel level (see Figure 14).

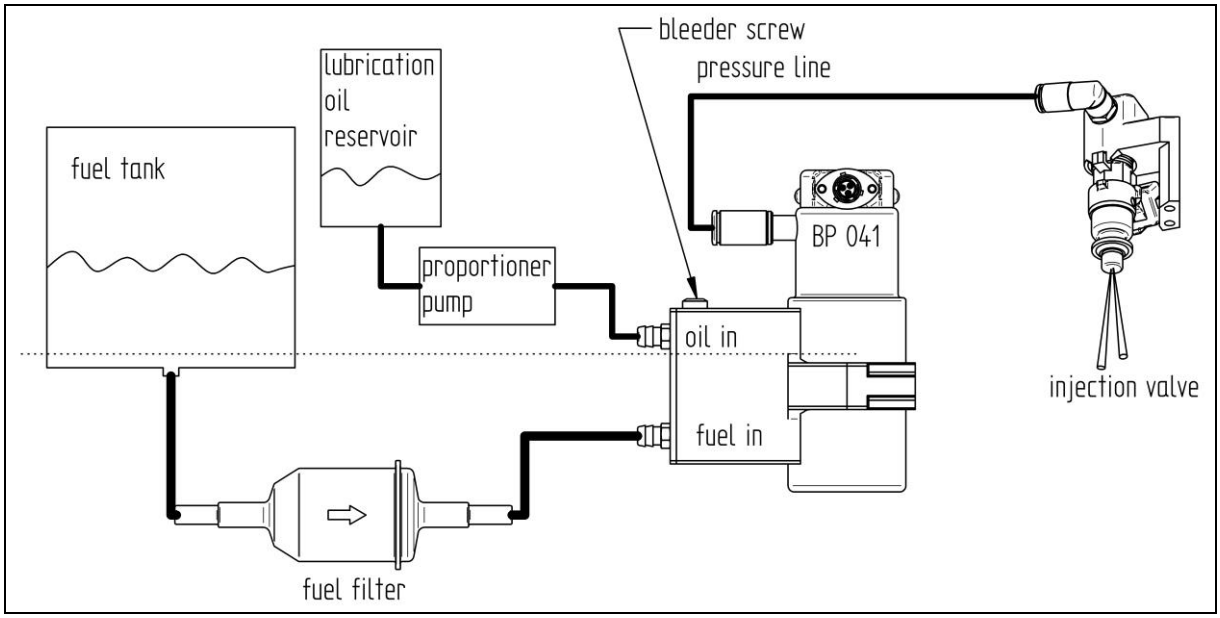


Figure 13: Fuel oil mix system

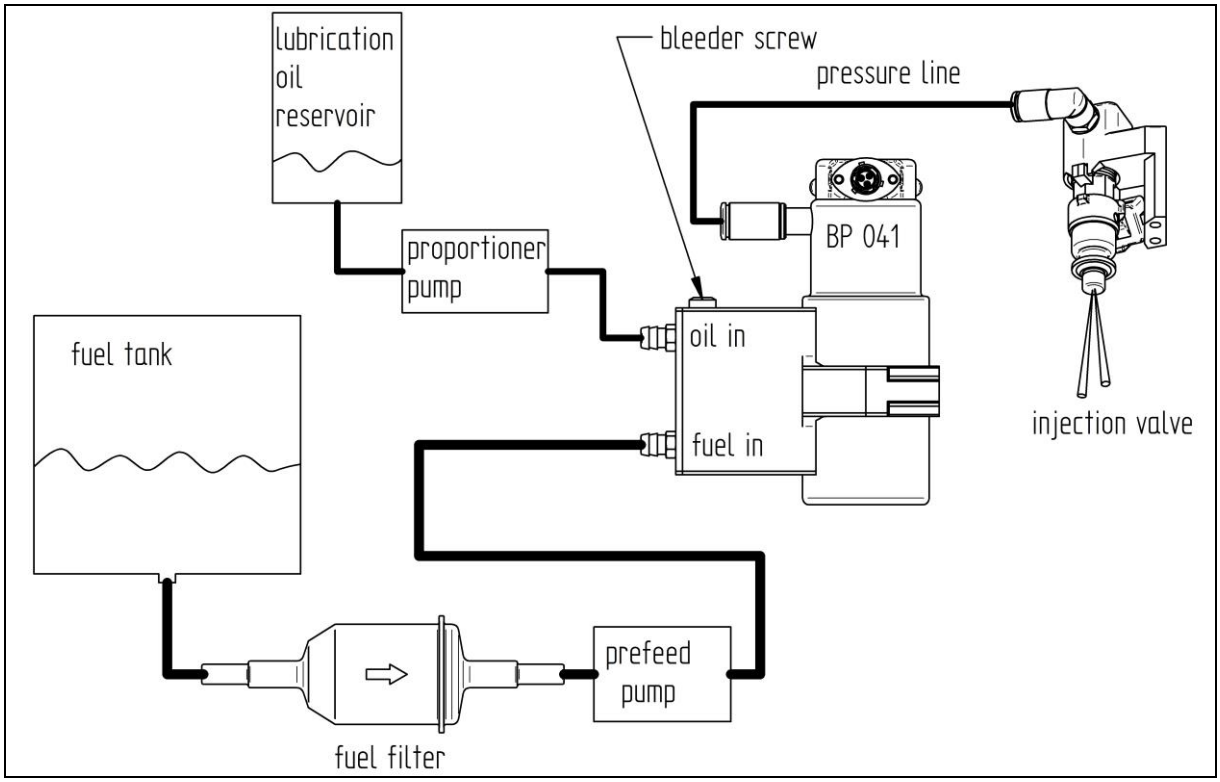


Figure 14: Fuel oil mix system pre feed pump

8 Board power definition

8.1 *Board power supply*

48V Battery
20Ah min. Capacity

The board supply has to be connected to Connector C7 pin 1 to 4 (see Table 10).

Parameter	min.	Typ.	max.	Unit
Board supply voltage	11.5	13.4	14.5	Vdc
Board supply current			5	A
Board supply voltage ripple at max load			0.1	V

Table 2: Board supply parameter

A 12V DC/DC converter is recommended to supply board net of the combustion engine system. The DC/DC converter should be able to source 5A continuous output current.

8.2 *Starter generator supply*

The starter generator controller has to be connected to a 48V battery pack. The capacity and the peak current of the battery have to be at least big enough to start the combustion engine. In an application where the combustion engine gets boosted by the electrical motor, the battery pack must have a bigger capacity.

Parameter	min.	Typ.	max.	Unit
Starter generator controller supply voltage	20	48	75	Vdc
Current consumption during engine start		30A	50A	A
Current duration during engine start		5	7	s
Min. battery capacity		10		Ah
Generator mode continuous charge current		20	40	A
Generator mode peak charge current			100	A

Table 3: Starter generator supply parameter

8.2.1 Engine start

The following chart shows the drawn battery current during a normal engine start. During cold start the maximum battery current can be up to 50A.

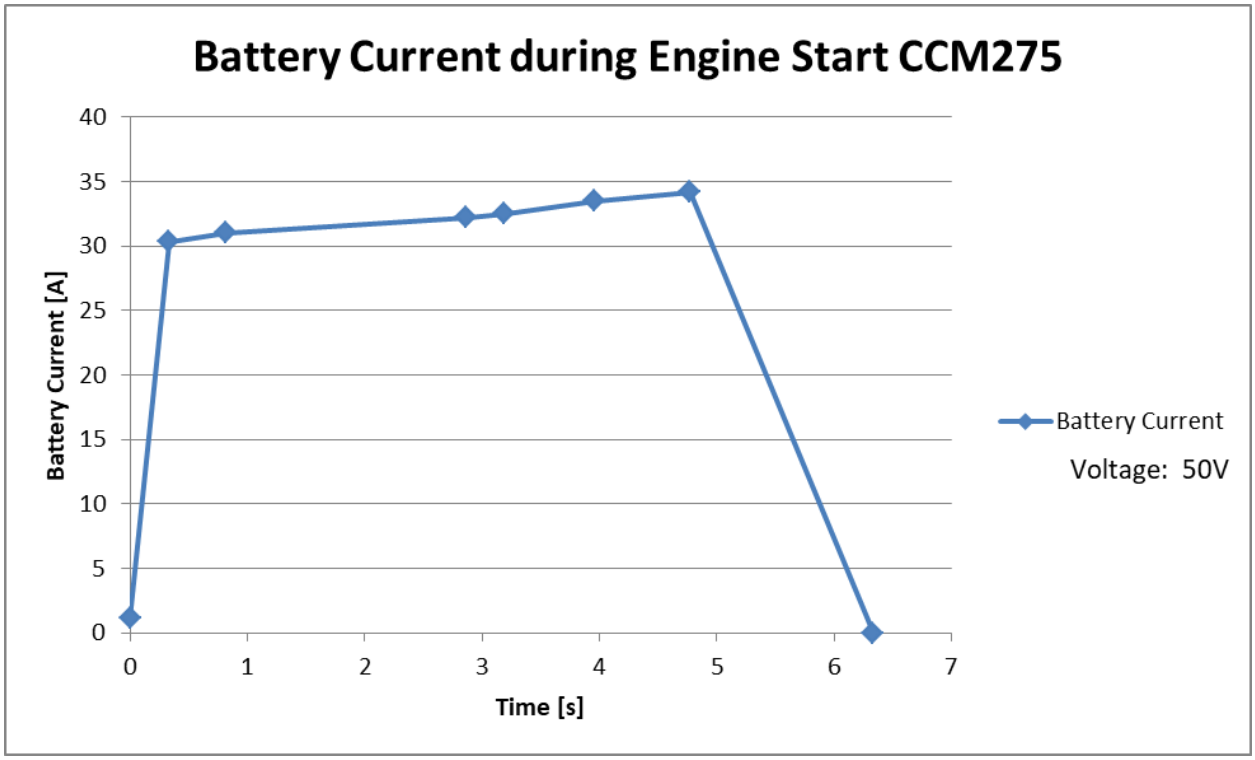


Figure 15: Battery current during engine start

8.2.2 Generator mode

During operation of the combustion engine, the generator is able to charge the 48V battery pack. A DC/DC converter (48V to 12V) can be connected to the battery to supply the board system.

9 Wiring schematic

9.1 *Overview wire harness*

The illustrates an overview of the wire harness. The ECU 030 is connected to the engine with the wire harness KS 557. The SGC 352 is connected with the wire harness KS 569 to the engine. The starter generator sensors are directly connected to the SGC 352. The customer is able to connect the 12VDC power supply, the user control unit and the fuel pump to the wire harness KS 558. The 48V-power source is connected with a Anderson Power connector, the connection harness includes a fuse socket.

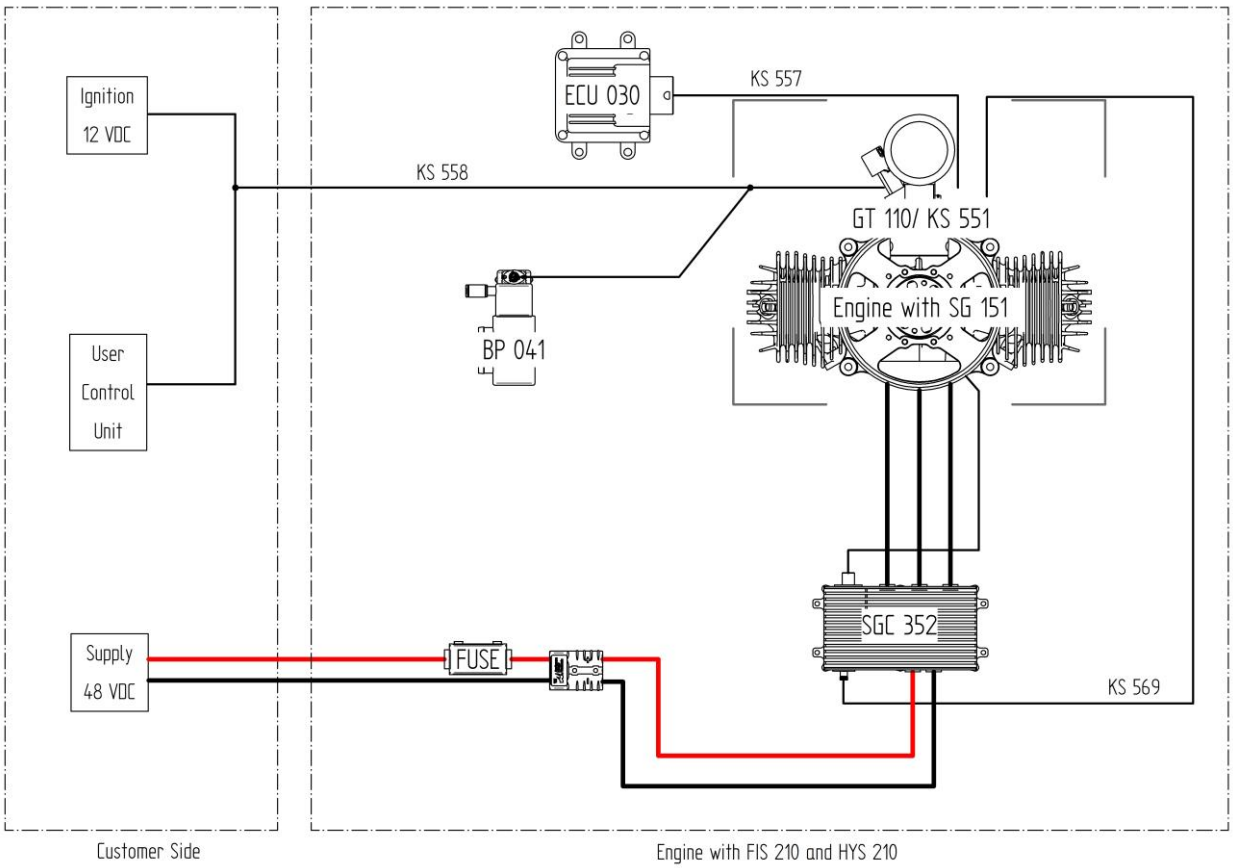


Figure 16: Wire harness overview

Attention: SGC 352 and Ignition module with control cables must be mounted at a distance of approx. 500 mm.
A ground connection between SGC 352 and the engine has to get installed.

9.2 Wire harness KS 557

The wire harness KS 557 connects the ECU 030 with the equmitent carrier plate GT 110.

9.3 Wire harness KS 558

The KS 558 is the customer connections wire harness. Figure 17 shows the schematics. The 12VDC power supply has to be connected to connector C7 pins 1 to 4. The CAN communication signals has to be connected to pin 5 and 6. The user control unit must have an integrated 120Ω termination resistor. Pin 9 to 11 can be used for engine control with analog control signal. Pin 12 and 13 are resvered. The fuel pump has to be connected to connector C12.

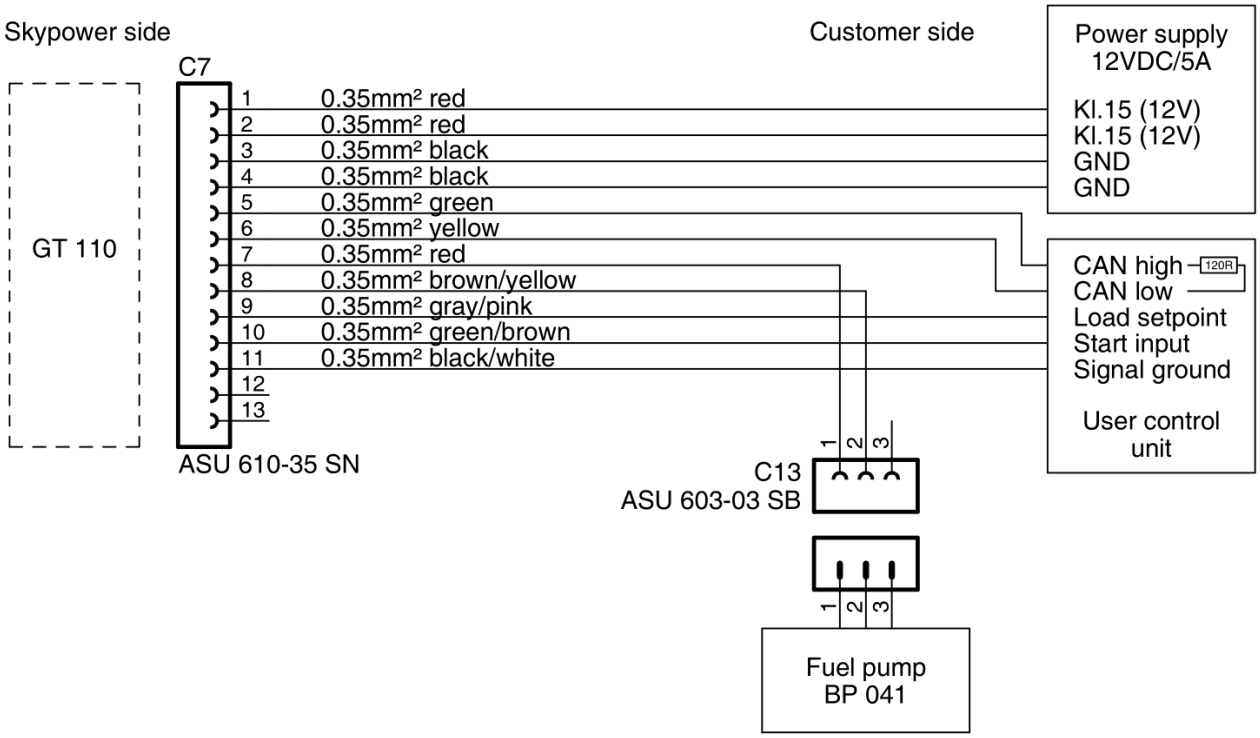


Figure 17: KS 558 customer connections wire harness schematics

9.4 Wire harness KS 551 / GT 110

Figure 18 shows the equiment carrier plate GT 110 with integrated wire harness KS 551. The KS 551 is the interface between all sensors, throttle, injection valve and ignition units. The ECU 030 is connected to the central plug A1 with the wire harness KS 557. The customer supply wire harness KS 558 is connected to the connector C7. The hybrid system wire harness KS 559 is connected to connector C12.

The exhaust gas temperature sensors is connected to C3 and C10 (orange marked). The engine temperature sensors are connected to C2 and C9 (blue marked). The speed sensor is connected to C6 (green marked). The air temperature sensor is connected to C5 (yellow marked).

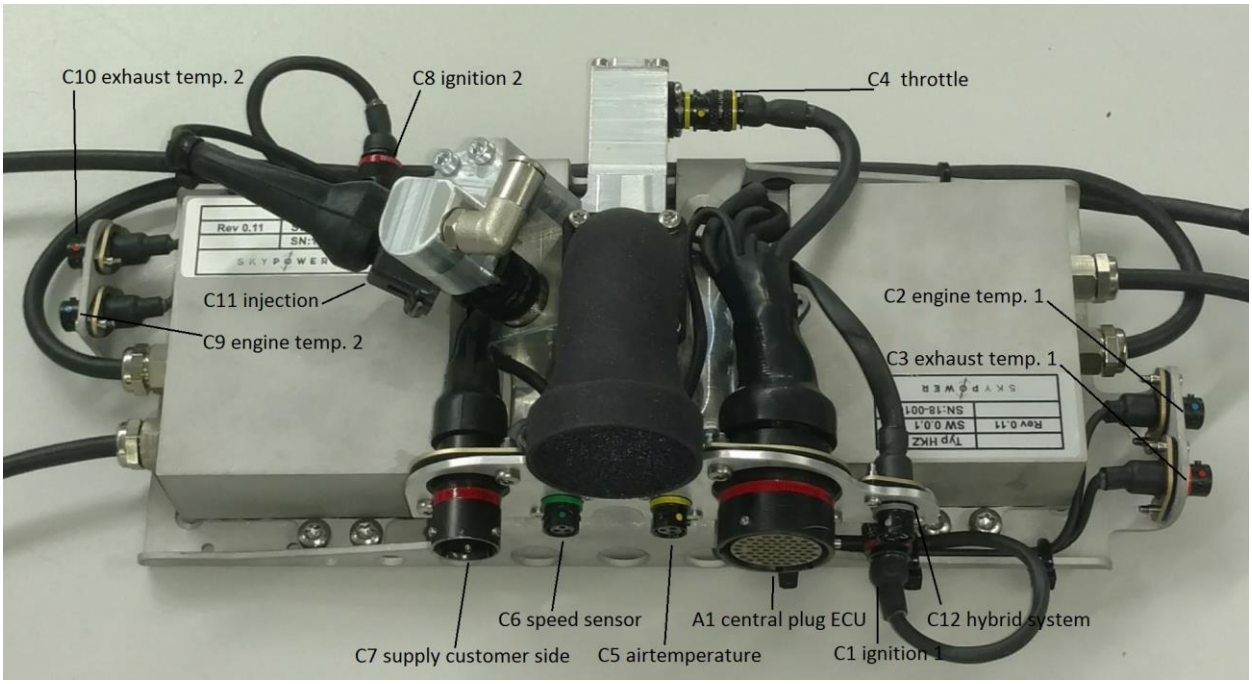


Figure 18: GT 110 / KS 551 connector discription

9.5 *Pin assignment*

This chapter lists all pin assignments of all connectors in all wire harness.

PIN	Function	Color	Connector 55-pol.
1	Kl.15 (12V)	red	A1/ 7
2	GND	black	A1/ 8
3	N/C		
4	signal 1	gray	A1/ 9
5	signal 2	white/purple	A1/ 10

Table 4: Ignition coil 1 C1

PIN	Function	Color	Connector 55-pol.
1	signal ht 1	red/yellow	A1/ 3
2	signal GND ht	black/white	A1/ 4
3	N/C		

Table 5: Head temperature 1 C2

PIN	Function	Color	Connector 55-pol.
1	signal egt 1	pink/blue	A1/ 24
2	signal GND egt	black/white	A1/ 25
3	N/C		

Table 6: Exhaust gas temperature 1 C3

PIN	Function	Color	Connector 55-pol.
1	n/c		
2	CAN High	green	A1/ 43
3	supply +5V	purple	A1/ 16
4	signal GND	black	A1/ 17
5	CAN Low	yellow	A1/ 44

Table 7: Throttle C4

PIN	Function	Color	Connector 55-pol.
1	signal	white	A1/ 1
2	signal GND	black/white	A1/ 2
3	N/C		

Table 8: Air temperature C5

PIN	Function	Color	Connector 55-pol.
1	+5V	purple	A1/ 21
2	signal	yellow	A1/ 22
3	signal GND	black/white	A1/ 23

Table 9: Engine speed C6

PIN	Function	Color	Connector 55-pol.
1	Kl.15 (12V)	red	A1/ 28
2	Kl. 15 (12V)	red	A1/ 29
3	GND	black	A1/ 30
4	GND	black	A1/ 31
5	CAN high	green	A1/ 32
6	CAN low	gelb	A1/ 33
7	+12V fuel pump	red	A1/ 34
8	switched GND fuel pump	brown/yellow	A1/ 35
9	load setpoint analog	gray/pink	A1/ 36
10	start input	green/brown	A1/ 37
11	signal ground	black/white	A1/ 38
12	N/C		
13	N/C		

Table 10: Supply C7

PIN	Function	Color	Connector 55-pol.
1	Kl.15 (12V)	red	A1/ 11
2	GND	black	A1/ 12
3	N/C		
4	signal 1	green/yellow	A1/ 13
5	signal 2	gree/white	A1/ 14

Table 11: Ignition coil 2 C8

PIN	Function	Color	Connector 55-pol.
1	signal	brown	A1/ 5
2	Signal GND	black/white	A1/ 6
3	N/C		

Table 12: Head temperature 2 C9

PIN	Function	Color	Connector 55-pol.
1	signal	gray/yellow	A1/ 26
2	signal GND	black/white	A1/ 27
3	N/C		

Table 13: Exhaust gas temperature 2 C10

PIN	Function	Color	Connector 55-pol.
1	signal	pink	A1/ 19
2	Kl.15 (12V)	red	A1/ 20

Table 14: Injection valve C11

PIN	Function	Color	Connector 55-pol.
1	Kl. 15 (12V)	red	A1/ 39
2	GND	black	A1/ 40
3	CAN high	green	A1/ 41
4	CAN low	yellow	A1/ 42
5			

Table 15: Hybrid system C12

PIN	Function	Color	Connector 55-pol.
1	Kl. 15 (12V)	red	C7/ 7
2	switched GND fuel pump	brown/yellow	C7/ 8
3	N/C		

Table 16: Fuel pump C13

For older GT110 versions with serial CAN servo:

PIN	Function	Color	Connector 55-pol.
1	signal	Brown	A1/ 15
2	N/C		
3	supply +5V	Red	A1/ 16
4	signal GND	Black	A1/ 17
5	shielding	-	A1/ 18

Table 17: Throttle C4 (Serial Servo)

9.6 Wire harness plug part numbers

Plug	Function	Typ	Pole	Manufacturer	Part number
C1	ignition coil 1	socket	5	deutsch	ASU 603-05 SN
C2	head temperature 1	socket	3	deutsch	ASX 002-03 SC
C3	exhaust gas temperature 1	socket	3	deutsch	ASX 002-03 SB
C4	throttle	socket	5	deutsch	ASX 602-05 SA
C5	air temperature	socket	3	deutsch	ASX 002-03 SA
C6	engine speed	socket	3	deutsch	ASX 002-03 SD
C7	supply	pin	13	deutsch	AS 610-35 PN
C8	ignition coil 2	socket	5	deutsch	ASU 603-05-SN
C9	head temperature 2	socket	3	deutsch	ASX 002-03 SC
C10	exhaust gas temperature 2	socket	3	deutsch	ASX 002-03-SB
C11	injetion valve	socket	2	Tyco	
C12	hybrid system	socket	3	deutsch	ASX 002-06 SE
C13	fuel pump	socket	3	deutsch	ASU 603-03 SB
A1	central plug	socket	55	deutsch	AS 016-35 SN

Table 18: Connector part numbers

9.7 Cable description

Cable cross section
0,35mm²

Conductor
Soft-annealed electrolytic copper Cu-ETP1 occ. to DIN EN 13602, bare.
Structure of conductor occ. to ISO 6722.

Insulation
Soft PVC with properties occ. to ISO 6722, class B,
Lead free.

Special characteristics
Temperature range: -40°C……. +105°C

Standards and specifications
BMW GS 95007-1, VW 60306, DBL 6312/ MB 22014,
Ford WSK 1A348-A2, LV112, MAN 3135, Bosch 5 998 340…,
FIAT 91107/ 13, FIAT 91107/ 18

10 Sensors

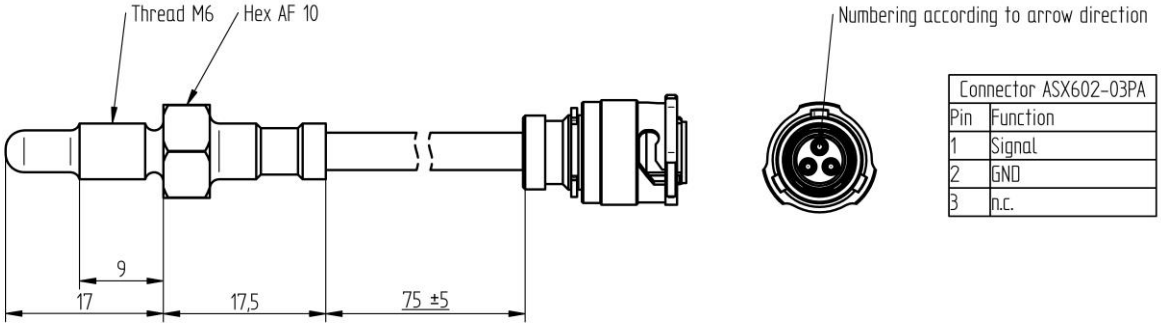
10.1 RPM

The rpm sensor is a hall effect sensor HS155 (part nr.: 90180014) and collects the 18-1 trigger signal of the trigger wheel. It is mounted on a special adapter bracket (part nr.: 90180081) on the front of the crank case.

(200mm ASX602-03PD).

10.2 Air Temperature

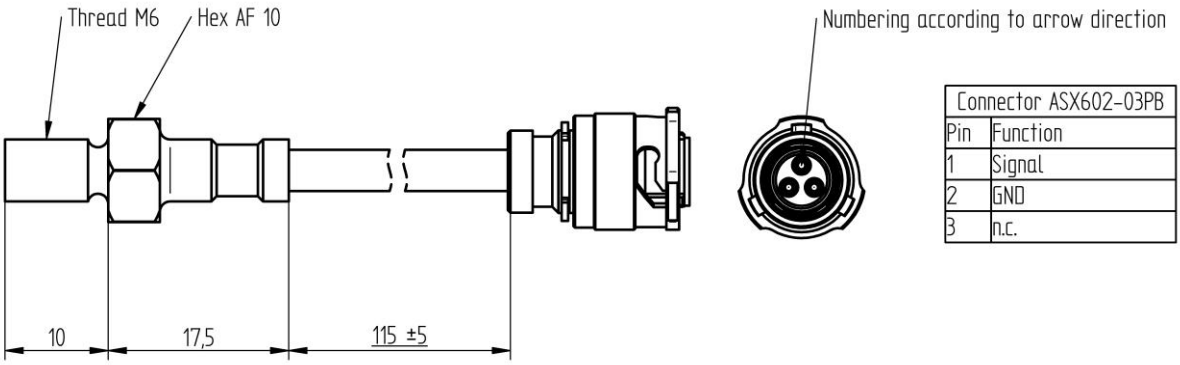
The air temperature sensor NTC135 (part nr.: 9017085) is a NTC thermistor with enclosed tip.



Parameter	Typ.	Unit	Comment
Dimension	see **Fehler! Verweisquelle konnte nicht gefunden werden.**	mm	
Weight		g	
Resistance	1800Ω @ 25°C		
Sensor element	NTC		
Temperature range	-50…+150°C	°C	
Material Sensor	stainless steel		
Material Cable	Silicone		
Max. temp. cable	180	°C	

10.3 *Engine temperature sensor*

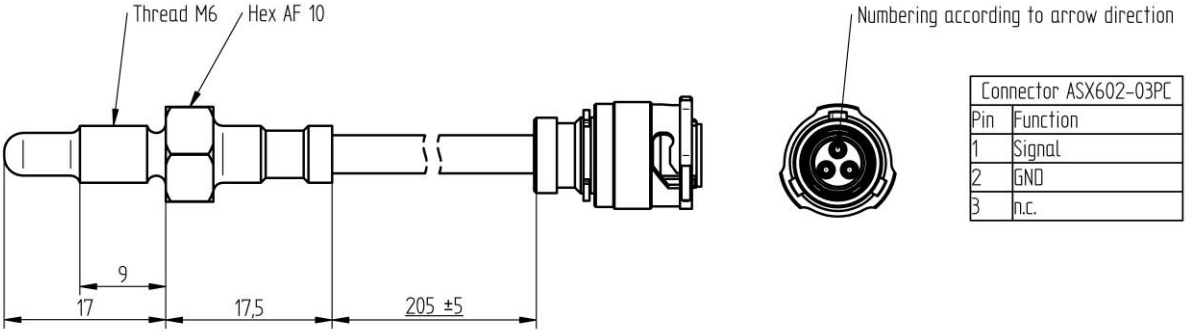
The engine temperature sensor PT405 (part nr.: 90200068) is a PTC thermistor with enclosed tip.



Parameter	Typ.	Unit	Comment
Dimension	see **Fehler! Verweisquelle konnte nicht gefunden werden.**	mm	
Weight		g	
Resistance	1000Ω @ 0°C		
Sensor element	PT		
Temperature range	-50…+400°C	°C	
Material Sensor	stainless steel		
Material Cable	Glass fibre/braided steel		
Max. temp. cable	400	°C	

10.4 *Exhaust gas temperature sensor*

The exhaust gas temperature sensor AGT610 (part nr.: 90200067) is a PTC thermistor with enclosed tip.



Parameter	Typ.	Unit	Comment
Dimension	see **Fehler! Verweisquelle konnte nicht gefunden werden.**	mm	
Weight		g	
Resistance	1000Ω @ 0°C		
Sensor element	PT		
Temperature range	-50…+600°C	°C	
Material Sensor	stainless steel		
Material Cable	Glass fibre/braided steel		
Max. temp. cable	400	°C	

11 Ignition system

11.1 HKZ 218

The HKZ 218 (part nr.: 90200083) is a Capacitor Discharger Ignition unit with 2 individually controlled channels.

11.2 Spark plugs

The spark plugs are M10 resistor spark plugs with Hex AF 16.

12 Starter generator system

12.1 SG151

The starter generator 151 is a brushless DC generator with an stator diameter of 150mm.

12.2 SGC 352

The starter generator controller 352 (SGC 352) is an advanced brushless motor speed controller with following features:

- Advanced combustion engine start
- Generator mode with battery charging
- Trapezoidal communtation with hall sensors (BLDC)
- Input voltage 20V-75V
- Over current protection
- Over/under-voltage shutdown
- Temperature derating
- PWM control
- Phase current control
- Battery current control
- RPM control

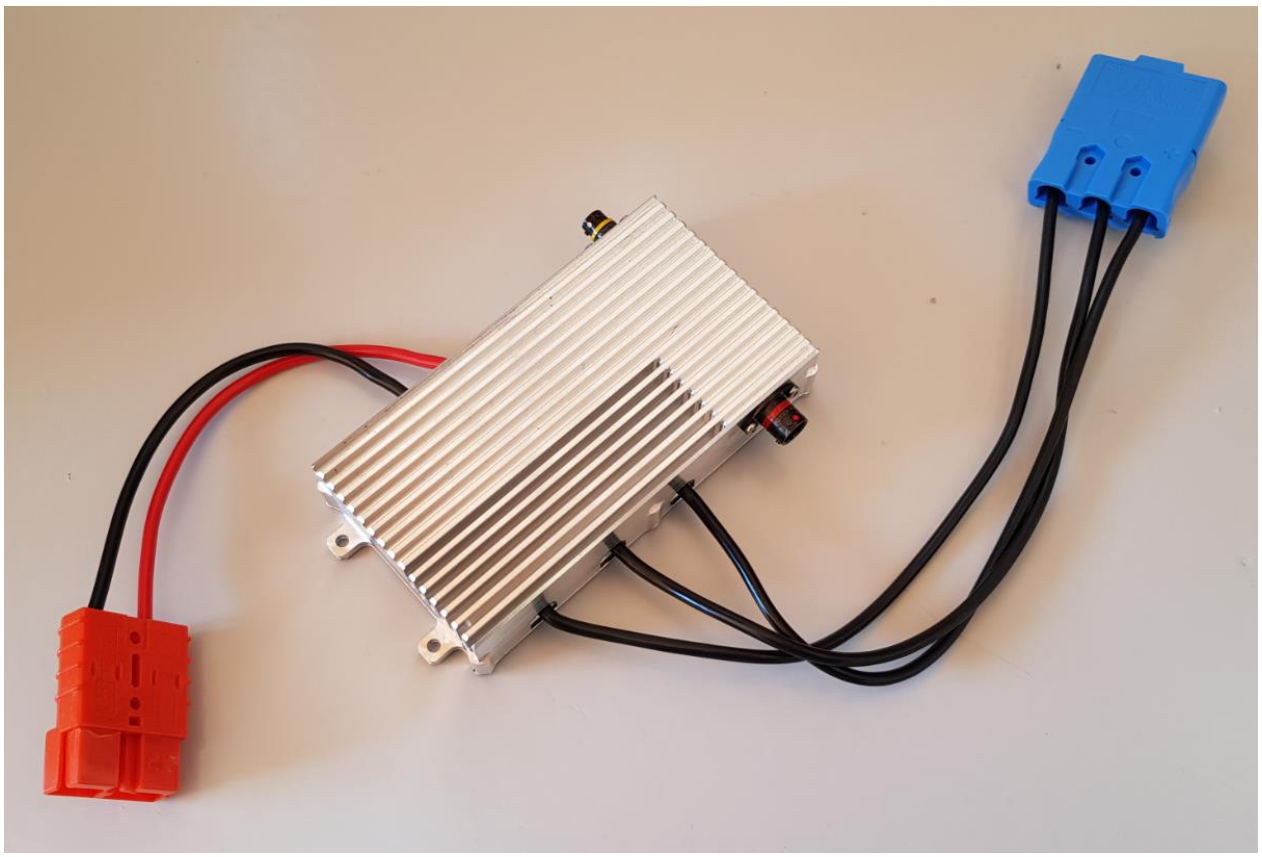


Figure 19: Picture of SGC 352

Inputs

- CAN 2.0A 500 kBit
- Digital input (motor start)
- Optional analog or PPM input (user configurable)
- Enable input (KL15, ignition key)
- PC control / configurator and programing software (GUI)

Control Modes

- PWM-Mode
- Phase Current-Mode
- Battery Current-Mode
- RPM-Mode
- Engine start
- Battery charging

Sensors

- HALL sensors for 120° block commutation
- Motor temperature sensor
- 3x MOSFET temperature sensors
- 3x Phase current shunt sensors
- Battery current sensor

Pin	Description	Signal	V_{DC} [V]	Color
1	Battery +		20-75	Red
2	Battery -		0	Black

Table 19: Power connector Anderson SB50A orange

Pin	Description	Signal	V_{DC} [V]	Color
1	Motor output 1	Out 1	20-75	Black
2	Motor output 2	Out 2	20-75	Black
3	Motor output 3	Out 3	20-75	Black

Table 20: Motor connector Anderson SBS75G blue

Pin	Description	Signal	V_{DC} [V]	function
1	Motor temperature ground	T-Mot GND	0	Black
2	Motor temperature sensor	T-Mot	0-5	Green
3	Hall sensor input 1	Hall 1	0-5	Yellow
4	Hall sensor input 2	Hall 2	0-5	Blue
5	Hall sensor input 3	Hall 3	0-5	Grey
6	Signal ground	GND	0	Brown
7	Sensor supply 5V	+5V	5	Violet
8	-			
9	-			

Table 21: Motor sensor connector Deutsch ASDD006-09SN

Pin	Description	Signal	V_{DC} [V]	function
1	Ignition	Ignition	12-75V	Red
2	GND	GND	0	Black
3	CAN High	CANH	0-5	Green
4	CAN Low	CANL	0-5	Yellow
5	Input 1	IN1	0-5	Orange/black
6	Input 2	IN2	0-5	Yellow/blue

Table 22: Control connector Deutsch ASX026-PE

Discription	ID	min.	Typ.	max.	Unit
Battery voltage	U_{bat}	20	48	75	V
Continuous phase current	I_{eff}		100		A
Peak phase current	I_{peak}		350		A
Power loss			Tbd.		W
Switching frequency	f	20	40	40	kHz
Over voltage threshold		20		75	V
Input fuse			100		A
DC link capacity	C		2900		µF
Weight (incl. power cable and connectors)			500		g

Table 23: Technical data

Discription	ID	min.	Typ.	max.	Unit
Operating temperature	T_{amb}	-40		+85	°C
Lagertemperatur Bereich	T_{Lager}	-40		+85	°C
Protection housing			IP64		
Protection power connectors			IP21		
Vibration			tbd.		

Table 24: Environmental conditions

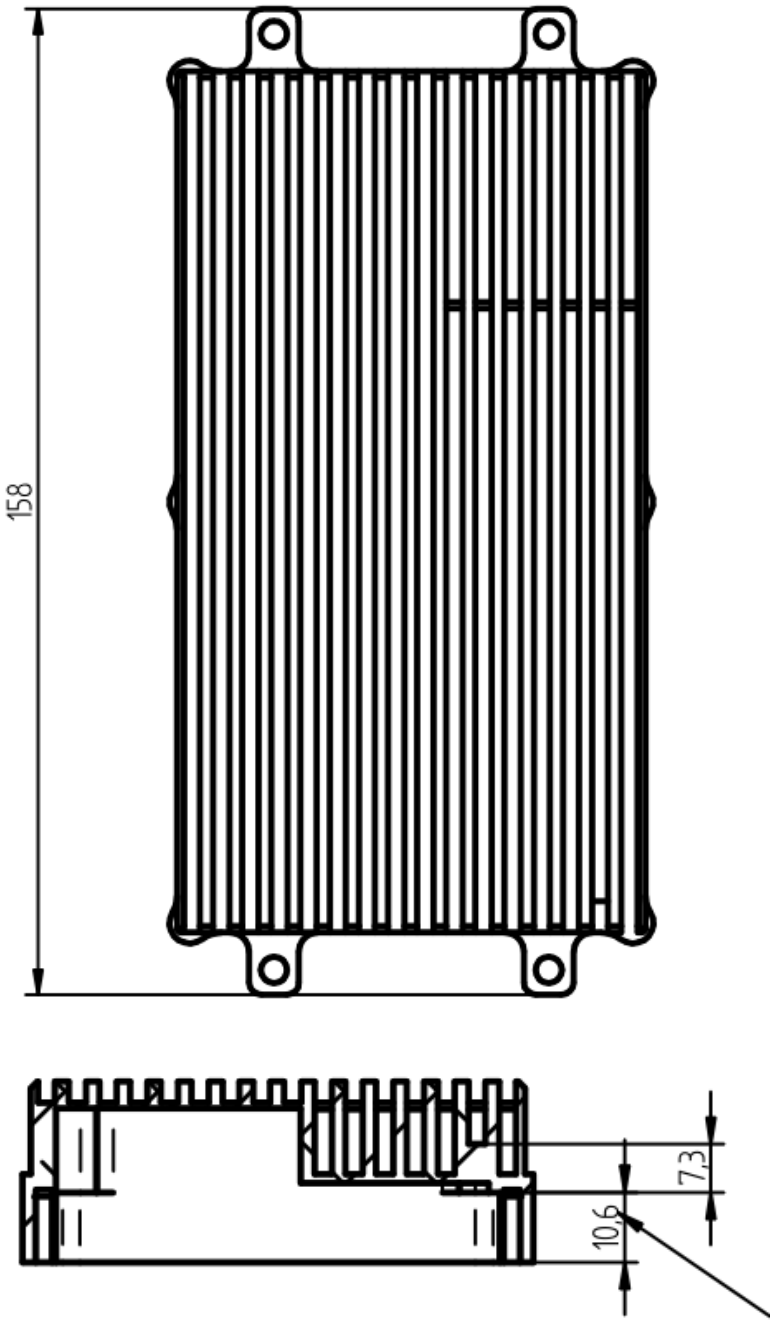


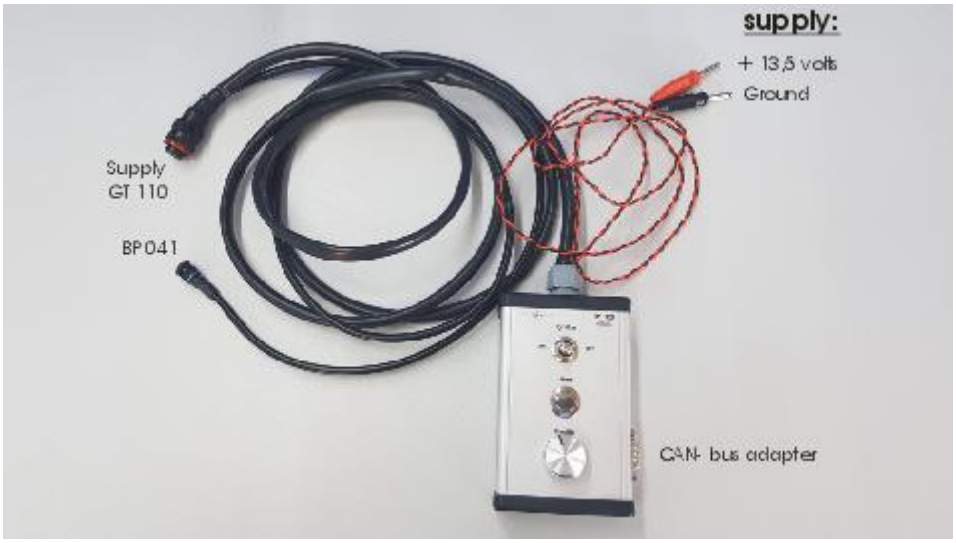
Figure 2: Mechanical dimensions of SGC 352 Dimensions (HxWxD): 158x75x27,5mm

13 ECU 030

The ECU is the control unit for the complete system. Main task ist to control injection and ignition of the SP275 and monitore all temperatures but it also controls the SGC 352 or the KHU100. It has an 48-Pin Connector. More information about the ECU030 can be found in the corresponding data sheet.

14 Control Panel TP100

With the test panel TP100 (part nr.: 90200064) the engine can be easily tested and operated without beeing connected to the aircraft harness. The red and black wire of the TP100 need to be connected to a 10A @ 12V (11,5-14,5V) power supply. The 13-pin Deutsch connector connects to C7 of the harness on the equipment carrier. The 3-pin Deutsch connector connects to the fuel pump BP041. On the side of the TP100 is a 9-pin sub-D connector where the CAN-bus adapter can be plugged in to connect the system to the Unical for diagnosis.
To start the engine with the TP100 the ignition must be switched on. By pushing the “Start” button the SG151 starts the engine. When the engine is running the throttle can be controlled by the poti “Throttle”. To stop the engine the ignition must be switched off.



15 Operation and Maintenance Instructions

15.1 Pre start checks

Before starting the engine the following checks must be done:

Oillevel for fuel mix (systems with separate oil and fuel tanks)
Wiring harness if there are damaged wires
Spark plugs
Airfilter

15.2 Maintenance schedule

Fasten all mounting hardware
Spark plugs

15.3 Troubleshooting

16 Functional description

16.1 Start / stop function

The combustion engine can be started as well as stopped via CAN bus commands. See CAN Bus communication specification for details.

- Starting the combustion engine:

The combustion engine is cranked by the starter generator by the time the ECU receives a specific trigger information on the CAN bus. With the reception of the start command the ECU executes a start function that sets the SG control current for a certain time according to a start current curve parametrized in the SGC352.

CAN message command:

Default value (byte position 0): 0x00
Start command (byte position 0): 0x0A

CAN ID (hex)	Length	Data (hex)							
0x00000505	8	0A	00	00	00	00	00	00	00

Table 25: Example CAN message engine start command

NOTE:

The start function will only be executed if the system is stopped, i.e. engine speed is zero.
- Stopping the combustion engine:

With sending the specific stop function CAN command injection and ignition of the combustion engine is timed out.

Can message example:

CAN ID (hex)	Length	Data (hex)							
0x00000505	8	00	00	00	00	00	00	00	0A

Table 26: Example CAN msg engine stop command

Default value (byte position 7): 0x00
Stop command (byte position 7): 0x0A

NOTE:

In order to reactivate injection and ignition of the combustion engine the stop command byte has to be replaced by the default value (0x00).

16.2 Ignition test function

The combustion engine control unit provides the possibility to test the ignition when the engine is running. The working principle of this function is to shut off the ignition for a certain ignition output in order to notice a slight drop of the engine speed. Each of the four ignition outputs of the control unit can be tested by a specific CAN command.

The following tables give an example how a ignition CAN command looks like:

CAN ID (hex)	Length	Data (hex)							
0x00000504	8	XX	00	00	00	00	00	00	00

Table 27: Example CAN message ignition test function

Ignition output #	Bit
1	0
2	1
3	2
4	3

Table 28: Overview spark plug number ignition test

Example ignition test function commands:

Default value: XX = 0x00
Shut off ignition output one: XX = 0x01
Shut off ignition output two: XX = 0x02
Shut off ignition output three: XX = 0x04
Shut off ignition output four: XX = 0x08

NOTE:

The default value of Byte XX is 0x00 for regular operation.

16.3 Charge management

The Starter Generator produces electrical power to charge batteries by braking the combustion engine. Therefore the ECU controls the charge current via charge current map. In this map the brake control current (-A) can be parametrized depending on the combustion engine speed and the actual supply voltage level of the starter generator.

Basically the higher the brake current (-A) the more electrical power is produced by the generator, but the available combustion engine power at certain working points has to be considered when adapting the brake current.

As Table 29 shows the current parametrization of the charge current provides at least 2kW electrical power for engine speeds greater than 3600 rpm. At lower engine speeds the control current is reduced in order to prevent stalling of the combustion engine due to its lower power at lower engine speeds.

The current configuration of the charge current curve also prevents the system from overcharging and damaging the batteries as the maximum control current (-A) is decreasing with increasing supply voltage level (see Figure 20).

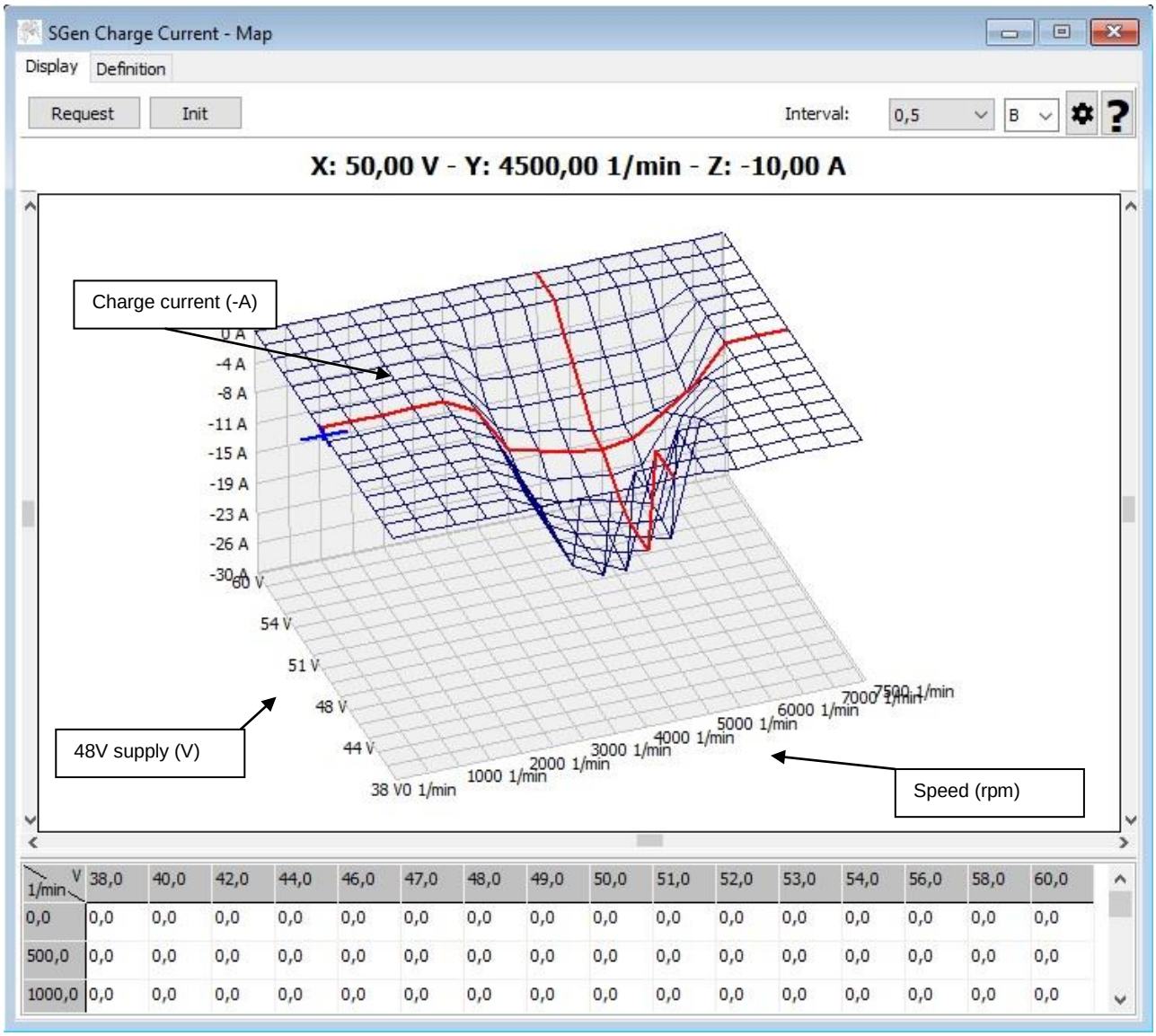


Figure 20: Generator charge map

SPEED	TORQUE	ENGINE POWER	MAX. CURRENT	MAX. E POWER
[RPM]	[Nm]	[KW]	[-A]	[eKW]
				@48V
2500	idle	-	0	0
2600	idle	-	0	0
2800	idle	-	0	0
3000	9,5	2,98	20	1,0
3400	9,5	3,38	35	1,7
3600	9,5	3,58	43	2,1
4000	9,5	3,98	48	2,3
4500	11	5,18	50	2,4
5000	11	5,76	50	2,4
5500	12	6,91	50	2,4
6000	12	7,54	50	2,4

Table 29: performance table combustion engine / SG

NOTE :

Wrong parametrization of the charge control current may lead to overcharging and damaging the batteries.

16.4 *Thermal limitation functions*

Thermal limitation functions serve as safety functions for the combustion engine as well as the starter generator unit to prevent damage due to overheating. These internal functions reduce either the maximum allowed load or the maximum allowed control current (charge current [-A]).

The following safety functions are implemented as characteristic curves in the ECU:

- max. allowed load depending on combustion engine temperature:

If the temperature of one of the cylinder heads gets to high the maximum allowed load will be limited in order to decrease the head temperature. This function also limits the maximum allowed load if the combustion engine temperature is below a specific value during warm up phase.

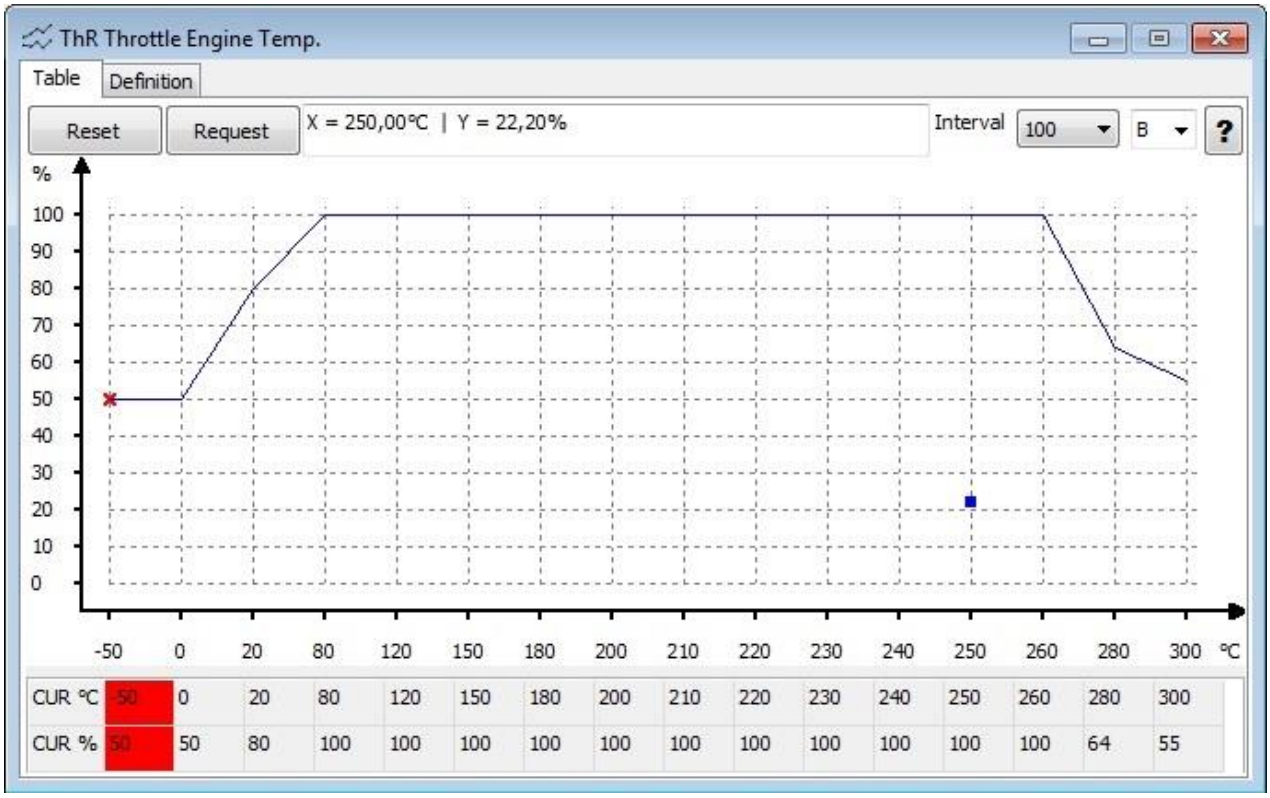


Figure 21: Thermal limitation load via engine temperature

- max. allowed brake control current depending on combustion engine temperature:

  If the temperature of one of the cylinder heads gets to high the brake control current will be reduced in order to decrease the engine temperature.

- max. allowed brake current depending on SG temperature:

  If the SG temperature gets to high the brake control current will be reduced in order to decrease the temperature of the electric motor.

- max. allowed brake current depending on SGC temperature:

  If the temperature of the Starter Generator Control Unit gets to high the brake control current will be reduced.

NOTE:

Thermal limitation flags indicate active limitation functions. See following section 8.5 for further details.

16.5 Status / error flags

16.5.1 Thermal limitation flags

Thermal limitation flags indicate that a specific parameter (load or SG control current) is limited due to overheating of components of the system. Following tables in this section give an overview on the different flags.

- Thermal limitation flags LOAD:

CAN ID (hex)	Length	Data (hex)							
0x00000107	8	00	00	XX	00	00	00	00	00

Table 30: Example CAN msg therm. limitation flags load

Flag description	Affected parameter	Bit
head temperature 1	load	0
head temperature 2	load	1

Table 31: Thermal limitation load flags

Limitation function inactive: 1
Limitation function active: 0

(Firmware Revision < 045 : Limitation function inactive: 0; Limitation function active: 1)

Example:

Head temperature 2 limitation active:

XX = 0xFD (0b11111101)

(Firmware Revision < 045: XX = 0x02 (0b00000010))

- Thermal limitation flags CONTROL CURRENT SG:

CAN ID (hex)	Length	Data (hex)							
0x00000107	8	00	00	00	YY	00	00	00	00

Table 32: Example CAN msg therm. limitation flags control current SG

Flag description	Affected parameter	Bit
head temperature 1	control current SG	0
head temperature 2	control current SG	1
SG temperature	control current SG	2
SGC temperature	control current SG	3

Table 33: Thermal limitation phase current flags

Limitation function inactive: 1
Limitation function active: 0

(Firmware Revision < 045 : Limitation function inactive: 0; Limitation function active: 1)

Example:

SG temperature limitation active:

YY = 0xFB (0b11111011)

(Firmware Revision < 045: YY = 0x04 (0b00000100))

16.5.2 Sensor error flags

CAN ID (hex)	Length	Data (hex)							
0x00000107	8	XX	00	00	00	00	00	00	00

Table 34: Example CAN msg sensor error flags

Flag description	Bit
head temp sensor 1 error	0
head temp sensor 2 error	1
exhaust temp sensor 1 error	2
exhaust temp sensor 2 error	3
air temp sensor error	4
air pressure sensor error	5

Table 35: Sensor error flags

Sensor error inactive: 1
Sensor error active: 0

(Firmware Revision < 045 : Sensor error inactive: 0; Sensor error active: 1)

Example:

Air temperature sensor error:
XX = 0xEF (0b11101111)

(Firmware Revision < 045: XX = 0x10 (0b00010000))

NOTE:
With single cylinder engines only head/exhaust temp sensor 1 is used.
In case of sensor malfunction the ECU replaces the faulty sensor value with predefined values in order to ensure that the combustion engine keeps running.

17 CAN communication

17.1 *Internal CAN communication*

description	designation	min.	Typ.	Max.	Unit
Baud rate			500		kBit
Terminator in ECU			120		Ohm
Data Frame			Extended		

Table 36: CAN bus specification

Unical communication								
UNI	name	range	unit	factor	time	ID	pos	length
BLOCKED	RX	--	--	--	--	0xA	0	8
	TX	--	--	--	--	0xB	0	8

Table 37: Unical commuication messages

Bootloader communication								
BL	name	range	unit	factor	time	ID	pos	length
BLOCKED	RX	--	--	--	--	0x55	0	8
	TX	--	--	--	--	0x56	0	8

Table 38: Bootloader communication messages

ECU > STG communication					
STG	name	First ID	Last ID	pos	length
BLOCKED	SGC communication block 1	0x01000000	0x01FFFFFF	0	8
	SGC communication block 2	0x0F000000	0x0FFFFFFF	0	8

	SGC communication block 3	0x1F000000	0x1FFFFFFF	0	8

Table 39: SGC communication address blocks

Engine communication								
ENG	**name**	**range**	**unit**	**factor**	**time(ms)**	**ID(hex)**	**pos**	**length**
1	engine speed	0-65535	rpm	1	10	0x100	0	2
	ignition angle	-10,0 - 40	°Crank	10			2	2
	throttle angle	0-90,0	°	10			4	2
	- internal data -	--	--	--			6	2
2	*- internal data -*	--	--	--	10	0x101	0	2
	- internal data -	--	--	--			2	2
	atmosphere air pressure	0-1100	hPa	1			4	2
	- internal data -	--	--	--			6	2
3	ignition gap	-15,0 - 15,0	°Crank	10	10	0x102	0	2
	injection angle	0-360,0	°Crank	10			2	2
	injection time	0-65535	us	1			4	2
	- internal data -	--	--	--			6	2
4	*- internal data -*	--	--	--	10	0x103	0	2
	- internal data -	--	--	--			2	2
	- internal data -	--	--	--			4	2
	- internal data -	--	--	--			6	2
5	supply voltage	0-16,0	V	10	10	0x104	0	2
	- internal data -	--	--	--			2	2
	- internal data -	--	--	--			4	2
	- internal data -	--	--	--			6	2
6	engine temperature head 1	-50,0 - 400,0	°C	10	10	0x105	0	2
	air temperature	-50,0 - 100,0	°C	10			2	2
	exhaust temperature head 1	-50,0 - 700,0	°C	10			4	2
	ecu temperature	-50,0 - 100,0	°C	10			6	2
7	revolution counter	0 - 4294967295	--	1	10	0x106	0	4
	operating time sec	0-59	s	1			4	1
	operating time min	0-59	min	1			5	1
	operating time hour	0 -65535	h	1			6	2
8	Sensor error flags	0-65535	--	1	10	0x107	0	2
	Thermal limitation flags	0-65535	--	1			2	2
	- internal data -	--	--	--			4	2
	- internal data -	--	--	--			6	2
9	*- internal data -*	--	--	--	10	0x108	0	2
	- internal data -	--	--	--			2	2
	- internal data -	--	--	--			4	2
	- internal data -	--	--	--			6	2
10	*- internal data -*	--	--	--	10	0x109	0	2
	- internal data -	--	--	--			2	2

	- internal data -	--	--	--			4	2
	- internal data -	--	--	--			6	2
11	*- internal data -*	--	--	--	10	0x10A	0	2
	- internal data -	--	--	--			2	2
	- internal data -	--	--	--			4	2
	engine target load	0 - 100,0	%	10			6	2
12	*- internal data -*	--	--	--	10	0x10B	0	2
	- internal data -	--	--	--			2	2
	injection valve load	0 - 100,0	%	10			4	2
	injection fuel consumption	0 - 65,535	l/h	1000			6	2
13	*- internal data -*	--	--	--	10	0x10C	0	2
	- internal data -	--	--	--			2	2
	engine temperature head 2	-50,0 - 400,0	°C	10			4	2
	exhaust temperature head 2	-50,0 - 700,0	°C	10			6	2
14	- internal data -	--	--	--	10	0x10D	0	2
	engine current load	0 - 100,0	%	10			2	2
	red factor	0,000 - 2,000	--	1000			4	2
	engine current torque	0,0 - 6553,5	Nm	10			6	2
15	engine current power	0,0 - 655,35	kW	100	10	0x10E	0	2
	- internal data -	--	--	--			2	2
	- internal data -	--	--	--			4	2
	- internal data -	--	--	--			6	2
16	current engine torque icao corrected	0,0 - 6553,5	Nm	10	10	0x10F	0	2
	current engine power icao corrected	0,0 - 655,35	kW	100			2	2
	fuel consumpition icao corrected	0 - 65,535	l/h	1000			4	2
	specific fuel consumption current	0 - 65535	g/kWh	1			6	2
17	MSL engine temperature head 1	-50,0 - 400,0	°C	10	1000	0x110	0	2
	MSL engine temperature head 2	-50,0 - 400,0	°C	10			2	2
	MSL exhaust temperature head 1	-50,0 - 700,0	°C	10			4	2
	MSL exhaust temperature head 2	-50,0 - 700,0	°C	10			6	2
18	specific fuel consumption map	0 - 65535	g/kWh	1	1000	0x111	0	2
	current altitude	0 - 65535	m	1			2	2
	isa altitude	0 - 65535	m	1			4	2
	current altitude feet	0 - 65535	ft	1			6	2
19	densitiy altitude	0 - 65535	ft	1	1000	0x112	0	2
	pressure altitude	0 - 65535	ft	1			2	2
	- internal data -	--	--	--			4	2
	- internal data -	--	--	--			6	2
20	*- internal data -*	--	--	--	10	0x331	0	1
	- internal data -	--	--	--			1	1
	maximum load	0 – 100,0	%	10			2	2
	- internal data -	--	--	--			4	2
	- internal data -	--	--	--			6	2

Table 40: Engine communication messages

Analog input communication								
AI	**name**	**range**	**unit**	**factor**	**time(ms)**	**ID(hex)**	**pos**	**length**
1	analog input 1 voltage	0,000 - 5,000	V	1000	100	0x325	0	2
	analog input 2 voltage	0,000 - 5,000	V	1000			2	2
	analog input 3 voltage	0,000 - 5,000	V	1000			4	2
	analog input 4 voltage	0,000 - 5,000	V	1000			6	2
2	analog input 5 voltage	0,000 - 5,000	V	1000	100	0x326	0	2
	analog input 6 voltage	0,000 - 5,000	V	1000			2	2
	analog input 7 voltage	0,000 - 5,000	V	1000			4	2
	analog input 8 voltage	0,000 - 5,000	V	1000			6	2
3	analog input 9 voltage	0,000 - 5,000	V	1000	100	0x327	0	2
	analog input 10 voltage	0,000 - 5,000	V	1000			2	2
	analog input 11 voltage	0,000 - 5,000	V	1000			4	2
	analog input 12 voltage	0,000 - 5,000	V	1000			6	2
4	analog input 13 voltage	0,000 - 5,000	V	1000	100	0x328	0	2
	analog input 14 voltage	0,000 - 5,000	V	1000			2	2
	analog input 15 voltage	0,000 - 5,000	V	1000			4	2

Table 41: Analog input communication messages

Starter G**enerator communication SGC350/SGC450**								
GEN	**name**	**range**	**unit**	**factor**	**time(ms)**	**ID(hex)**	**pos**	**length**
1	*- internal data -*	--	--	--	100	0x113	0	2
	current output	-450 - 450	A	1			2	2
	- internal data -	--	--	--			4	2
	- internal data -	--	--	--			6	1
	- internal data -	--	--	--			7	1
2	el. motor speed	-32768 - 32767	rpm	1	100	0x114	0	2
	phase current	-327,68 - 327,67	A	100			2	2
	supply voltage	0,00 - 635,35	V	100			4	2
	bridge voltage	0,00 - 635,35	V	100			6	2
3	temperature	-3276,8 - 3276,7	°C	10	100	0x115	0	2
	controller temperature	-3276,8 - 3276,7	°C	10			2	2
	battery current	-327,68 - 327,67	A	100			4	2
	- internal data -	--	--	--			6	2

Table 42: Generator communication messages SGC350/450

Starter G**enerator communication SGC352**								
GEN	**name**	**range**	**unit**	**factor**	**time**	**ID**	**pos**	**length**
1					10ms	0x2E0	0	2
							2	2
	RPM	0 - 65535	rpm	1			4	4
2					10ms	0x2E1	0	2
							2	2
	supply voltage	0 - 75	V	100			4	2
							6	2
3					10ms	0x2E2	0	2
							2	2
							4	2
	MOSFET 1 temperature (controller temp1)	- 50 - 150	°C	10			6	2

4	MOSFET 2 temperature (controller temp2)	- 50 - 150	°C	10	10ms	0x2E3	0	2
	MOSFET 3 temperature (controller temp3)	- 50 - 150	°C	10			2	2
	SG temperature	- 50 - 150	°C	10			4	2
	Battery current	- 300 - 300	A	100			6	2

Table 43: Generator communication messages SGC352

Communication to ECU								
	name	**range**	**unit**	**factor**	**time**	**ID**	**pos**	**length**
1	comb mode	0 - 65535		1	⋮	0x500	0	2
	mode 1: target load mode	0,0 - 100,0	%	10			2	2
	mode 2: tbd	--	--	1			4	2
	mode 3: tbd	--	--	1			6	2
2	mode 4: tbd	--	--	1	⋮	0x501	0	2
	mode 5: tbd	--	--	1			2	2
	mode 6: tbd	--	--	1			4	2
	mode 7: tbd	--	--	1			6	2
3	mode 8: tbd	--	--	1	⋮	0x502	0	2
	mode 9: tbd	--	--	1			2	2
	mode 10: tbd	--	--	1			4	2
	mode 11: tbd	--	--	1			6	2
4	mode 12: tbd	--	--	1	⋮	0x503	0	2
	mode 13: tbd	--	--	1			2	2
	mode 14: tbd	--	--	1			4	2
	mode 15: tbd	--	--	1			6	2
5	Ignition test	0 - 255	--	1	⋮	0x504	0	1
	tbd	--	--	1			1	1
	tbd	--	--	1			2	2
	tbd	--	--	1			4	2
	tbd	--	--	1			6	2
6	Start engine	0 / 10	--	1	⋮	0x505	0	2
	tbd	--	--	1			2	2
	tbd	--	--	1			4	2
	tbd	--	--	1			6	1
	Stop engine	0 / 10	--	1			7	1

Table 44: ECU control messages

17.2 Combustion engine control

The combustion engine can be controlled via CAN Bus. This section describes available control modes and the related CAN commands.

Mode selection:

CAN ID (hex)	Length	Data (hex)							
0x00000500	8	01	00	00	00	00	00	00	00

Table 45: Example CAN msg combustion engine mode

NOTE:

Byte 0x01 represents Torque mode which is currently the only available combustion engine mode.

- **Target load mode (combustion engine mode 1):**

In target load mode the combustion engine is controlled by load set point that adapts the angle of the throttle valve.

Load target minimum value: 0 %
Load target maxmimum value: 100 %
CAN factor: 10

Example load target 59,5 %:

595 (decimal) = 0x0253 (hexadecimal)

CAN ID (hex)	Length	Data (hex)							
0x00000500	8	01	00	53	02	00	00	00	00

Table 46: Example CAN msg load target

- **PPM Load control (combustion engine mode 2) → optional:**

Please refer to attachment 22.1 for further information.

18 Performance data

18.1 Full power performance map SP 275 TS @ MSL (on Dyno)

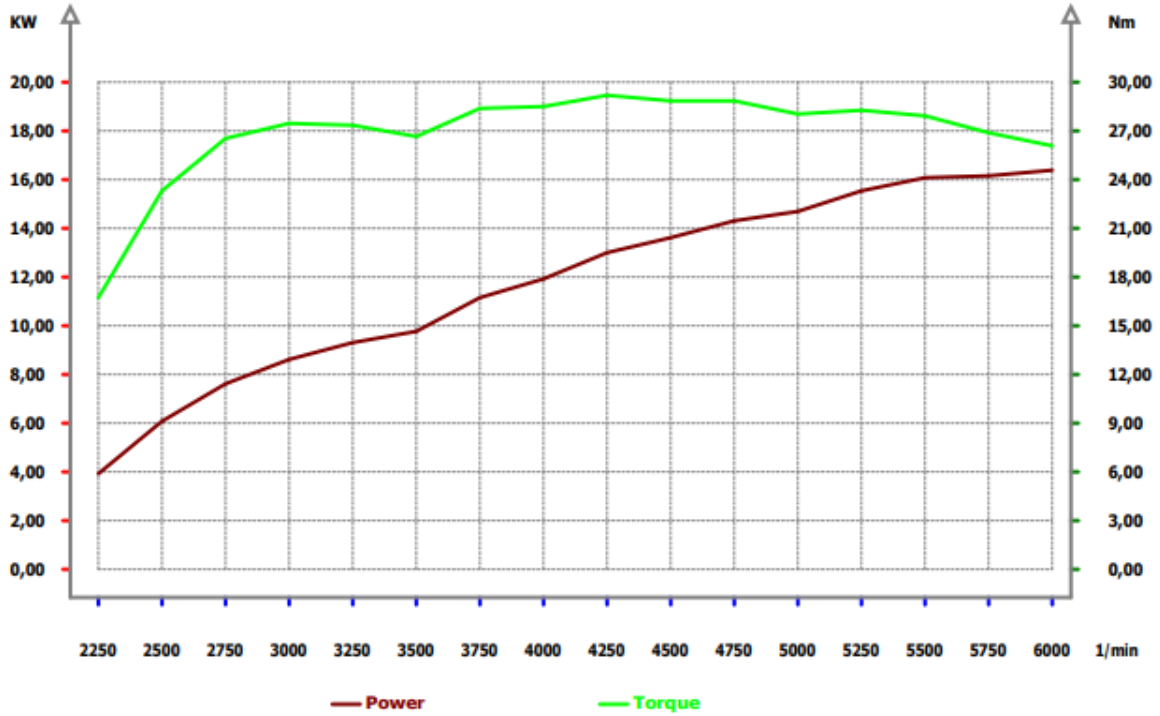


Figure 22: Full power map SP 275 TS (MSL)

RPM	(1/min)	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	5750	6000
Load	(%)	60	80	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Torque	(Nm)	16,71	23,27	26,54	27,45	27,29	26,6	28,42	28,45	29,19	28,86	28,8	28,06	28,28	27,87	26,9	26,07
Power	(kW)	3,92	6,08	7,64	8,61	9,33	9,74	11,15	11,9	12,98	13,59	14,32	14,68	15,54	16,04	16,2	16,37
Consump.	(l/h)	2,934	3,974	5,359	5,881	6,457	6,93	6,783	6,643	7,62	8,635	8,971	9,263	9,508	9,748	10,2	10,78
spec. Consump.	(g/kWh)	561	490	526	512	519	533	456	418	440	476	469	473	458	455	474	494

Table 47: Power data SP 275 TS (MSL)

Test conditions:

Air pressure: 1013hPa

Air temperature: 15°C

19 Mechanics

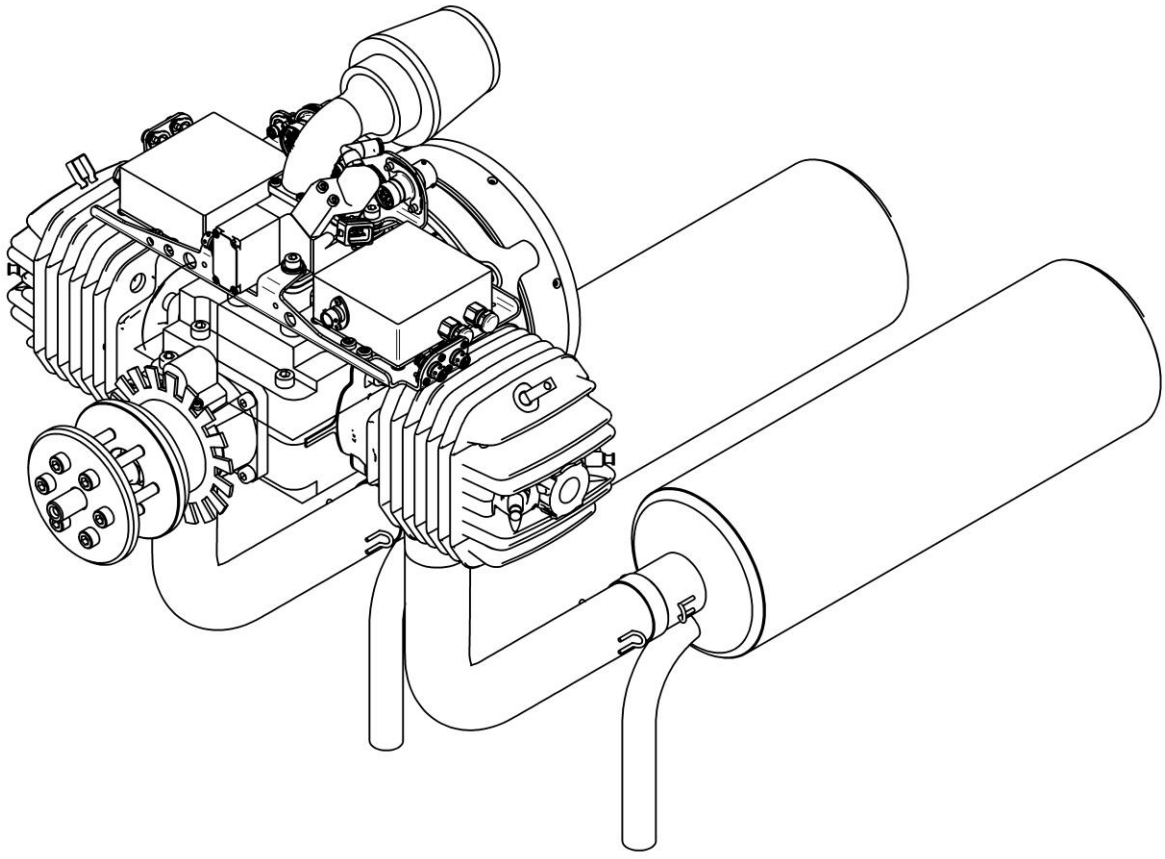


Figure 23: SP 275 complete engine with exhaust system

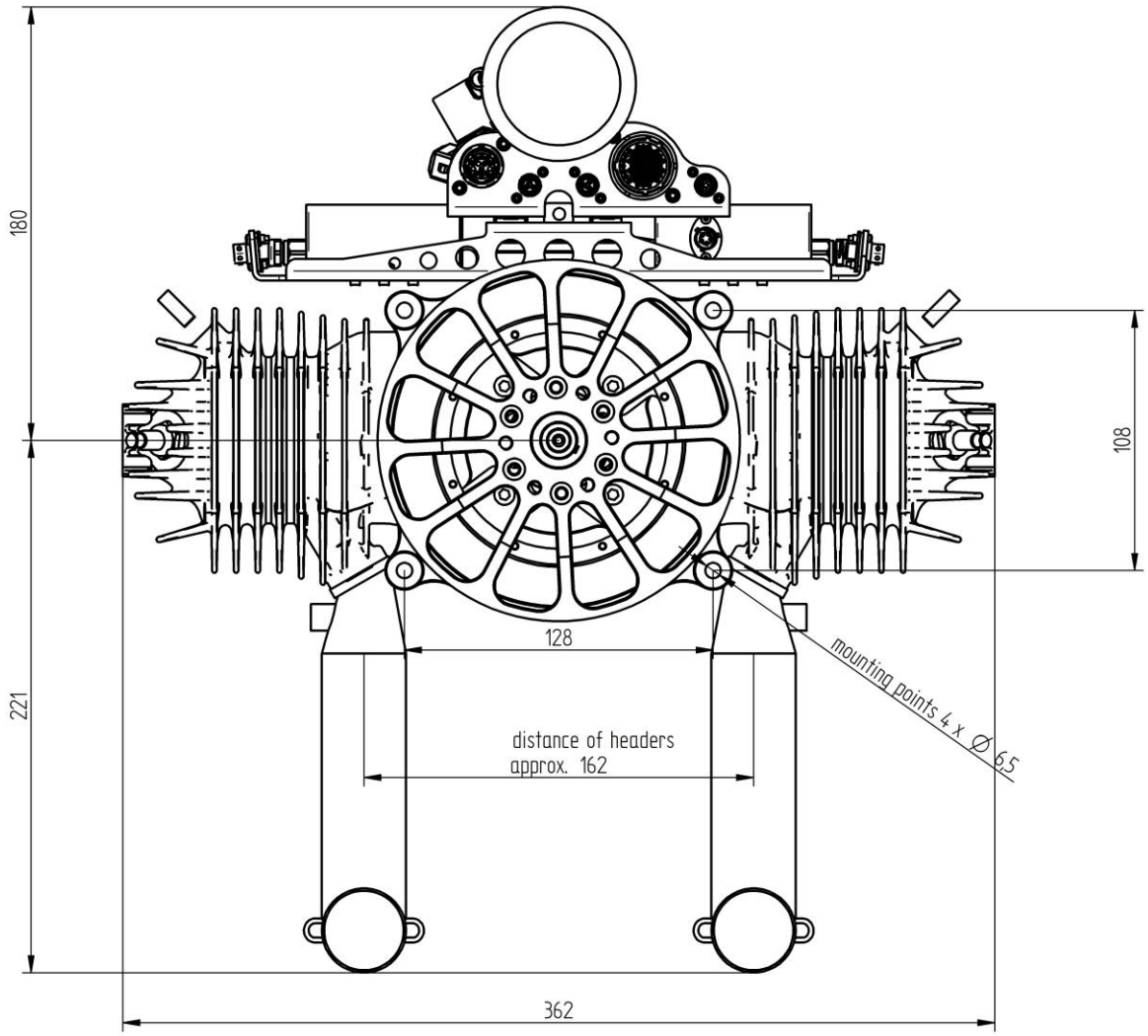
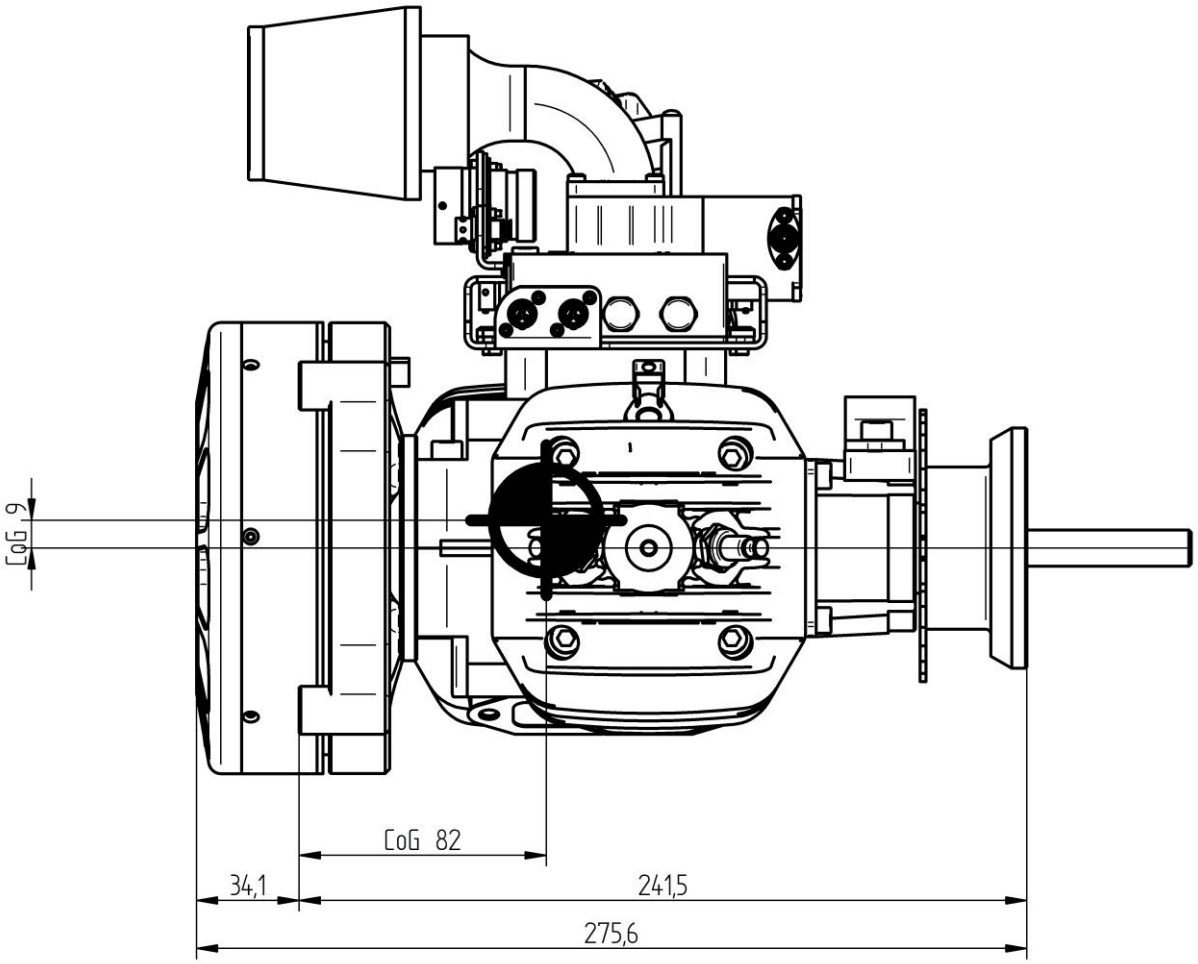


Figure 24: SP 275 rear view with mounting points



CoG of SP 275 FI TS Hybrid without header and prop.
Total weight 10,47kg.
CoG approx. 82mm in front of mounting points
and approx. 9mm above center of crankshaft.

Figure 25: SP 275 side view with CoG

20 Abbreviations

CAN ..... *Controller Area Network*
DK ..... *Drosselklappe (engl. throttle)*
ECU ..... *Engine control unit*
GND ..... *Ground*
GT ..... *Geräteträger (engl. equiment carrier plate)*
HKZ ..... *Hochvolt Kondensator Zündanlage (engl. high-voltage capacitor ignition unit)*
KS ..... *Kabelstrang (engl. wire harness)*
SG ..... *Starter generator*

21 Appendix

21.1 PPM Load control

This mode is optional. Special hardware and wire harness is necessary.

In PPM Load control mode the combustion engine is controlled by a load set point that adapts the throttle angle. Therefore a PPM signal is used as load target value. In this mode 1000 – 2000 us (PPM signal) match 0 – 100,0% load.

For PPM control a modified version of the wire harness KS 557 is necessary, which connects the ECU030 with the GT110. This version has a separate 2-pole Superseal connector with the following pin assignement.

PPM wire harness (Superseal 2-pole connector):

Description	Pin#	Color
PPM signal input (5V)	1	yellow / orange
Ground	2	black

Table 48: PPM wire harness pin assignment

Load target minimum value:	0 %	→	1000 us (PPM signal)
Load target maxmimum value:	100 %	→	2000 us (PPM signal)
Factor:	10		

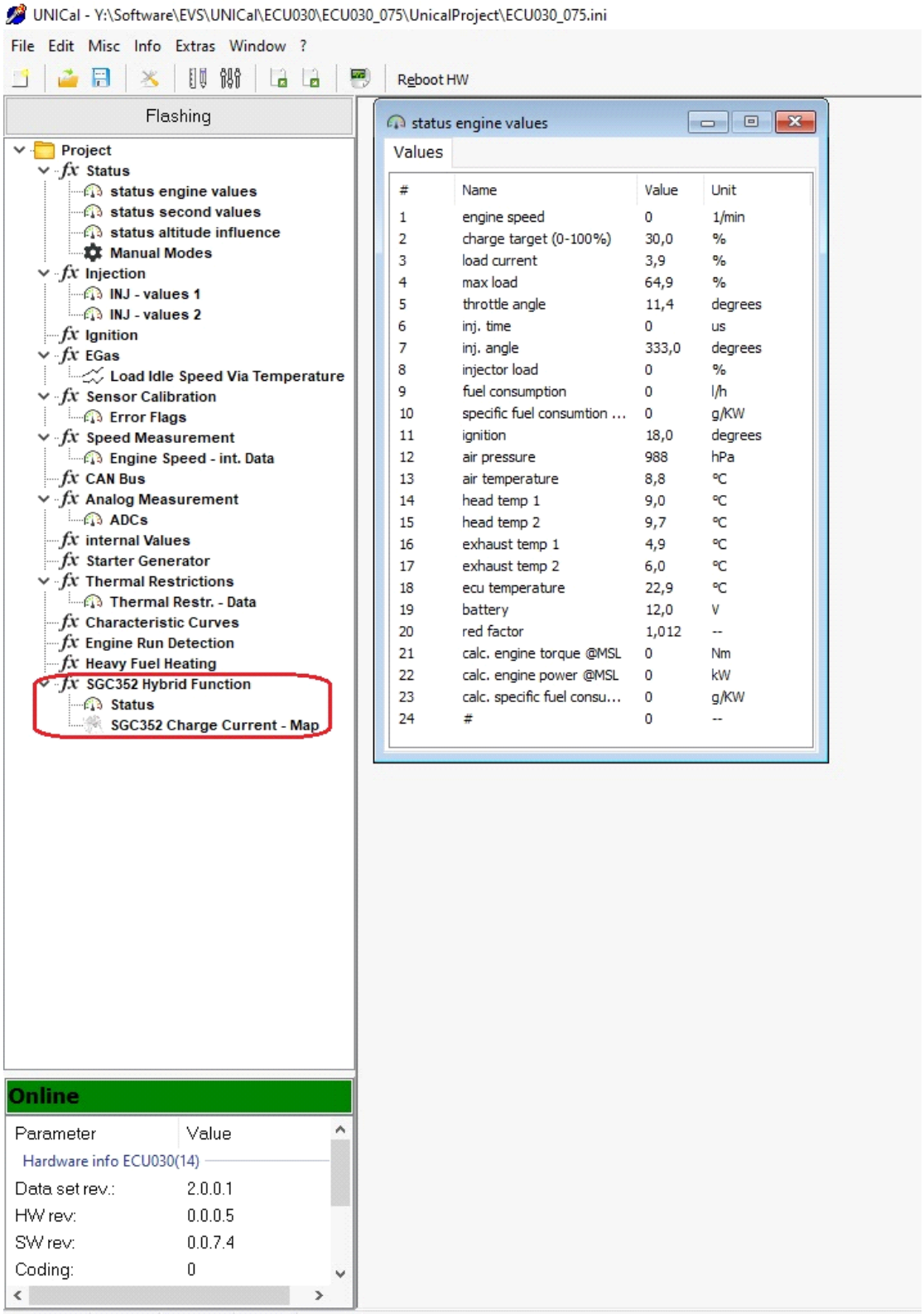
Example load target 39,7 %:

397 (decimal) → 1397 us (PPM signal)

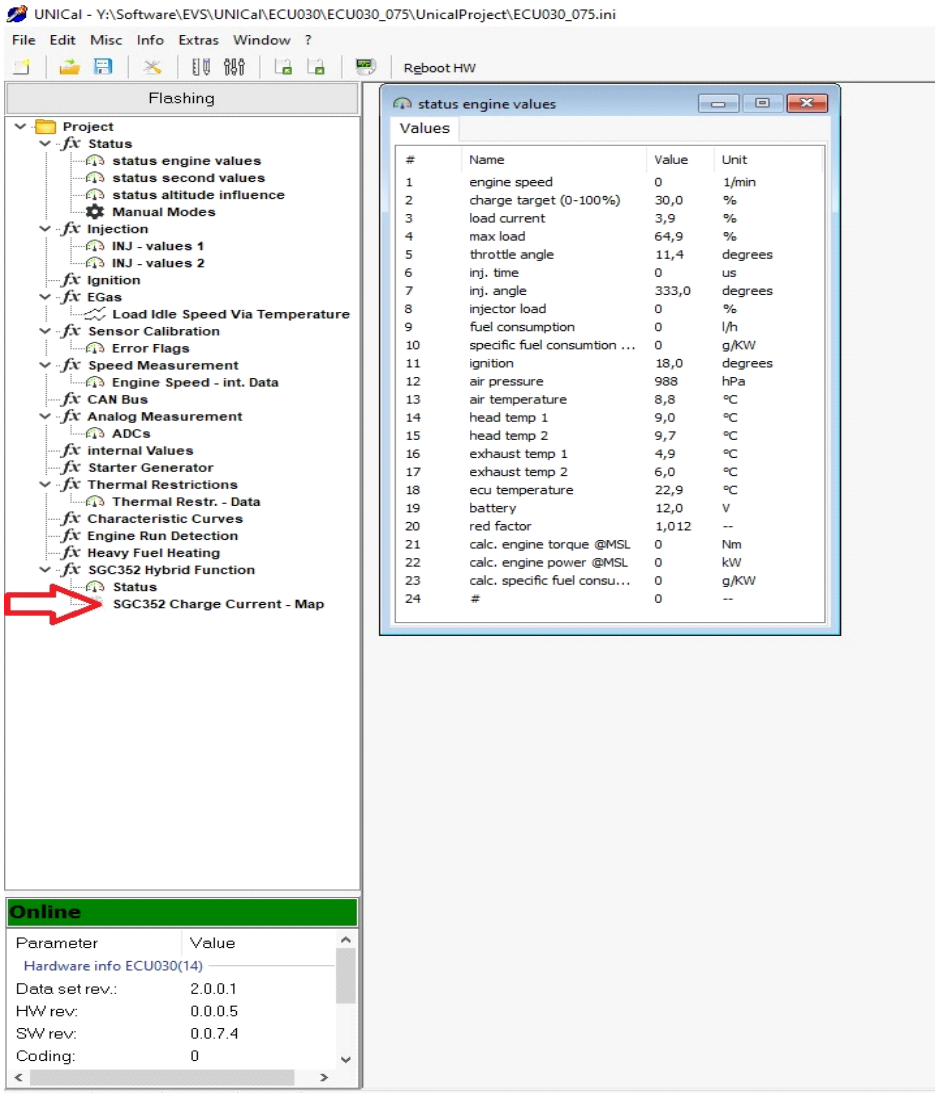
21.1 SGC settings:

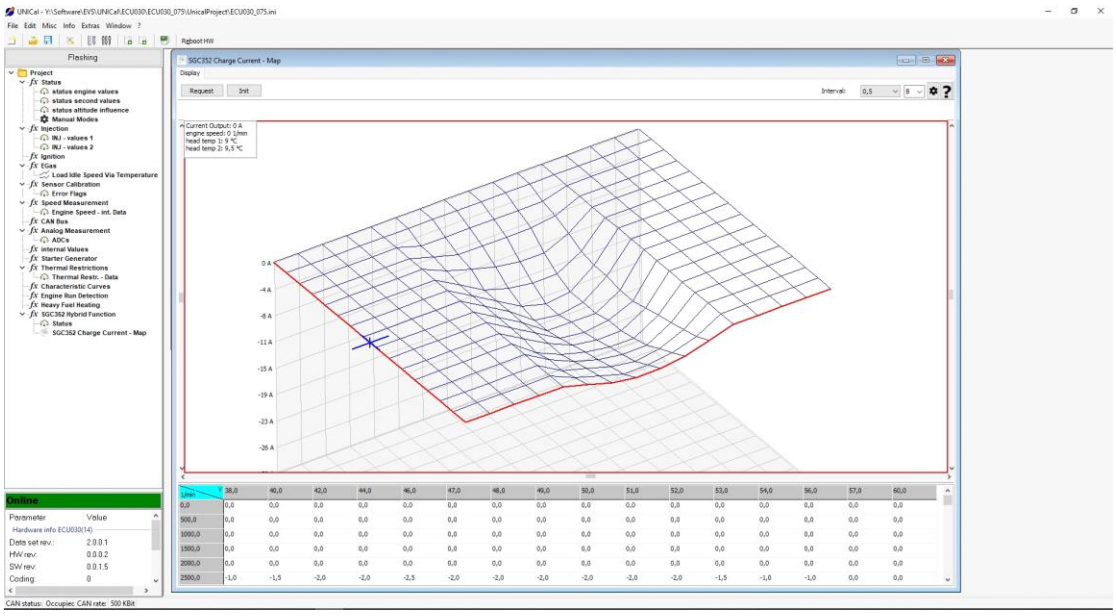
Screenshot N1, N2: Open Unical Program,

locate "SGC..... Hybrid Function".



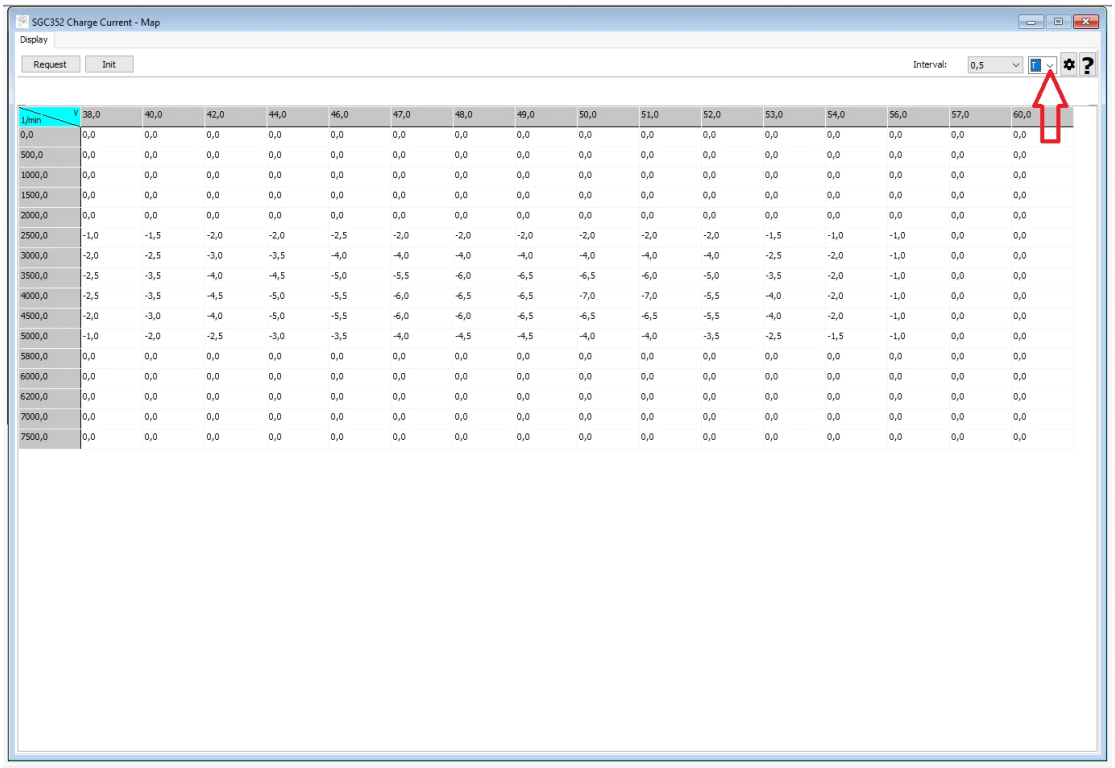
Screenshot N2/N3: select “SGC.... Charge Current-Map”.



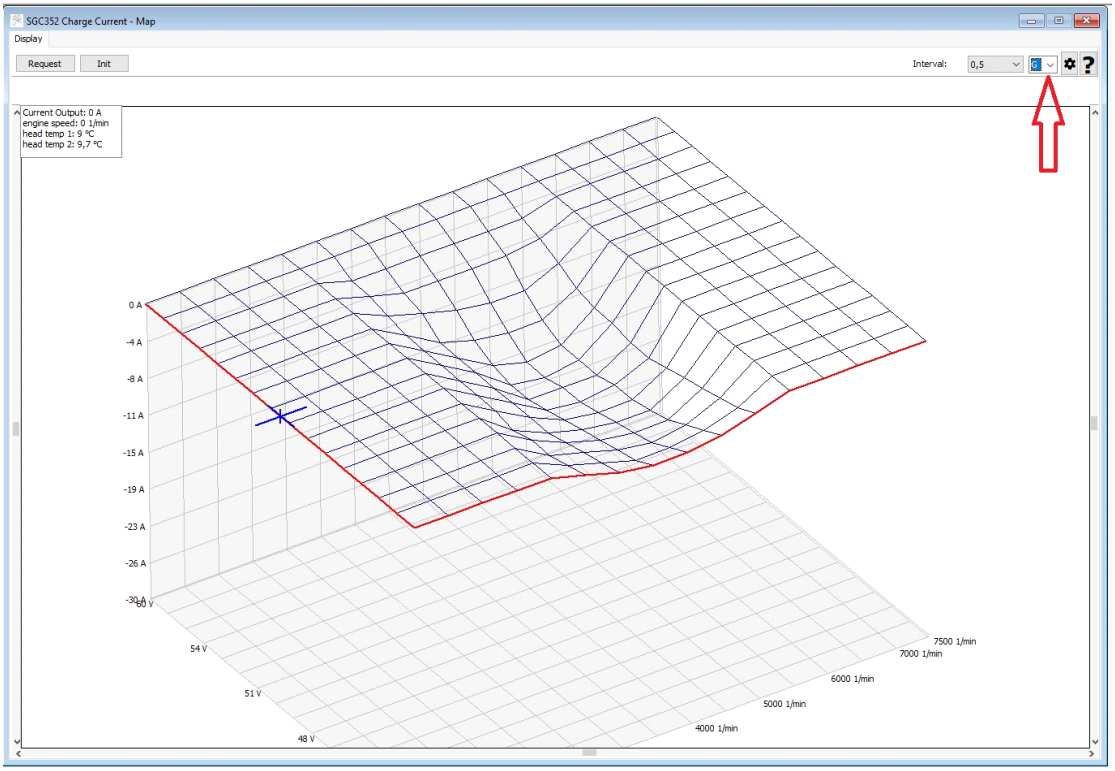


Screenshot N4....N6: Selection in the display:

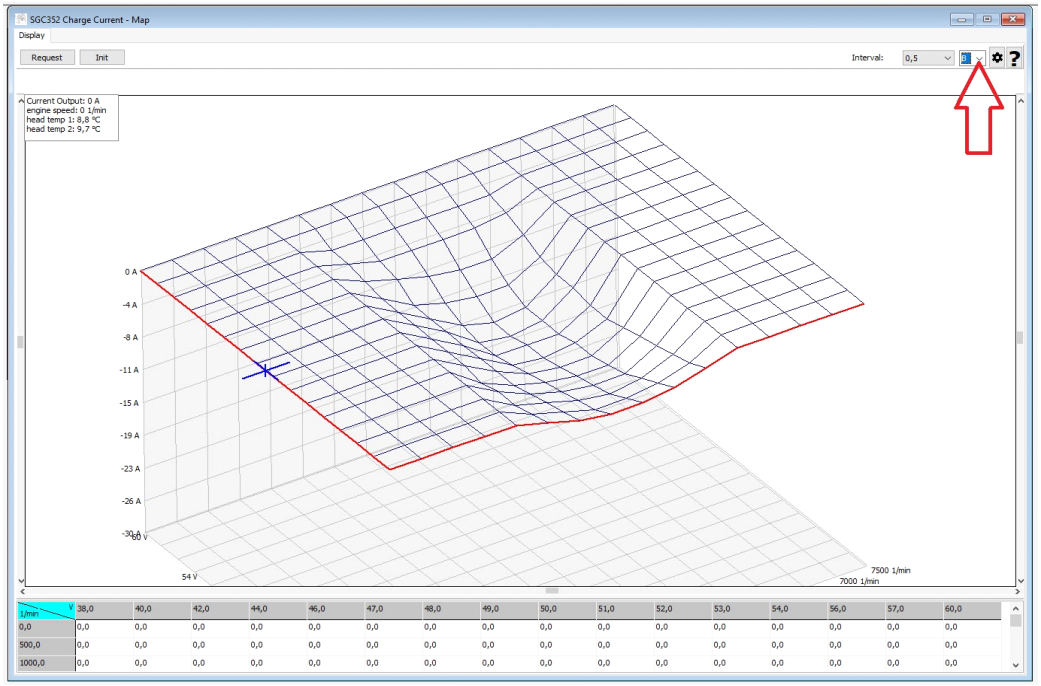
N4) the table only,



N5) only the 3D diagram

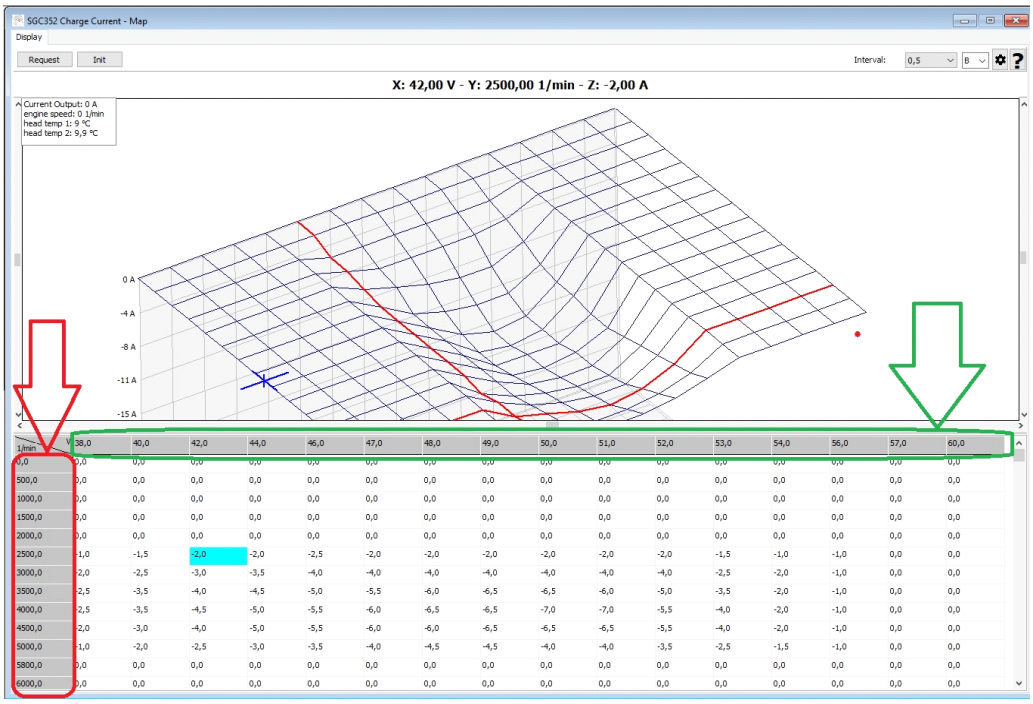


N6) Both: 3D diagram and the table



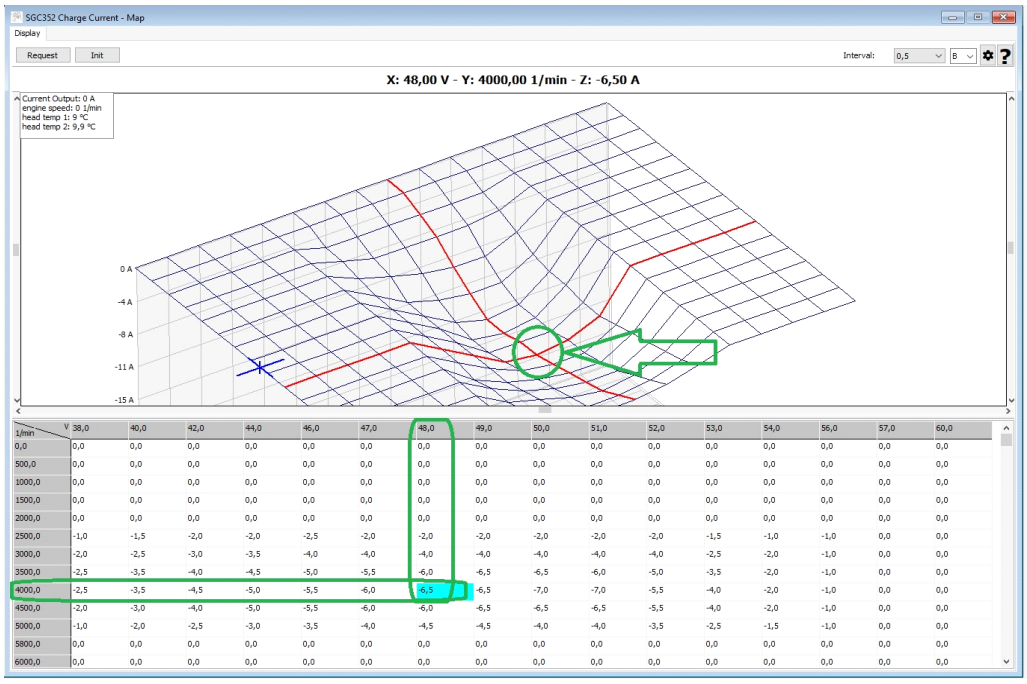
Screenshot N7: The voltage operation range is marked in green,

the speed range is marked in red.

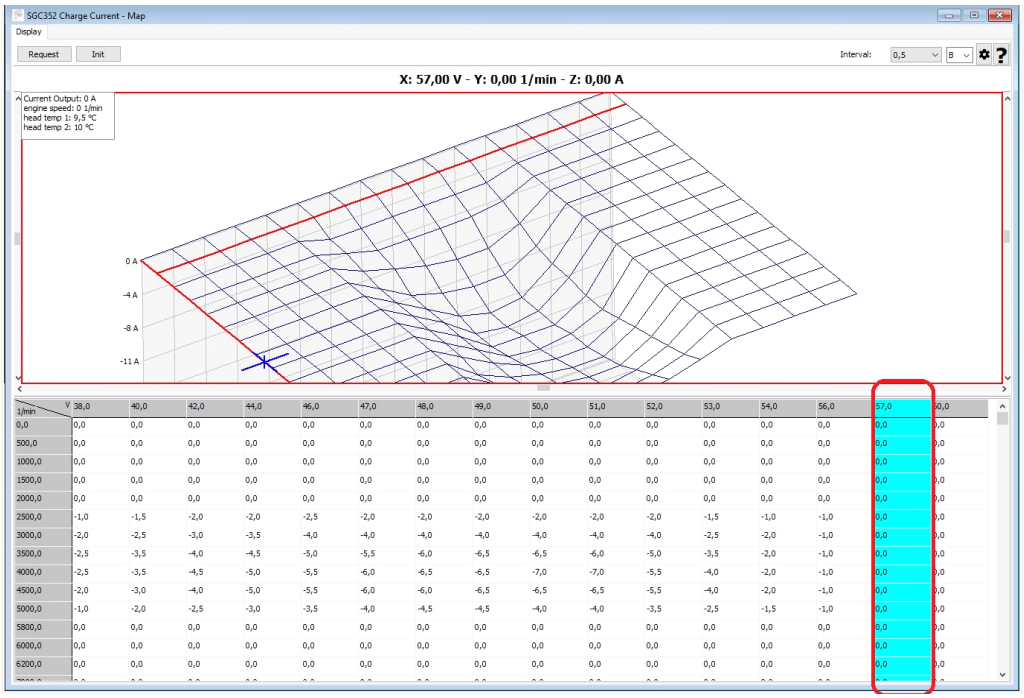


Screenshot N8: Setting example:

At RPM 4000 1/min the generator produces 6.5Ah/48V (312 Watt) and the point is displayed in the diagram

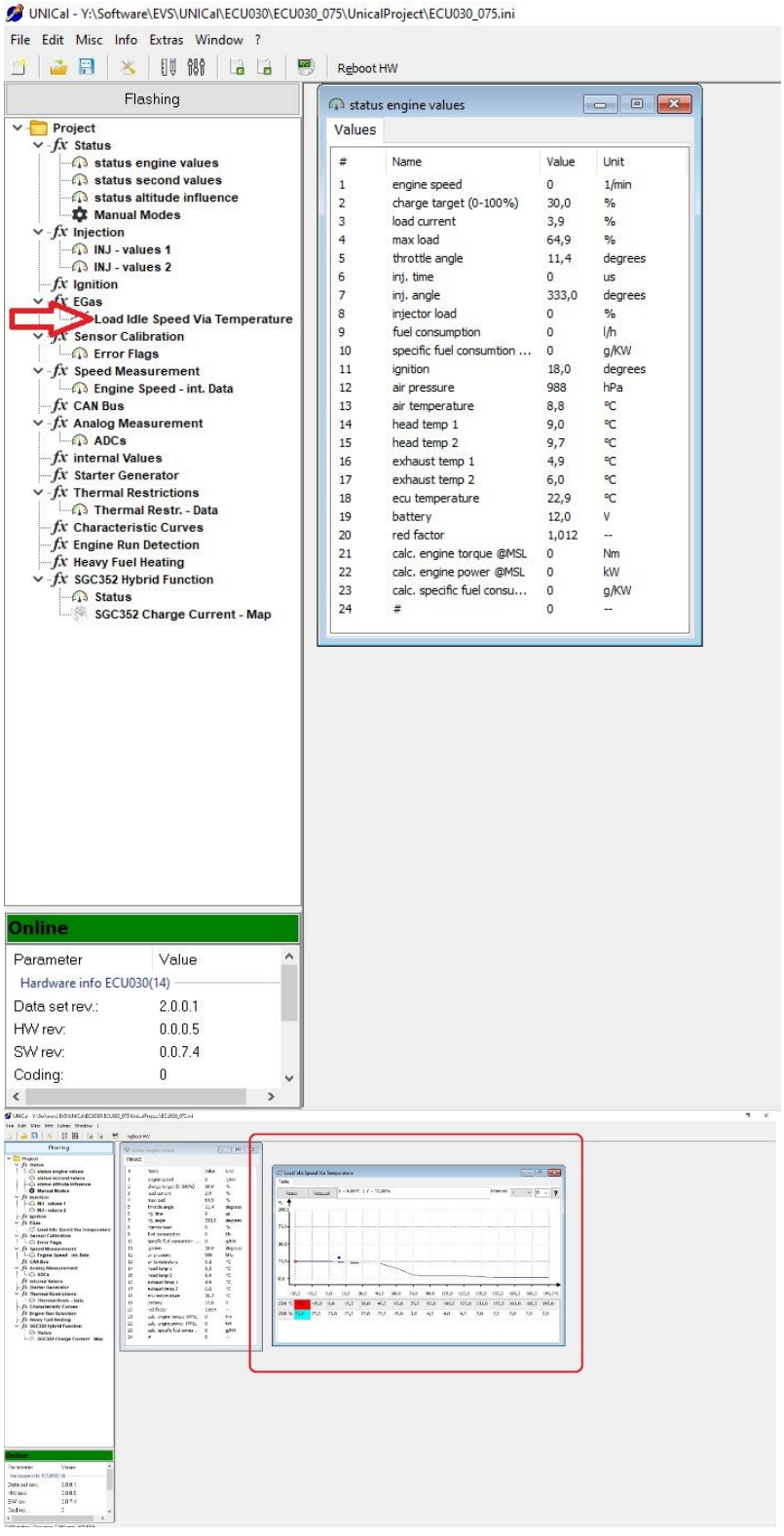


Screenshot N9: The example shows the maximum charge voltage of 56.9 Volt.



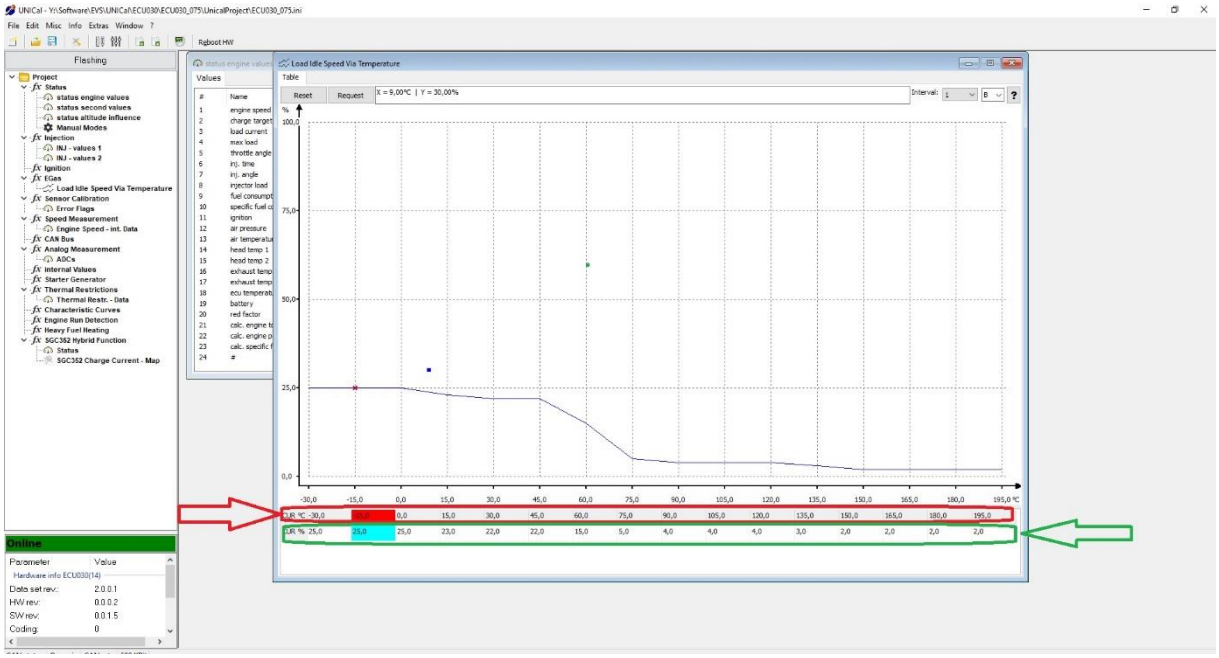
21.2 Idle Speed settings:

Screenshot N1/N2: Open the UNICal program, locate and select“Load Idle Speed Via Temperature“.



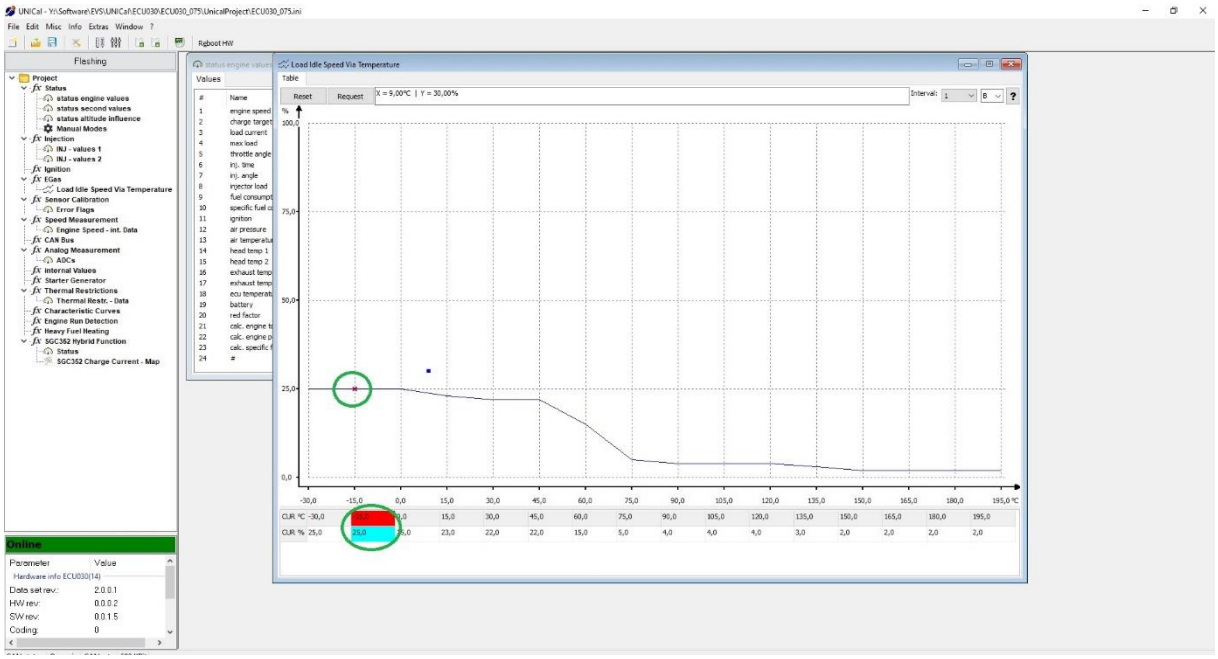
Screenshot N3: The Engine Temperature (Head Temp.) is red marked,

The Throttle oppening angle in % , green marked, that means: WOT is 100%, Throttle Closed is 0%.



Screenshot N4: Example: the Engine Temp. -15°C, the Throttle position in Idle is 25%.

It posible to change the „CUR%“ to adjust opperational „Idle Speed“.



397 (decimal) → 1397 us (PPM signal)

