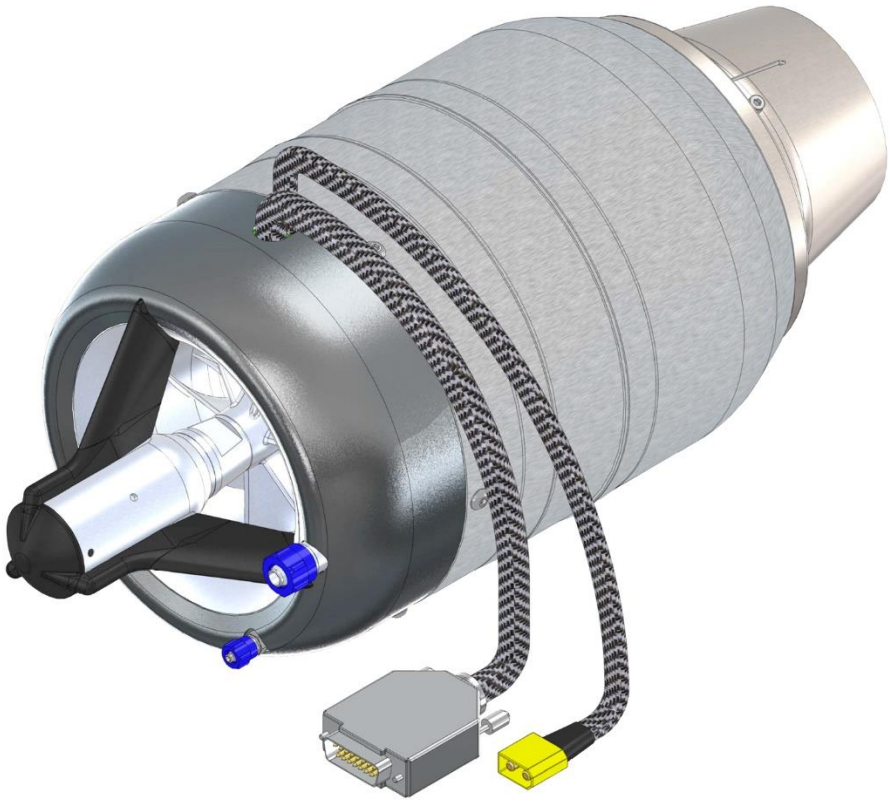
10/2021 *Operating instructions*

JetCat PRO Engines



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Introduction

Welcome to the Jet Age of model aircraft! ***JetCat*** is pleased to sell, support and service the ***JetCat*** engine and greatly appreciates your purchase. We hope the ***JetCat engine*** brings you many days of pleasurable flying.

To begin, read this manual thoroughly. Develop an overall impression of the engine and its operating procedures, equipment, and accessories. Study the material step-by-step and ascertain how to install, operate, and maintain your jet engine. If you are unsure about anything, re-read it again, or contact JetCat for further support.

DO NOT OPERATE THE *JetCat ENGINE* BEFORE YOU HAVE READ THE MANUAL AND FULLY UNDERSTAND EVERY PROCEDURAL DETAIL

Should you still have doubts or questions, do not hesitate to contact ***JetCat*** for further assistance.

The ***JetCat*** jet engine closely functions like a full-size jet engine. A centrifugal compressor compresses the incoming air which is mixed in the combustion chamber with fuel (jet fuel / kerosene) and ignited. The result is a rapidly expanding volume of gas that drives an axial engine wheel. The gas exiting the exhaust cone produces the required thrust for the jet model. To start the engine, an electric motor is mounted on the front of the engine.

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Features

The JetCat-PRO engine provides the highest level of integration and maximum ease of installation.
All necessary peripheral systems necessary for the engines operation are fully integrated below the engines front cowling.
There are no further external peripherals required like ECU/ Valves or igniter system.
All of this is integrated at the engines front end!
Therefore, besides the supply battery, the fuel tank, and some external control signals there are no further external subsystems required!

The control signals are fed out on a pigtail cable terminated with a 15-pin SUB-D connector (other connector types available on request).
The power supply is made via a second pigtail cable with a XT60 connector for direct battery connection. Other power connector types possible upon request.

JetCat-PRO engine features:
Integrated Engine Components:

- ECU (electronic control unit)
- Electric starter motor or brushless starter/generator, depending on engine type
- Brushless fuel pump
- Fuel & Kerosene-start Solenoids
- Fuel filter
- Direct kerosene start-up
- Barometric altitude / pressure sensor for automatic engine tuning upon operation altitude.
- 4-pin Molex expansion connector (e.g., for smoke pumps / fuel transfer pumps)
- Optional bleedair port with integrated one-way valve (e.g., for pressurization of fuel system)
- Air restart capability
- Automatic engine cool down cycle after shutting down.
- Direct quick start on kerosene
- Reporting of fuel consumed
- Engine power up via digital control signal
- Engine safety shut down input, for instant engine shut down from flight termination system. This will kill power to fuel pump and shut off safety valves. Whilst ECU can stay powered on (for continued data reporting and or engine cool down).
- Monitoring and reporting of all currents / voltages (e.g., supply voltage / current, pump driving voltage)
- AutoRestart option for automatic engine restart on flameout due to fuel supply interruption (air bubble in fuel)
- High Performance ceramic bearings

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Power supply:
Typical via 3-cell LiPo battery / XT60 Power connector / capacity 3000mAh or higher
Max.(peak) electrical start-up power: 300W

On newer engines, supply voltage can range from 10-35V max. On these systems the battery type and cell count are adjustable in a large range. On these engines the output voltage of the integrated DC/DC converter will automatically adjust in correspondence to the selected battery! (only GL/GH versions).

On older GL/GH engines the battery must be a 3s Lipo type, as the output voltage of the DC/DC converter is fixed and matched to these battery voltages!

Data connector:
Via 15pin SUB-D (male) this provides for the following control options:

- *1x Power On control signal*
- *2x PWM input channels (e.g., for RC remote control; THR/AUX)*
- *2x independent serial interfaces (baudrate:9600 up to 115000 bps) for computer remote control, data reporting and/or interconnection of multiple engines, RS485 signal level upon request.*
  Engine addressing feature allows to connect multiple engines to same serial interface.
- *1x analogue voltage control / sensor input*
- *1x JetCat Bus interface, e.g., for connection of GSU and/or other JetCat accessories (LCU / flow sensor/ BMS system etc.)*
- *CAN-Bus interface for control and data reporting*
- *Customer specific data connectors including customer specific pinouts are possible on request*

JetCat PRO-Interface, Option

By using the "JetCat-PRO" interface, not only can all PRO engines easily be used in RC-model applications, but it also provides a ready-made solution, and easy interface point for educational and industrial applications.
It also provides full functionality of our JetCat Telemetry-Adapter if desired!
Furthermore, the PRO-Interface allows for an easy access point to connect other accessories such as:

- *One or two channel RC control (from receiver)*
- *Telemetry output for: Jeti, Graupner, Hott, Multiplex M-BUS and Futaba SBUS-2*
- *RJ12 jack for connection of GSU*
- *Air Speed sensor header*
- *6 and 8 pin ERNI flat cable connectors (e.g., for connection of LCU / Mini GSU)*
- *RS232 header for computer control*
- *CAN-Bus header*
- *Header to JetCat BMS (Battery Management System)*
- *Cross check communication port (for interconnecting / synchronizing two engines).*
- *3x Status LEDs*
- *Analog and digital inputs for:*
  - *Power On/Off*
  - *Engine On/Off Control*
  - *Engine RPM command/ control via a directly connected potentiometer*

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Safety, meaning of symbols

	**ATTENTION!** This symbol highlights the following points which must be strictly observed by the user! Any violation of the corresponding restrictions may impair the safe operation and the safety of the user.
	**ATTENTION!** This symbol highlights restrictions which must be strictly observed by the user! Any violation of the corresponding restrictions may impair the functional efficiency and severely compromise user safety.
	**ATTENTION!** This symbol highlights information that should be heeded by the user to ensure safe operation of the device
	**ATTENTION!** Fire or explosion hazard!
	**ATTENTION!** This symbol warns of hot objects and surfaces. Any violation of the corresponding restrictions may affect the health of the user.

Safety Precautions

	**WARNING!** Errors and / or defects in the construction or operation of a jet model can lead to personal injury or even death.
	**ATTENTION!** Before you put a model aircraft in operation, you must learn about the law. Legally, a model aircraft is a real aircraft and is subject to applicable laws which must be strictly adhered to. The rules of other countries are to be observed accordingly.
	**WARNING!** It is your responsibility to protect others from injury. The minimum operating distance of residential areas to ensure the safety of people, animals and buildings must be at least 1 mile. Never operate model engine jet aircraft in or around residential or heavily populated areas. Keep a safe distance away from power lines. Do not fly the model in bad weather with low clouds or fog. Never fly into direct sunlight, otherwise you might lose sight of the model. To avoid collisions with manned or unmanned aircraft, land your model immediately if a plane approaches. Persons or animals must comply with the minimum safety distances from an engine model **Make sure to stand clear of hazardous areas.**
	**WARNING!** The construction and operation of the model and / or engine under the influence of alcohol, drugs, medicines, etc. are strictly forbidden. These activities must take place only in the best physical and mental health condition. This applies to both the operator and any assistants.
	**WARNING!** The *JetCat* engines were designed exclusively for model aircraft and are NOT suitable for any other purpose. Never use for any other purpose except for the flight of the model. Any other types of uses may result in personal injury or death.
	**WARNING!** Any deviations from these instructions or the instructions of the manufacturer, the use of other parts or materials or changes to the system may have an adverse effect on the functionality and reliability of the turbines and therefore must be avoided at all costs.

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	**WARNING!** The operation of a model jet engine can only be done under strict accordance of the model, remote control, and engine operation manual. Before flying the model, all control functions, and surfaces as well as the range of the remote-control system must be checked in the accordance of the manufacture. The checking of these operations must be repeated with a running engine including the remote-control system range.
	**WARNING!** In case of a mishap, fire extinguishers should always be on hand. JetCat recommends the CO/2 variety. Powdered extinguishers will corrode the precision components inside the engine and void your warranty.
	WARNING! When the engine is running, never place your hands closer than six inches into the area of the intake. An extreme suction which can grasp a hand, fingers or other objects in an instant exists in this area. Always be aware of this source of danger! Prevent foreign materials from entering the intake or exhaust when working with the engine. Before operation, make sure there are no lose parts or debris near the engine. Objects being sucked in can cause severe damage. If your installation allows, we highly recommend using a “Jet Net” to protect the intake.
	**WARNING!** Never run the engine in a closed room, or an area near any kind of flammable matter. Do not fly engine-powered aircraft near flammable materials, nor in forested tracts or areas experiencing drought or dryness. Obey all forest fire regulations and warnings by refraining from operating the JetCat engine in restricted fire zones.
	**WARNING!** The overflight of people, especially at low altitude, is strictly prohibited
	**Attention!** Always exercise caution around the hot parts of the engine, to avoid burns. The outer case at the engine stage and nozzle reaches 450-600□ (Celsius), while the exhaust gas may exceed 800 □C.
	**WARNING!** Assure that the fuel is mixed with approximately 5% synthetic oil. Use only synthetic engine oils available at local airport fuel suppliers. Synthetic engine oils are dangerous and should only be handled as per the manufactures MDS sheets. JetCat has available a compatible oil that is less harmful that also contains an antistatic ingredient. Contact JetCat for more information.
	**WARNING!** To the avoid hearing damage, always use hearing protection when you are near a running engine!

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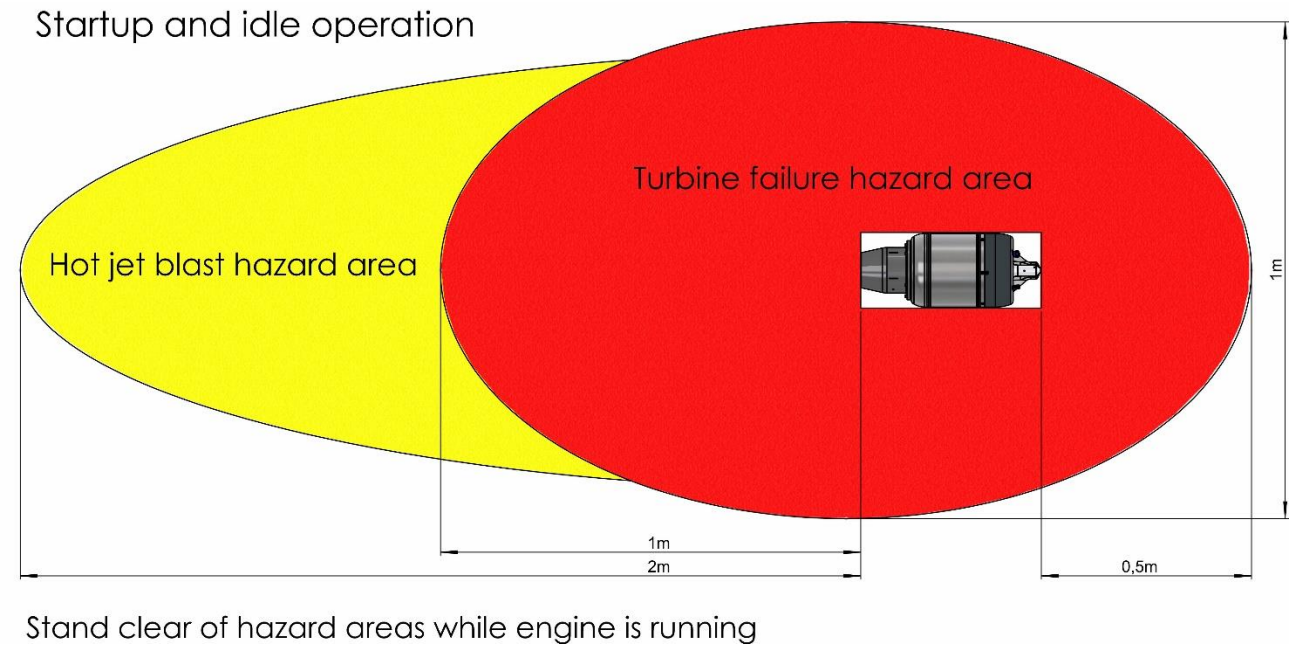
Hazard Areas

The following diagrams show the hazard areas during engine operation.

- Please make sure that these safety areas are kept free of persons during operation.
- Always wear safety glasses when operating a jet engine.
- Make sure intake area is free of any parts/obstacles possibly being sucked in by the compressor (FOD)! The engine will produce an immense suction able to aspirate unsecured parts in quite a large radius! Keep fingers away from intake area!
- Make sure that fire extinguishing equipment is present (CO2 fire extinguisher with at least 5kg content)

Hazard areas on engine start-up and idle operation



Stand clear of hazard areas while engine is running

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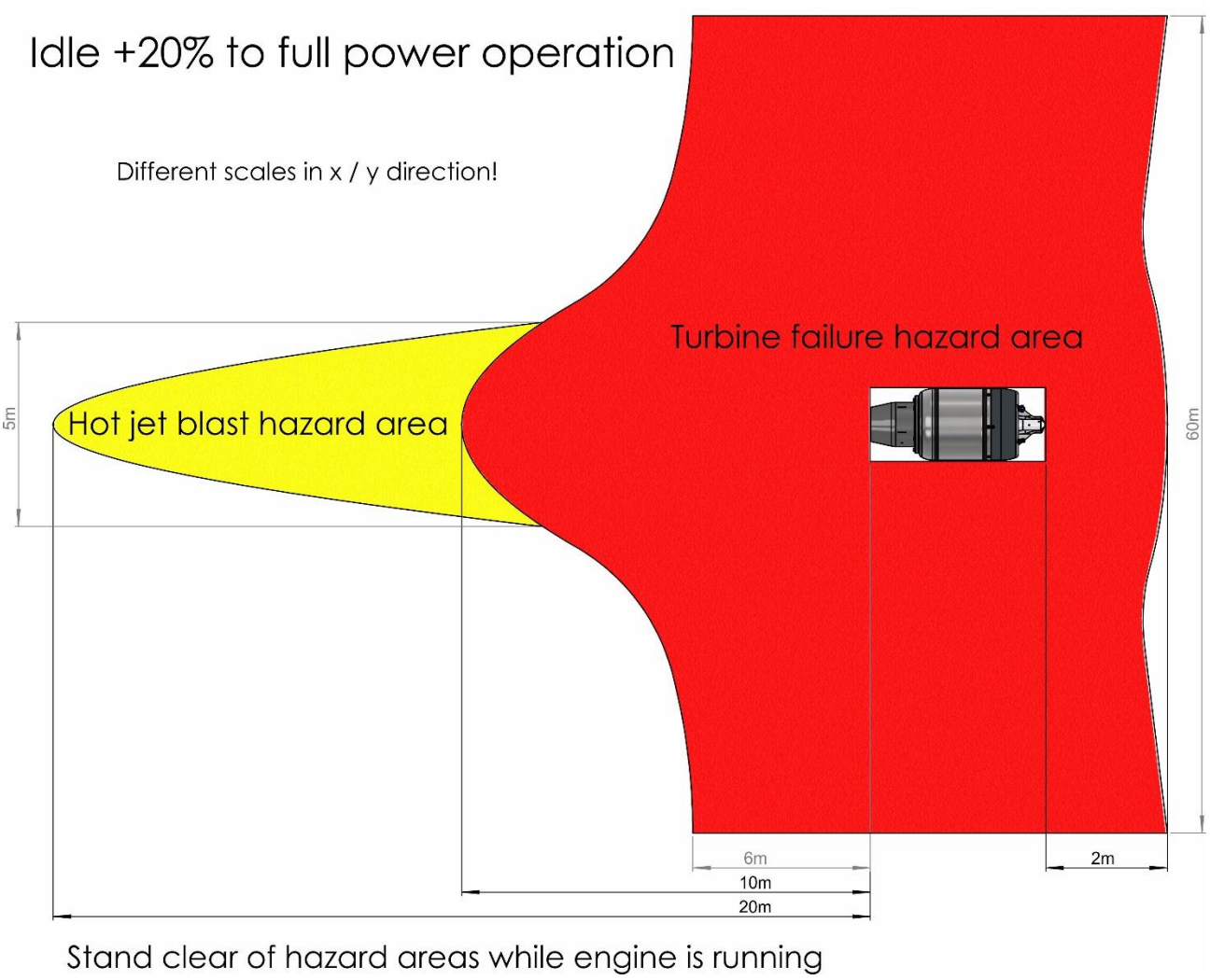
Hazard areas on engine idle +20% to full power operation



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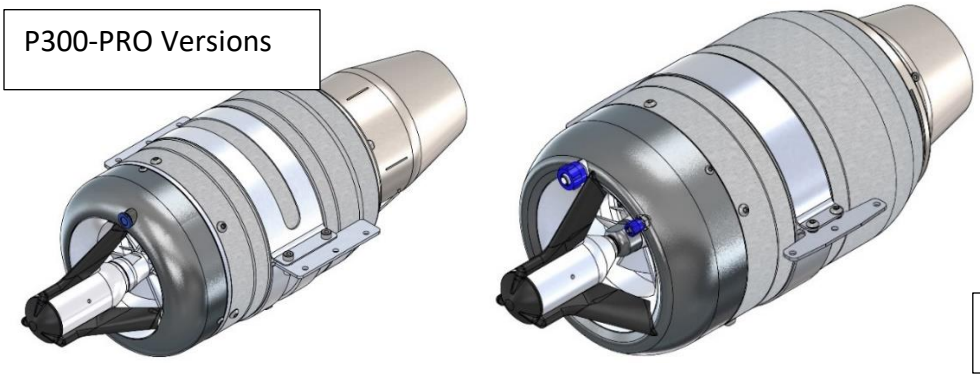
Mounting / fixing of the engine

Dedicated mounting brackets are available for mounting of the engine. Place the brackets around the engine as shown in the pictures below. Do not over tighten the fixing screws not to deform the engines casing.

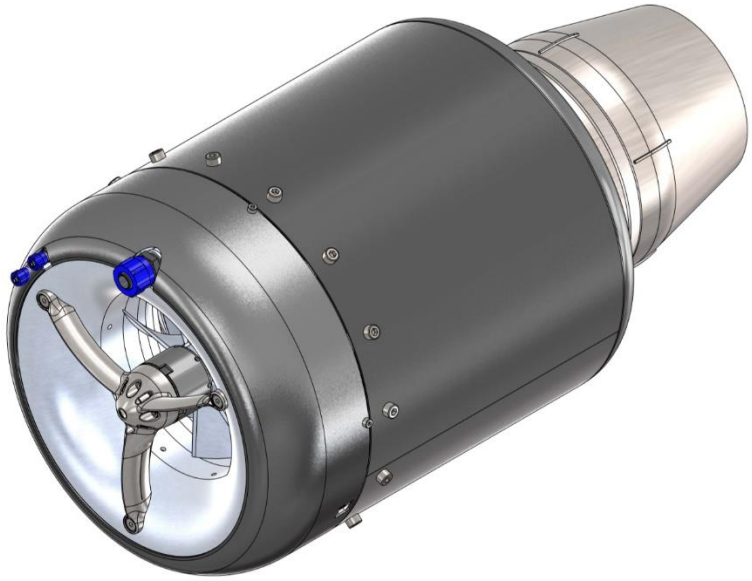
P300-PRO Versions



P400-PRO Versions

P550-PRO Versions

Best rotation orientation position of the P550 engine is to rotate the engine such, that the fuel input is located around the 4 o´clock position (looking from front).



P1000-PRO

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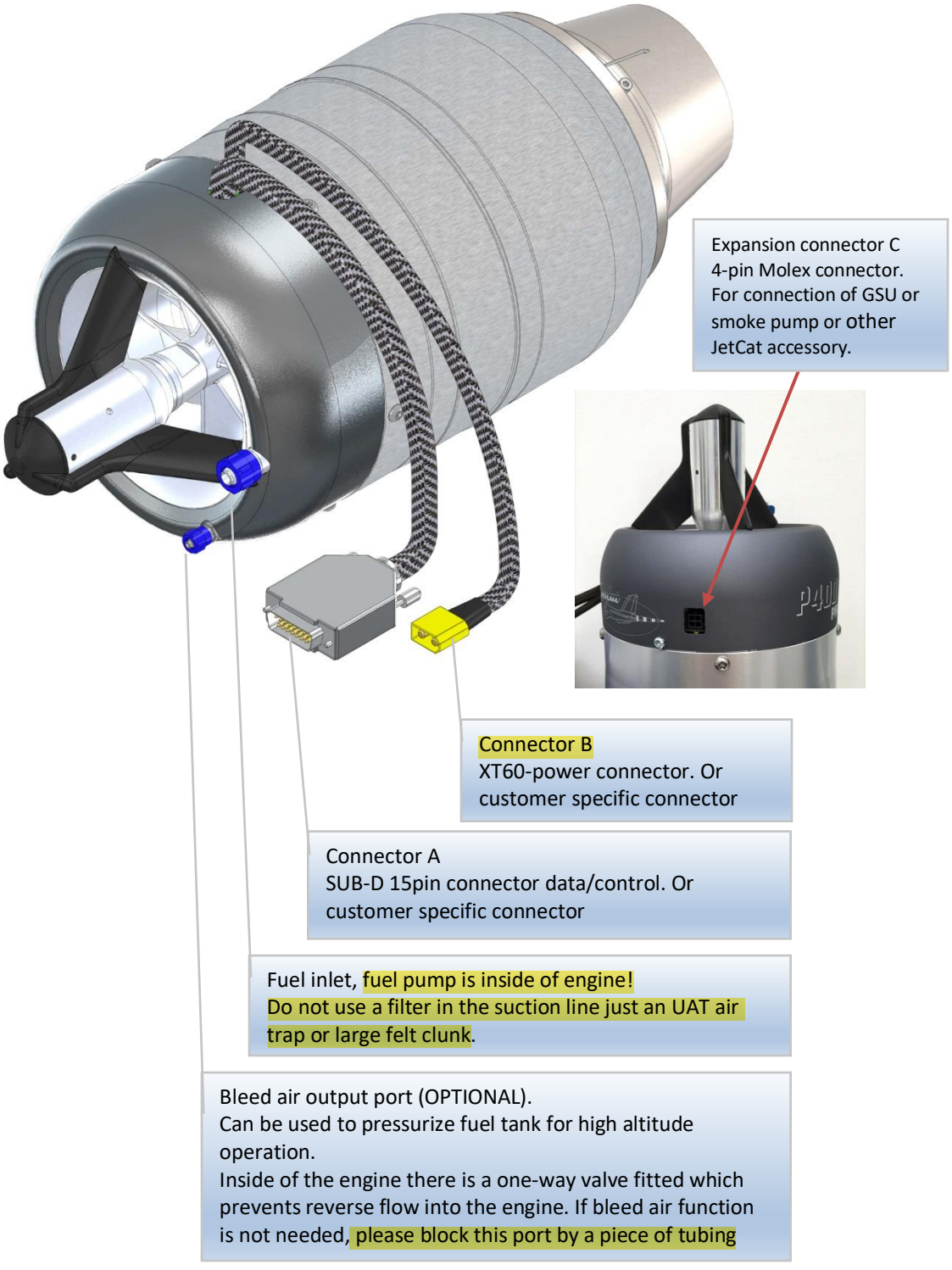
Connections on the engine, overview

Once you have unpacked and identified all the components, follow the system diagram/photo for all connections.



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Data connector (A)

The data connector of the engines provides all necessary control signals for engine control as well as power on.

15pin SUB-D male connector

FCT - A MOLEX COMPANY FL, Sub-D Connector, 15-pin, straight, male
RS -No.: 812-6359
Pin-Inserts:
Sub-D-contact, Series: FK20PL, Male, Crimp, 24 → 20 AWG FK20PL-08V
RS -No.: 812-6220

Pin	Description	Info	Suggested connection
1	GND	Signal Ground	Connect to ground/negative pole of supply battery
2	Throttle PWM input	RC-PWM Signal (THR)	Connect to servo PWM signal (0,8-2,2ms) if throttle control should be made via PWM signal
3	CAN-L	CAN-BUS	
4	GSU-Bus-D	GSU bus (do not use!)	
5	TXD 3,3V (COM1)	Serial interface transmit line	
6	RXD-Cross Check, COM2	Secondary serial interface receive signal	
7	AUX PWM input	RC-PWM Signal (AUX)	
8	Safety Shutdown input / engine “kill” signal.	Safety shut down input. This is an input for additional flight termination systems. This input pin should not be used to stop the engine under normal conditions. Needs to be connected to GND to allow engine to run. This signal is only present on P1000 engines or engines with ECU hardware setup V2.0 or higher!	Connect this pin to GND to enable internal valves and pump! If left open, valves and pump are disabled by septate hardware circuitry! (→ engine cannot run). If disconnected during engine run, engine will be shut down immediately with GSU message: “Kill Sig”
9	Power On Signal (4-14V) See note 1 below!	Apply a positive voltage to power up ECU/engine	Connect to positive pole of power supply, to switch on ECU/engine system. If disconnected ECU is turned off. See also page 35 Engine Power ON/OFF
10	CAN-H	CAN-BUS	
11	GSU-Bus-C	GSU-bus (do not use!)	
12	RXD 3,3V (COM1)	Serial interface receive line	
13	+5V out, max 200mA	+5V output to GSU	
14	TXD-Cross Check, COM2	Secondary serial interface transmit signal	
15	Airspeed	0-2,5V Airspeed Sensor or Analog input	

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Note 1:

Power On Signal (Pin 9) treatment:

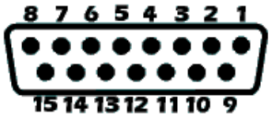
Normally the ECU will switch off instantly if the control voltage on this pin is removed.
However, this default behaviour depends on the selected operation mode as well as on the setting of parameter "Self Power funct." (→Limits menu).

Parameter "SelfPower funct." can be set to 3 different options:

1) **"OFF"**
   In this case the ECU will be instantly depowered when the control voltage on pin 9 is removed, no matter if the engine is running or not.
2) **"run & cooling"**
   In this case the ECU will stay powered on even if the control voltage on pin 9 is removed, but only if the engine is currently running or in cooling mode. This setting ensures that a running engine cannot be accidentally shut down even if there should be glitches on the power on signal. ECU will only power down if the engine is not running and cool down has finished.
3) **"cooling"**
   With this option the ECU will stay powered on as long as the engine still is in cooling mode, even if the control voltage on pin 9 is removed. As soon as cooling is finished, the ECU will turn off. This ensures that the cooling cycle will be completed even if the power on signal should be removed after normal commanded shut down of the engine.

Important:
If the operation mode is set to "RC model" the system internally uses the "run & cooling" setting. The parameter "SelfPower funct." is not visible in this operation mode! This approach avoids accidental engine shuts downs (ECU power downs) due to possible instable system power supply of the RC-model.

Connector pinout:



male

Customer sided harness:

FCT - A MOLEX COMPANY FL, Sub-D, female, Crimp, 15-pin, straight
RS -No.: 812-6368

Pin-Inserts:
Sub-D-contact, Serie FK20SL, female, crimp, 24 → 20 AWG FK20SL-08V
RS -No.: 812-6232

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Power connector (B)

Power supply:

- Only use 3s LiPo battery with at least 3000mAh capacity should be used.
  The battery plugs directly into the engine or is connected via the JetCat Pro-interface.

  NEVER use a switch between the battery and engine!!!.

  If you plan to store the model for more than a few weeks, the battery should be disconnected.

  Alternatively, a 12V DC power supply with at least 35A rating or a 12V lead battery can be used.

- Verify for correct polarity (+/-)! There is no internal reverse voltage protection!
  Reverse voltage will damage internal electronics.

- To power up / switch on the engine system, an appropriate voltage needs to be supplied to the pins 9/1 of the data connector (see connector pinout). This control voltage can be taken from the main supply battery. If the PRO-Interface is used this control voltage is derived from one of the RC-control inputs (Thr/Aux). In this case, the system powers on automatically when the receiver is switched on.

	**Attention!** **Fire!** A LiPo/LiFePo battery can explode if incorrect charge parameters are used. You should therefore always refer to the manufacturer's charger instructions. **NEVER** charge the batteries unattended. **Do not exceed the batteries maximum allowed charging current. READ AND OBEY WARNINGS ON BATTERY BEFORE CHARGING!**

	Always ensure the batteries are at their optimal charge state before use. The battery is heavily loaded because of the kerosene start. Please also note that at very low ambient temperatures, LiPo/LiFePo batteries have lower capacities. **IMPORTANT: DO NOT INSERT A SWITCH BETWEEN THE BATTERY AND ENGINE connector**.

On newer PRO engines, the supply voltage can range from 10-35V max. On these newer systems the battery type and cell count is adjustable in a large range. On these engines the output voltage of the integrated DC/DC converter will automatically adjust in correspondence to the selected battery! (only GL/GH versions).

On older GL/GH engines the battery must be a 3s Lipo type, as the output voltage of the DC/DC converter is fixed and matched to these battery voltages!

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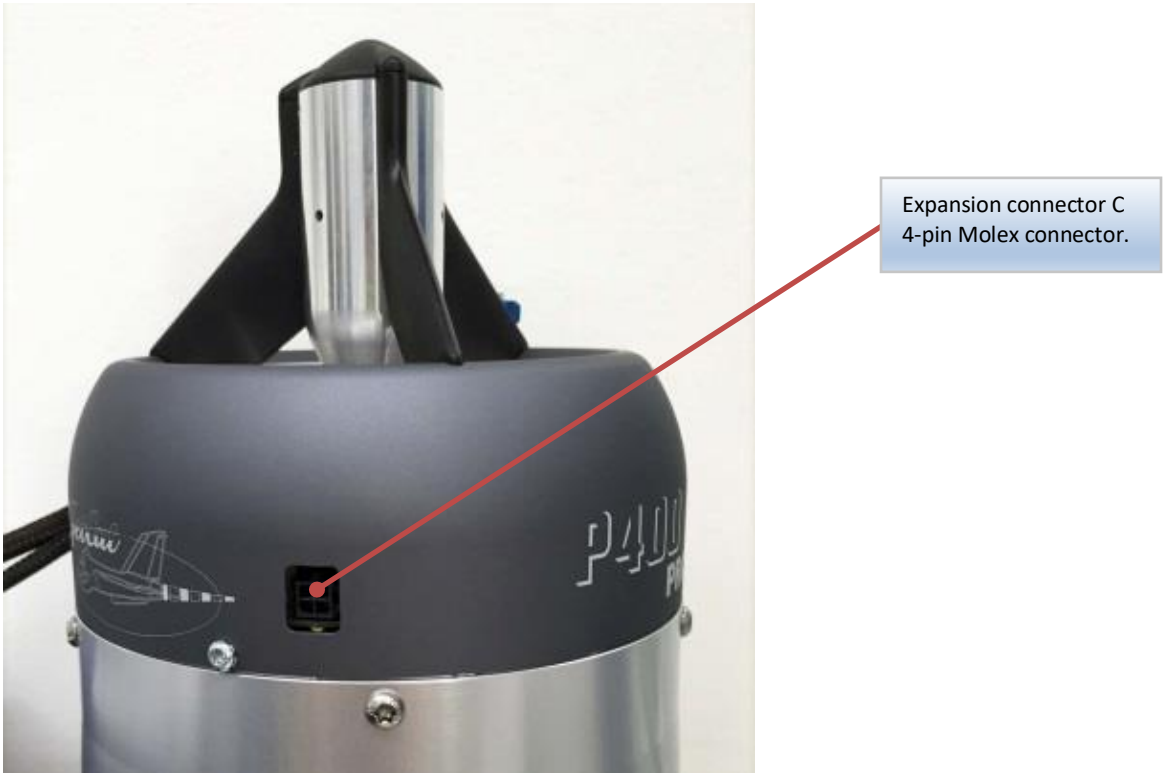
Expansion connector (C)

The 4-pin Molex expansion connector on the front side of the engine provides data and switched power to other optional JetCat accessories like:

- Smoker pump (Bus Type)
- Light control unit (LCU)
- GSU (via special bus adaptor)



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Generator function / internal AC-DC converter (only "GL/GH" engines)

The integrated power supply unit consists of the integrated three-phase generator, a rectifier, and a switched step up/down DC-DC power converter. This system will provide enough power to all internal consumers of the engine (ECU, pumps, solenoids) once the engine has been started up. Excess power is used to automatically re-charge the supply battery. The generator output voltage is rectified, and precision regulated to a constant output voltage via an integrated DC/DC converter. The output voltage and current are automatically matched to the selected (programmed) battery type and size. Therefore, the output voltage of the DC/DC converter is adjustable by the control system in a broad range from 10 to 30VDC.

The DC/DC converter can supply a maximum current of 7,8A (15,6A on P1000). It can maintain a constant output voltage up to this limit. If the current limit should exceed this or a lower programmable limit, the output voltage will drop.

Output current limiting function: Depending on selected battery type/size not to over current the attached supply battery on charging, the system monitors the current flowing in the supply line, by this the current flowing back to the supply battery can be limited to a safe limit when charging/buffering a connected battery.

The generator is installed in the compressor intake; The rectifier and DC/DC converter are integral part of the front mounted ECU.

Max. output current:	7,8A (15,6A on P1000)
Output voltage range:	10-30VDC, Output voltage is automatically set according to the selected battery type, cell count and chemistry of the connected supply battery. As an option, the DC-converter output can be completely disconnected from the supply battery, then acting as an independent output with user programmable output voltage.

Max power output capability depends on selected output voltage (used battery type). Examples are for engines ranging from P300…P550, P1000 has double output capability):

At 12,6V (3s LiPo), max power output is:	12,6V x 7,8A	= 98W
At 16,8V (4s LiPo), max power output is:	16,8V x 7,8A	= 131W
At 21V (5s LiPo), max power output is:	21,0 x 7,8A	= 163W
At 28V, max power output is:	28V x 7,8A	= 218W

From this output capability, the power required by the engine system itself must be deducted. At idle, the power consumption of the engine system is around: 12W@idle, at max power it is at around 43W (P300…P550); 24W/85W for P1000

System allows for automatic (re-) charge / buffering of connected supply battery. When engine runs, there will be no energy taken from supply battery.

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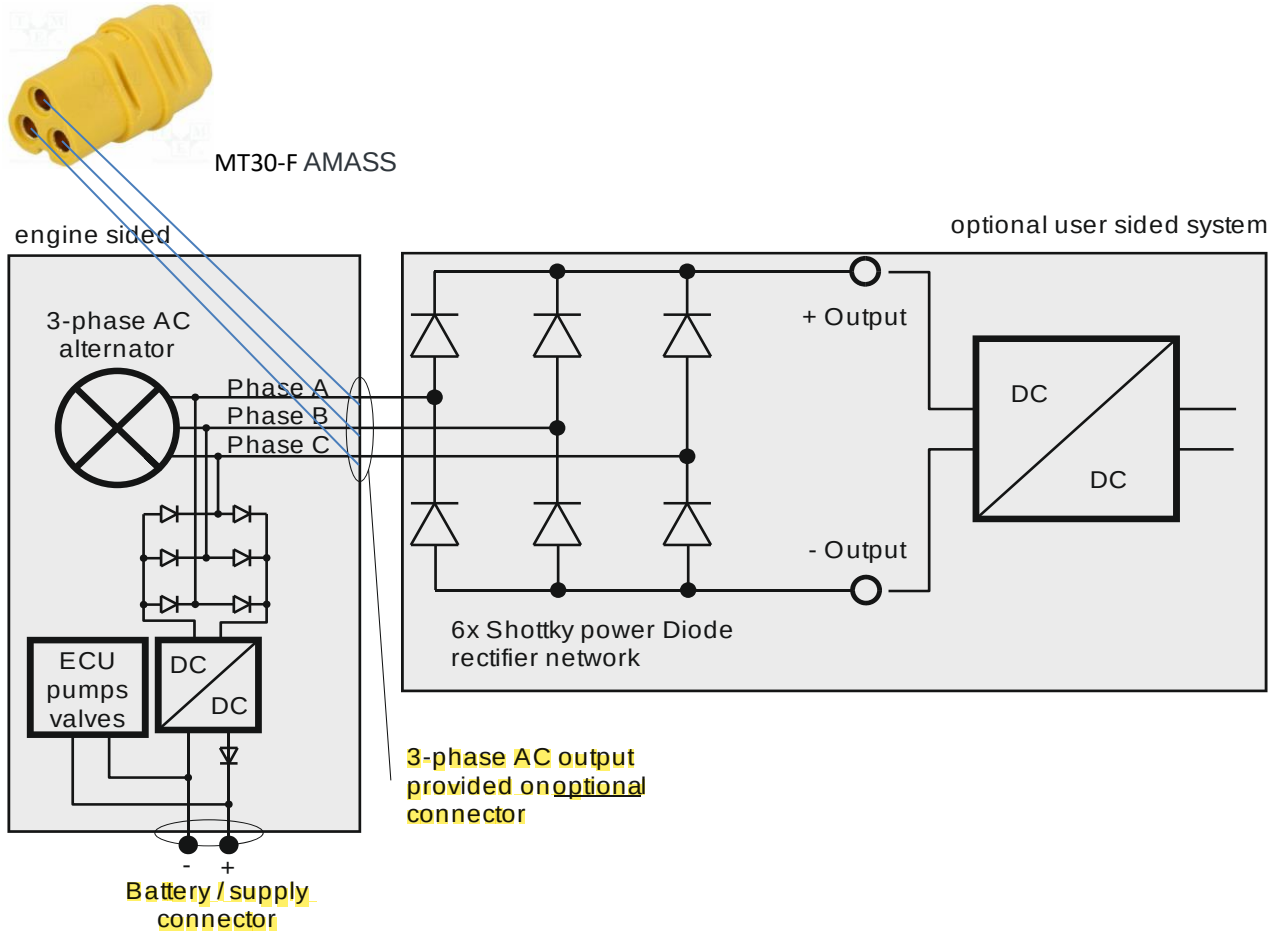
3-phase AC alternator output option („GH“ engines only!)

As an option, the 3-phase AC power output of the alternator is provided on a 3-pin generator output pigtail cable. Typically, this can be used to feed generator power into user specific circuits like external AC/DC rectifiers and/or higher power AC/DC converter circuitry. The 3-phase AC output follows a sine curve with 120° phase shifted outputs between phases A/B/C.

The 3-phase AC alternator output is normally provided on a 3-pin “MT30” type connector (female):



In case the 3-phase generator output is used, the user system must absolutely make sure that the following conditions are always met:

1) No generator loading during engine start-up or cooling phase → To avoid interference with engine start-up where the alternator is used/ actively powered as a starter motor by the ECU system, the user sided power conditioning system must be safely disabled until engine has reached idle rpm!
2) Generator loading by external circuitry is limited to below shown diagrams (depending on actual alternator size installed with engine).
   The user system must make sure that these limits are not exceeded at any time, otherwise damage of generator and/or coupling system may result!

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Generator output voltage/frequency in relation to engine rpm

The frequency and voltage of the generator AC-power output varies proportionally with engine rpm according to the following formulas:

AC-frequency [Hz] = engine rpm [1/min] * Generator_poles / 120
AC-output voltage[V] = engine rpm [1/min] / Gen_Contant

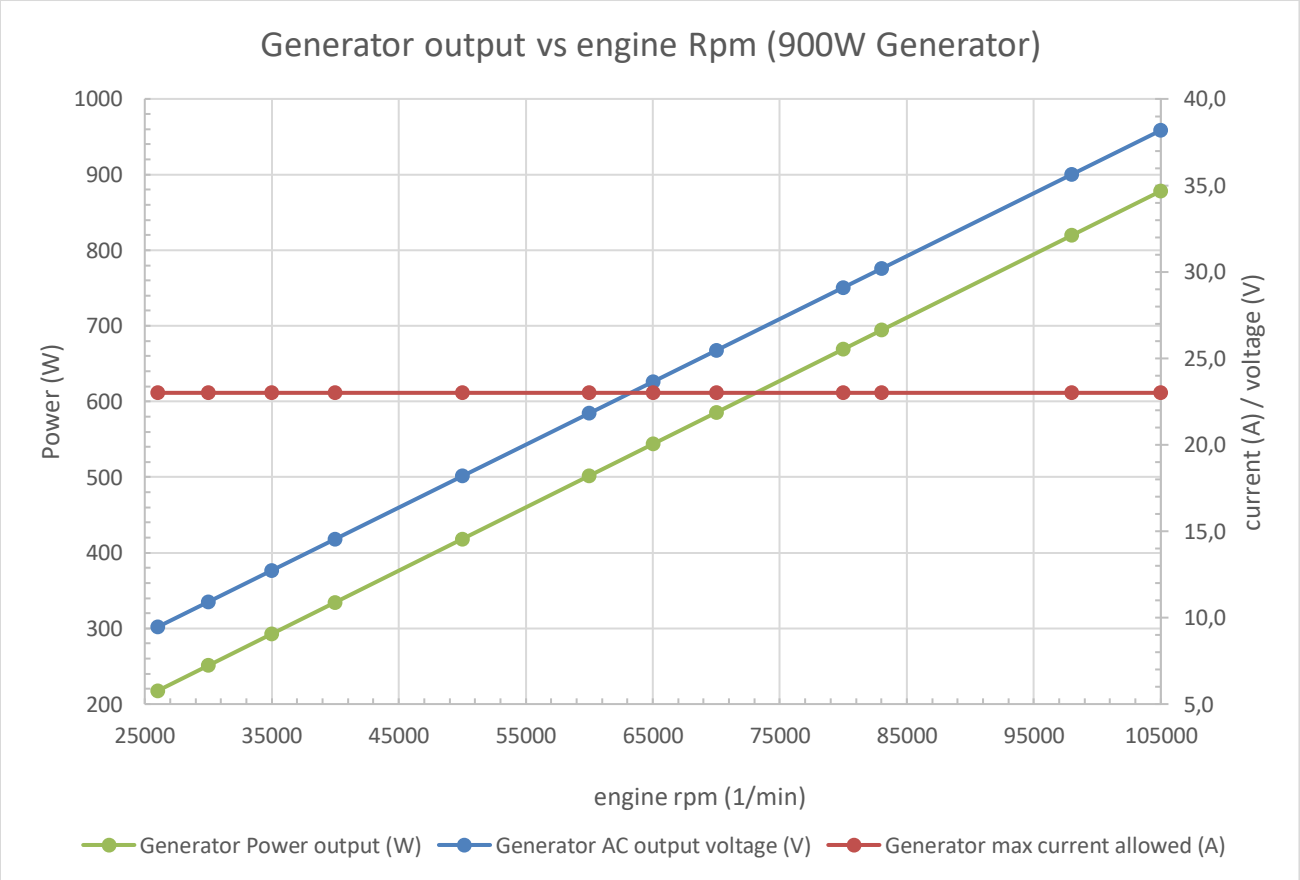
Example:

Engine rpm: 40.000 [1/min]
Generator_poles: 2
Gen_Contant [rpm/V]: 1900 [rpm/V]

➔ AC-frequency [Hz] = 40000 * 2 / 120 [Hz] = **666.667 Hz**
➔ AC-output voltage [V] = 40000[rpm] / (1900 [rpm/V]) = **21.05 V**

P300/P400/P500/P550 Generator data (GH-Versions)

Max generator power:	900 W	Generator_poles:	2
Gen_Contant [rpm/V]:	2750 [rpm/V]	Max current:	23 A



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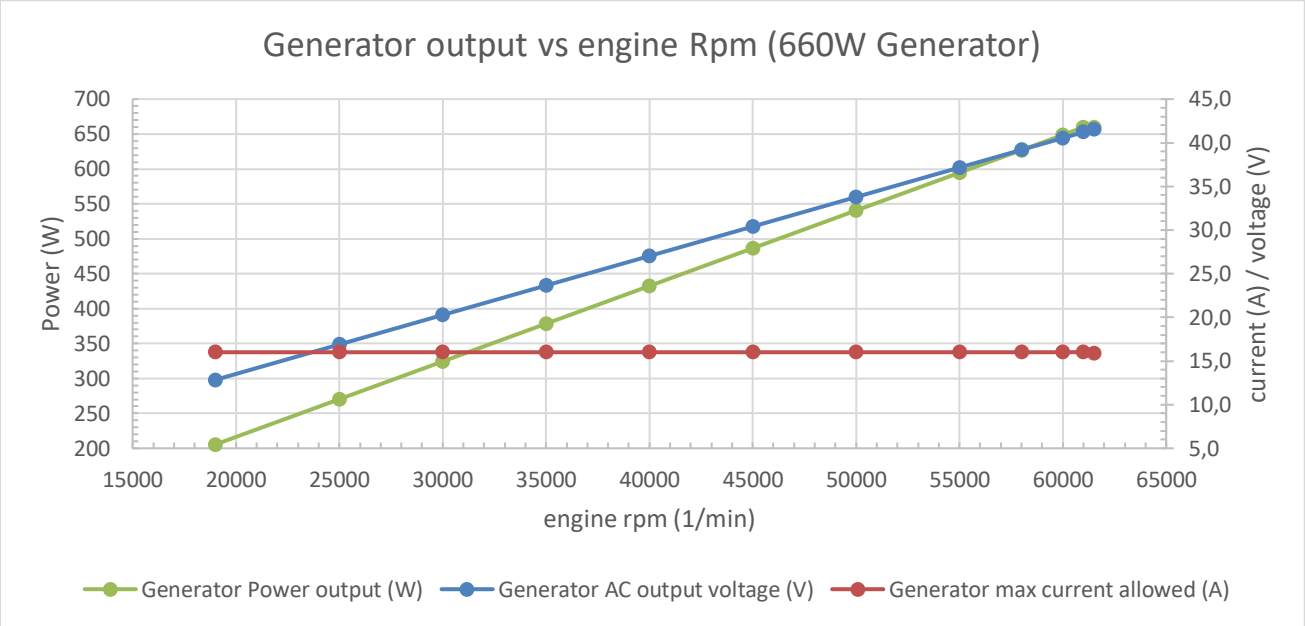
P1000 Generator data

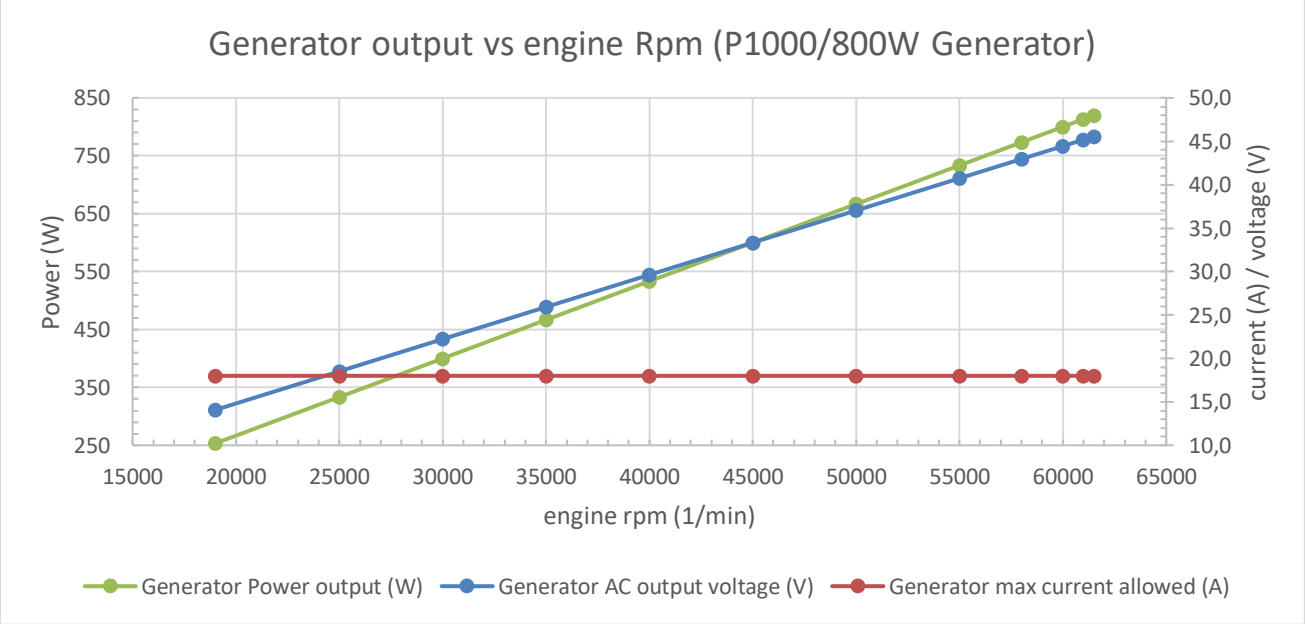
660W Generator (Standard):

Max generator power:	660 W	Generator_poles:	6
Gen_Contant [rpm/V]:	1480 [rpm/V]	Max current:	16 A



800W Generator (optional):

Max generator power:	800 W	Generator_poles:	2
Gen_Contant [rpm/V]:	1350 [rpm/V]	Max current:	18 A



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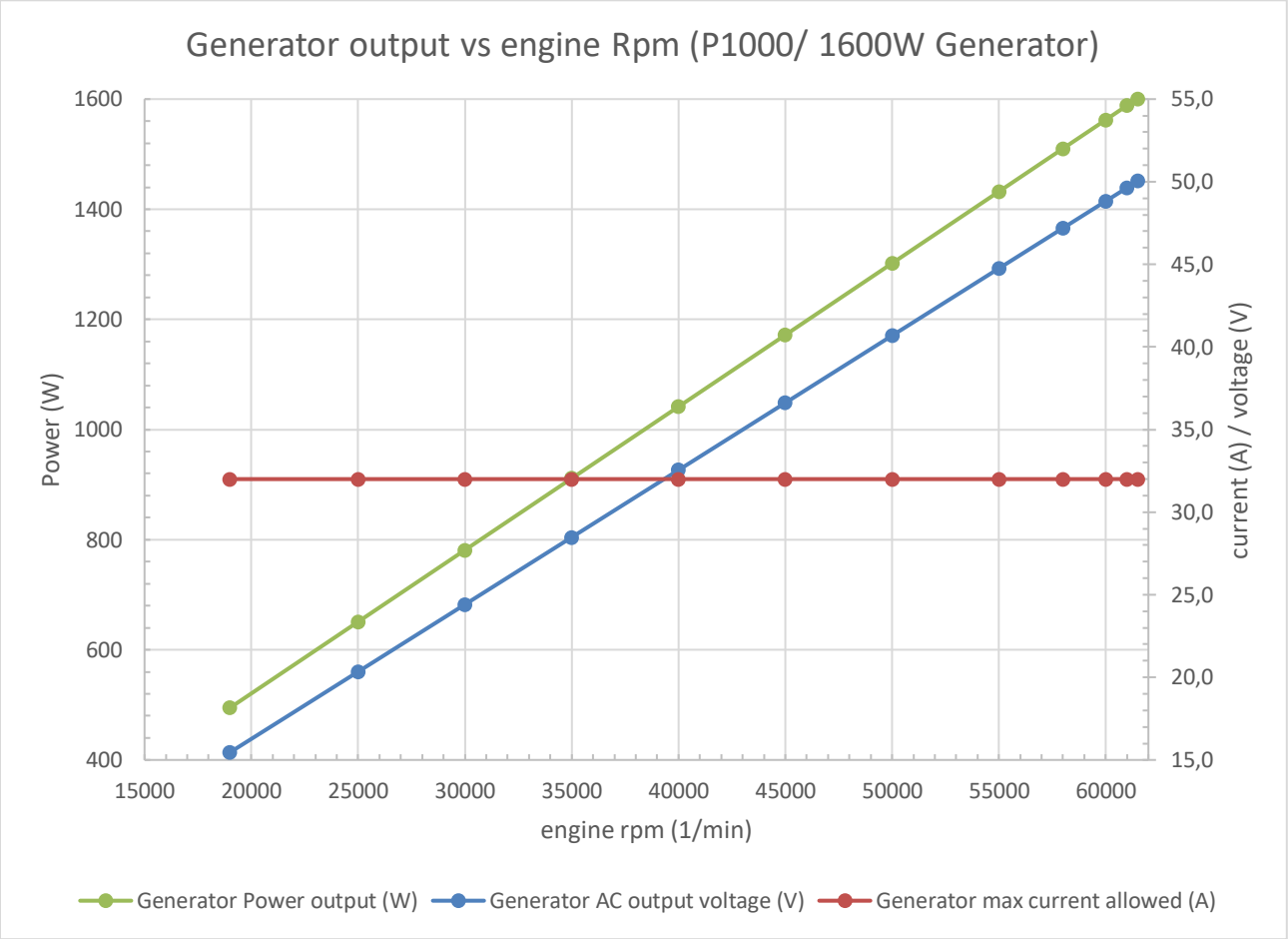
1600W Generator (optional):

Max generator power:	1600 W	Generator_poles:	2
Gen_Contant [rpm/V]:	1230 [rpm/V]	Max current:	32 A



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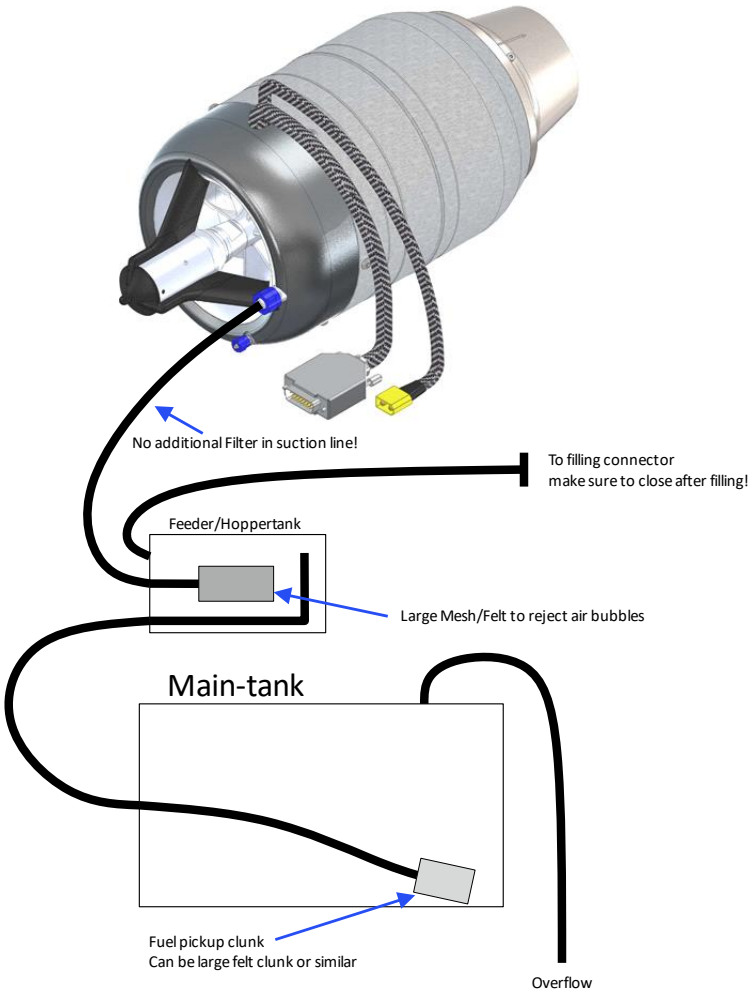
Fuel connector port

Fuel

- Use JetA1 premixed with 5% JetCat Turbine Oil
- Pre-filter the fuel when filling the fuel tank.
- Use a large size header tank in front of the engine, for additional fuel filtering and removal of air bubbles. The use of a “normal” fuel filter in the fuel supply line is not recommended, due to possible generation of cavitation air bubbles!

Fuel Connection Diagram



Do not use a filter in the suction line to the engine just an UAT air trap or large felt clunk!!!
On engines above 400N thrust two felt clunks in parallel might be needed not to restrict flow, or one high flow felt clunk from JetCat.

☞	The fuel demands are high, especially on larger engines, and require large tubing interconnecting the tanks. Use short connections and large diameter tubing’s.

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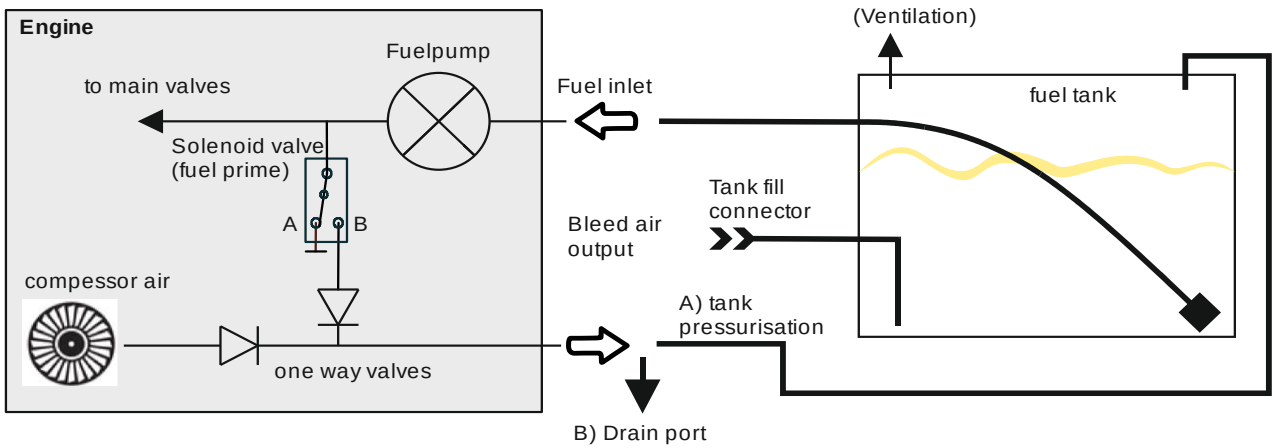
Fuel priming, integrated priming valve feature (P1000 only)

For easy fuel priming, the P1000 engine provides an integrated “fuel prime” solenoid valve
This allows for easy and safe fuel system priming (fill / deaerate fuel supply lines). This is accomplished by “sending back” the fuel aspirated (via the integrated fuel pumps) back out through the bleedair outlet port. This optional function can be software enabled and allows an easy and secure way to prime the fuel supply lines without any risk to accidentally dump fuel into the engine during the priming process.
In addition, an “auto priming function” can be activated which will do the priming automatically prior to every engine run and/or only if desired.

For this system to work, the only thing required, is to make a “loop back” connection from the engines bleed air output back into the fuel tank.



During normal operation, the “fuel prime solenoid” is switched to position A. In this case the bleedair pressure will be present at the bleedair output port (for optional tank pressurisation). The integrated one-way valves would prevent accidental flow back from the (pressurised) main tank back into the engines compressor system and/or fuel system.

During fuel priming, the “fuel prime solenoid” is switched to position B. In this case fuel aspirated by the fuel pump will be send back out through the bleedair port. Fuel will then flow back either into the fuel tank (“A), tank pressurisation”) or to a dedicated drain port (“B) Drain port”).

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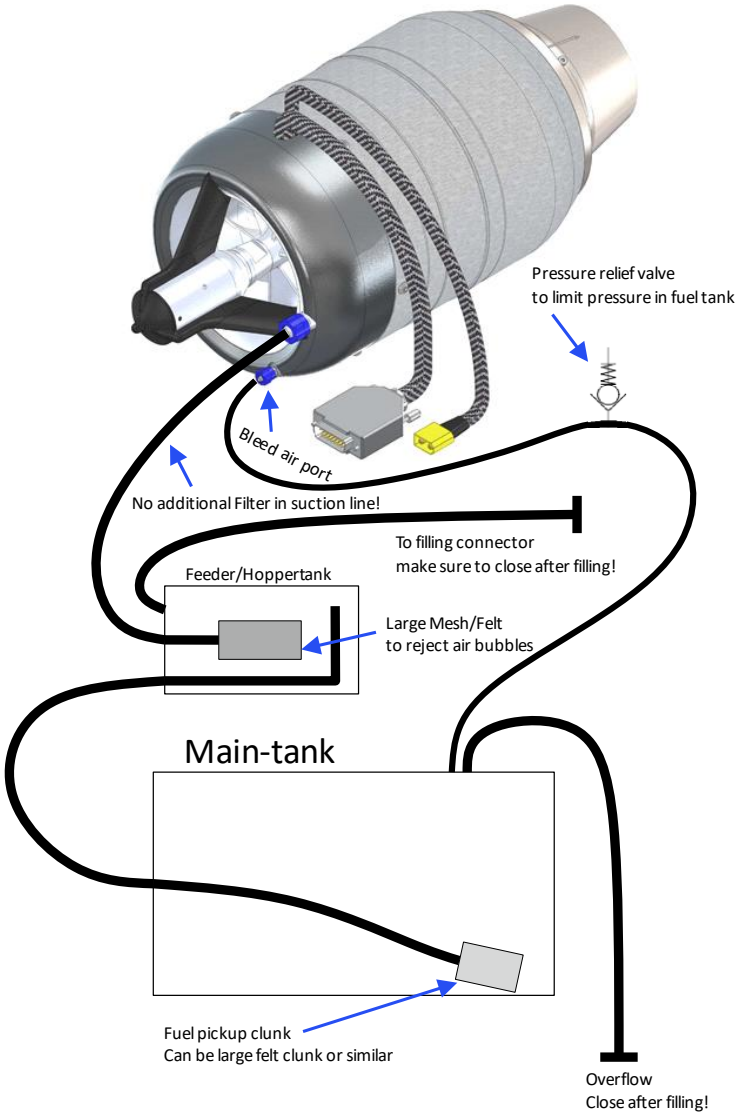
Bleedair port (optional) ; Pressurization of fuel tank

The bleedair port can provide compressed air derived from the engine's compressor stage.
In order to avoid any possible reverse flow back into the engine, an internal one-way valve is provided on the engine side. As the bleed air can be hot/warm, the use of a Teflon/PTFE tubing for the first 20cm is recommended!
The pressure on the bleedair port depends on the engine's operational rpm. On full power a pressure of up to 3,5 bars can be reached!
In case bleed air is not required/used, please block the outlet by a piece of crimped tubing.

Typically bleed air is used to pressurize the onboard fuel system to avoid degassing/bubbling of the fuel on high altitude operation of the engine (>5000m).
For full operation of this feature an additional pressure relief valve needs to be fitted in front of the fuel tank in order not to over pressurize the fuel tank!
The pressure relief valve should have a recommended relief pressure of 0,3-0,7 bars.

Fuel Connection Diagram, pressurized fuel tank



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JetCat PRO-Interface

By using the "JetCat-PRO" interface, not only can all PRO engines easily be used in RC-model applications, but it also provides a ready-made solution, and easy interface point for educational and industrial applications.
It also provides full functionality of our JetCat Telemetry-Adapter if desired!
Furthermore, the PRO-Interface allows for an easy access point to connect other accessories such as:

- One or two channel RC control (from receiver)
- Telemetry output for: Jeti, Graupner Hott, Multiplex M-BUS and Futaba SBUS-2
- RJ12 jack for connection of GSU
- Air Speed sensor header
- 6 and 8 pin ERNI flat cable connectors (e.g., for connection of LCU / Mini GSU)
- RS232 header for computer control
- CAN-Bus header
- Header to JetCat BMS (Battery Management System)
- Cross check communication port (for interconnecting / synchronizing two engines).
- 3x Status LEDs

Analog and digital inputs for:

- Power On/Off
- Engine On/Off Control
- Engine RPM command/ control via a directly connected potentiometer

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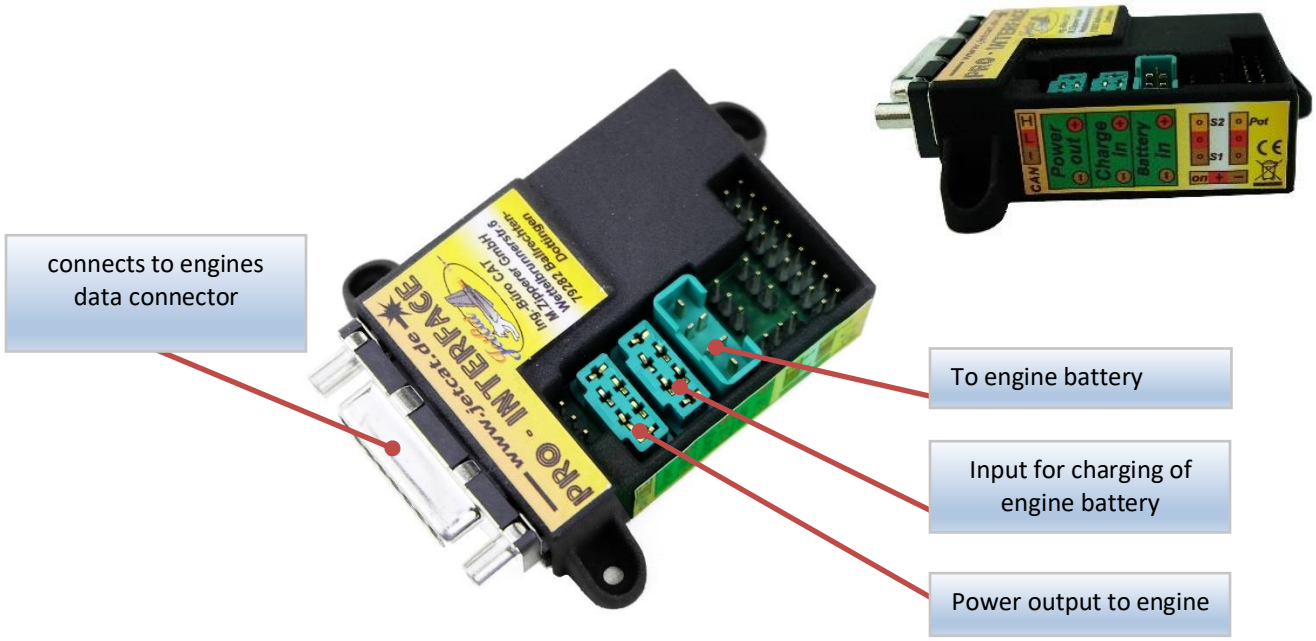
Connection Overview, PRO-Interface

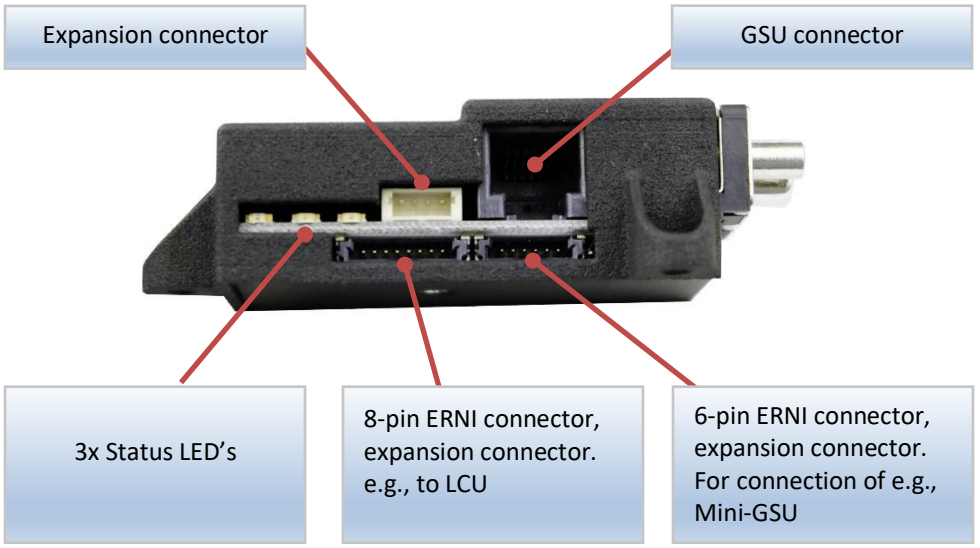
Top view:

Battery and engine connection



Side view:

GSU/LED´s and expansion connectors



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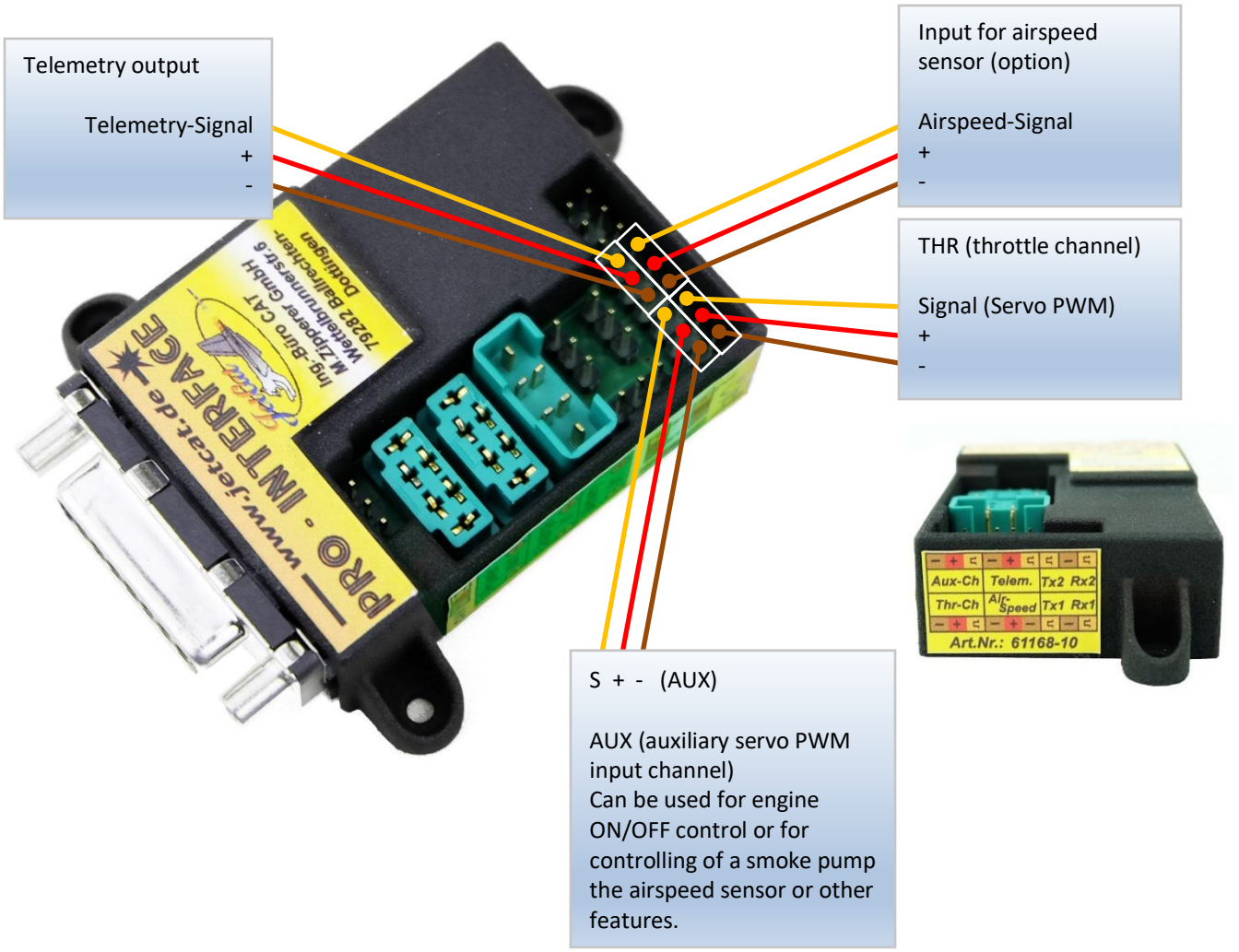
RC-Servo PWM inputs / Telemetry output /Airspeed input

The engine can be controlled by 1-2 Servo PWM inputs. If Servo PWM control is desired, at least the THR channel needs to be connected.

Power on via RC-signal

Besides the control function, the positive supply voltage on the servo inputs (THR/AUX) is used to power up the ECU/engine!
This means the ECU/engine will switched on as soon as the receiver is powered up / or when a voltage on the “+” pin of the servo inputs is supplied to the PRO-Interface.



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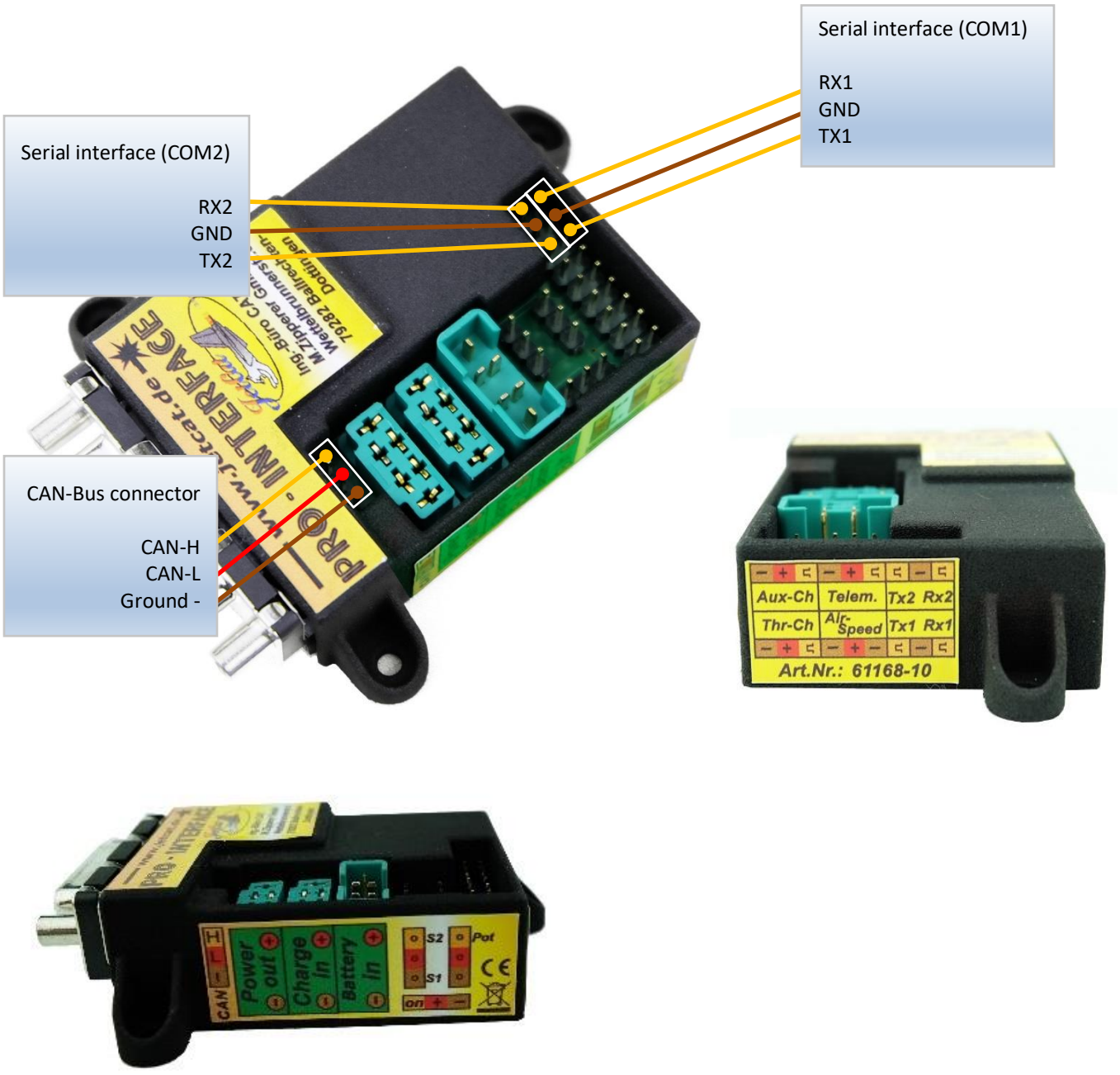
CAN-Bus / Serial port connectors

The engine provides a CAN-Bus interface as well as two serial interfaces (COM1/COM2).
COM1 is the main control interface, COM2 is used for special tasks as e.g., synchronizing two engines (cross checking feature). Signal level on COM1/2 is 3,3V TTL per default. COM1 signals are also fed out on the GSU connector.
Protocols for the CAN interface as well as the serial communication protocol can be obtained from JetCat on request.



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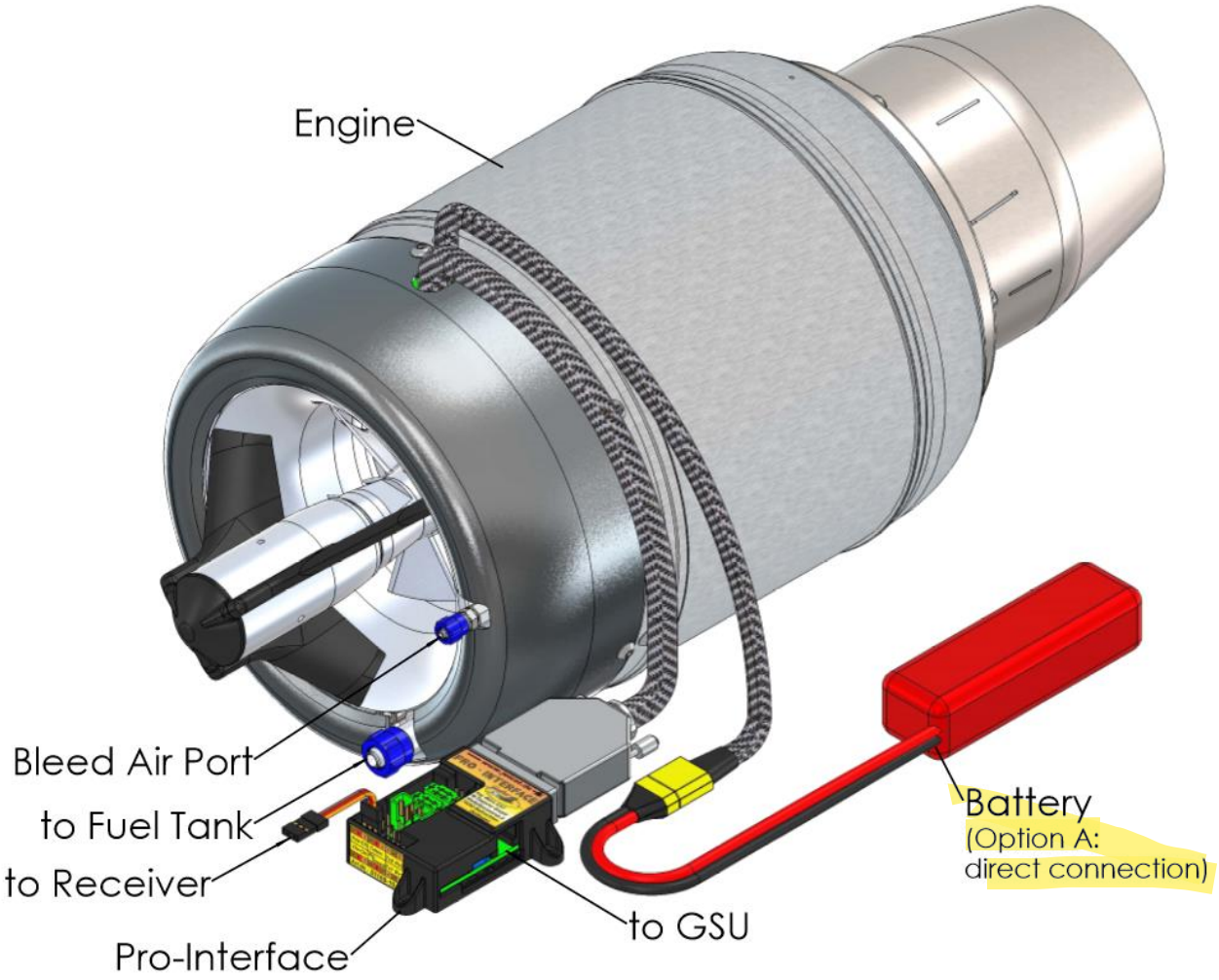
System Connection diagram with PRO-Interface

Connection diagram A); Direct battery connection



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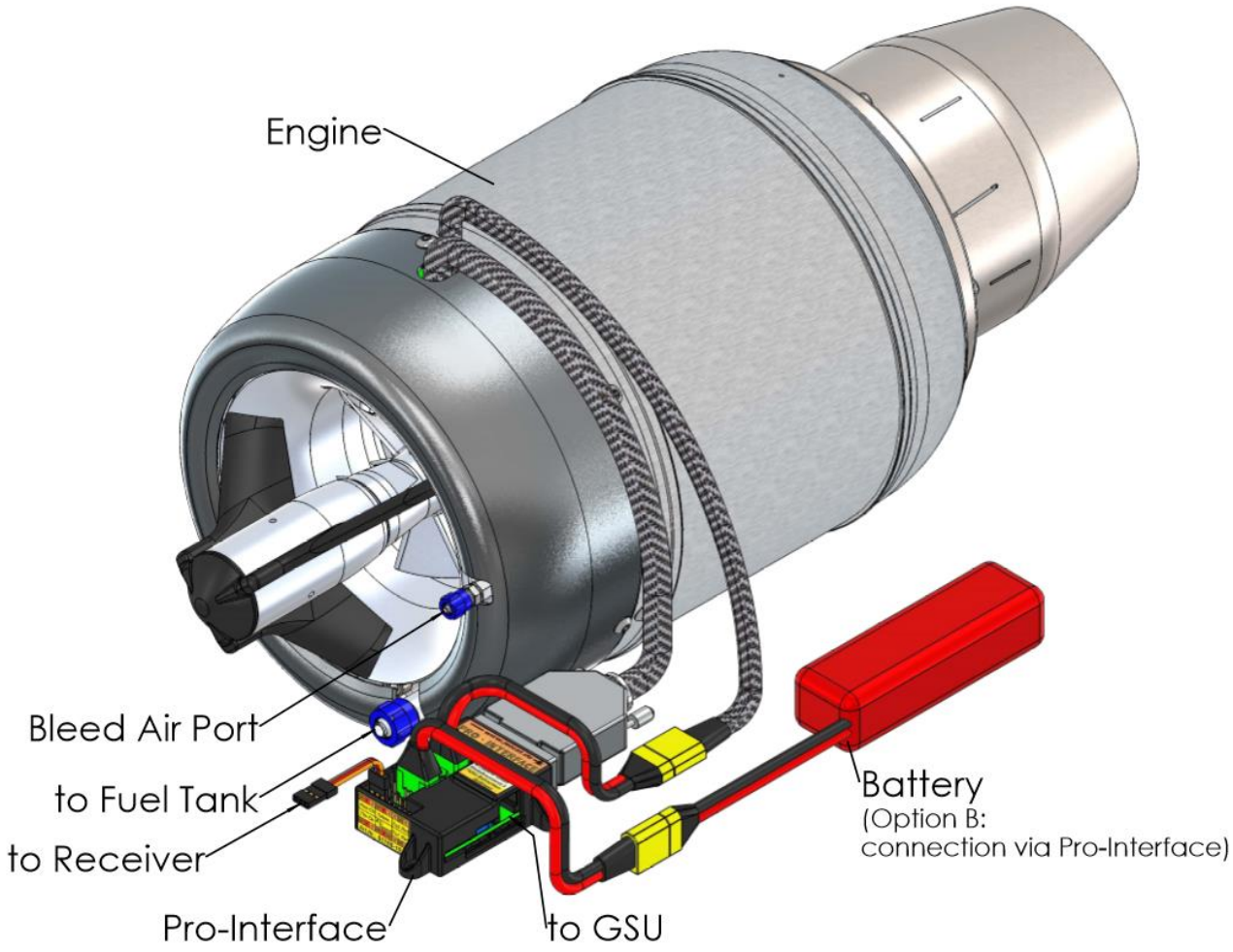
Connection diagram B); Battery connection via PRO-Interface



This way of connecting the battery allows for easy charging of the battery via the Pro-Interface

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Ground Support Unit (GSU)

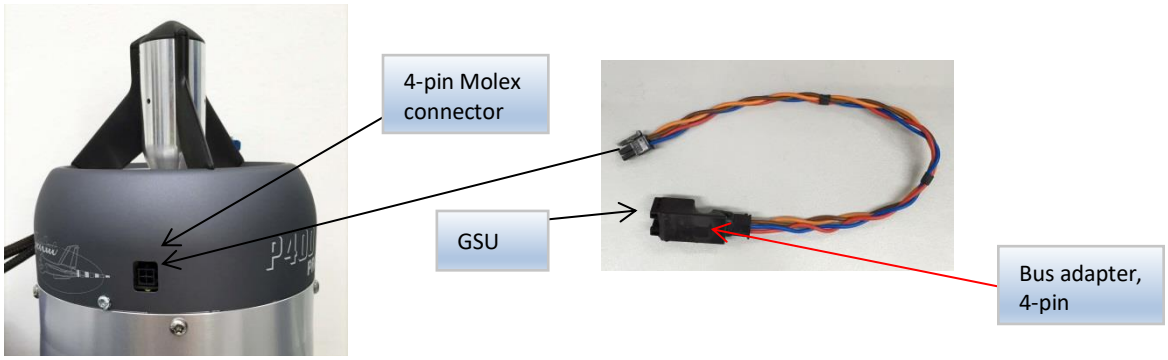
The GSU serves as a terminal for displaying and programming engine parameters. It may be connected or disconnected at any time. The real-time nature of the ECU allows the operator to adjust the engine parameters, even when the engine is running.

Connection of GSU:

There are different ways to connect a GSU to the JetCat-PRO engine:

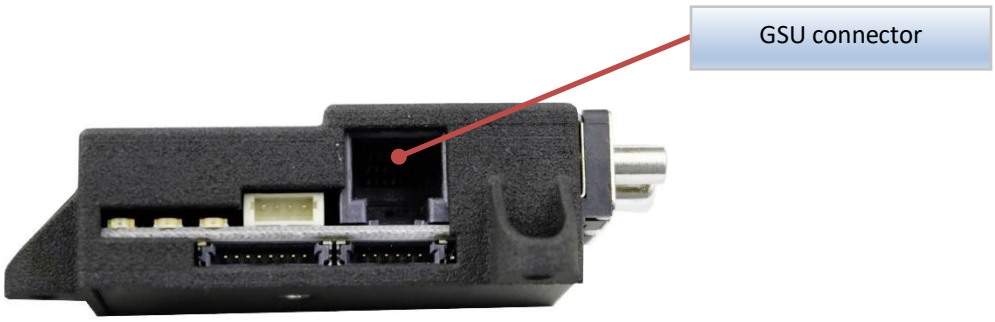
A) GSU connects to engine sided 4-pin Molex connector

- A GSU can be connected to the engine sided 4 pin Molex connector via Interface adaptor:
  This 4pin Molex connector also allows to connect e.g., a smoke pump or LCU.
  It supplies switched battery power and data to the devices attached.



If the GSU is connected this way (via 4-pin Molex connector), there is no serial interface connection available on the GSU connector!

B) GSU connects to the JetCat PRO-interface



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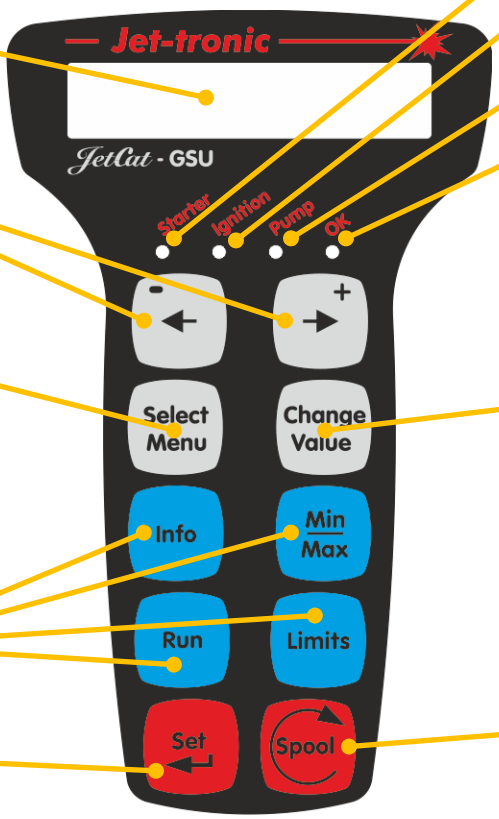
GSU Control Panel Descriptions



Alphanumeric, 2 line by 16 characters, backlit LCD display

-◄- or ► + Scroll within a menu or through different menus. Also used for changing parameter values

Select Menu key for selecting different menus in conjunction with the -◄- **or** ► + keys

(4) Hotkeys Directly enters the menu named on the corresponding blue key

SET – Enter parameters for several functions or together with "Set" key to direct start/stop engine from GSU

Starter - LED, (yellow)

Ignition - LED, (red)

Pump running - LED, (red)

OK - LED, (green)

Change value key for altering engine parameters in conjunction with the -◄- **or** ► + keys

Spool – Runs starter motor for testing or together with "Set" key to direct start/stop engine from GSU

OPTIONAL: Mini GSU, Part# 61161-0000
With all the functionality of the larger version and, because of its small size and weight, it can be mounted in the model providing direct access to all information and functions.

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GSU Button Descriptions

Key	Explanation
Info	Directly displays the **Info** menu (Hotkey).
Run	Directly displays the **Run** menu (Hotkey).
Limits	Directly displays the **Limits** menu (Hotkey).
Min/Max	Directly displays the **Min/Max** menu (Hotkey).
Select Menu	When the **Select Menu** key is pressed and held, the -◄- or ► + keys are used to select another menu. When a desired menu is reached, release the **Select Menu** key, and your selection becomes the currently displayed menu.
Change Value/Item	When the **Change Value/Item** key is pressed, and held, the -◄ or ► + keys are used to change the indicated value. If the value is admissible to change, a small arrow appears in the display before the value. If the indicated value cannot be changed (e.g.: current RPM or temperature), the display will indicate that the "Value/Item cannot be changed".

☞	Please take the time to understand the table above especially the descriptions for the **Select Menu** and **Change Value/Item keys**. These are often used for viewing additional menus other than the Hotkey menus and for changing ECU settings.

Description of LEDs on the GSU

Colour	Designation	LED is ON	LED flashes
Yellow	**Starter**	Starter Motor engaged	---
Red	**Pump**	Fuel pump is on	Kerosene glow plug defective or engine power / data cable is disconnected
Green	**OK**	Turbine running: throttle control active	If the engine is running, the EGT is exceeding the maximum temperature. If the engine is off, **Slow Down** mode is active
Red	**Ignition**	Ignition (glow plug) is on	---

☞	If the yellow **Starter** and green **OK** LED's blink simultaneously, the battery is low and must be recharged.

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Operation modes

The JetCat-PRO engine allows for different modes of operation:

- Operation mode for propulsion of RC-models (typically radio-controlled models)
- Industrial operation mode 0, normal altitudes
- Industrial operation mode 1, for high altitude operation of the jet engine, without altitude controlled low rpm governing.
- Industrial operation mode 2, for high altitude operation of the jet engine, with altitude controlled low rpm governing.

Per default the “Industrial/high altitude” mode is pre-set!
Before making other adjustments, it is highly recommended to first set the desired operation mode and thereafter make other adjustments, as switching the operation mode will automatically redefine some other settings!

Industrial operation mode, normal altitude

This mode allows for engine operation over a normal altitude range (0-2000m).
If selected, there are further options to “simulate” (dry run) the engine. This allows e.g., to test the serial communication without hot running the engine.

Industrial operation mode, High altitude-A, without altitude controlled low rpm governing.

This mode allows for engine operation over a wide altitude range (0-10000m). If selected the engine response will be more relaxed/slower to ensure safe engine operation in a very high-altitude band.
If selected, there are further options to “simulate” (dry run) the engine. This allows e.g., to test the serial communication without hot running the engine.

Industrial operation mode, High altitude-B, with altitude controlled low rpm governing.

Same as previous mode, in addition this mode will engage a governor system which will make sure that the commanded engine rpm is verified/limited not being possibly commanded too low for the actual flight altitude! When flying in higher altitudes, the user otherwise needs to assure that the engine is operated/commanded above a certain minimum required rpm (otherwise too low mass flows can lead to an engine flameout, especially in altitudes above 4000m). The ECU will automatically increase idle rpm to a safe value for the actual flight altitude.
This mode is only available in firmware releases equal or higher to V12.01Q.

Operation mode for propulsion of RC-models

This mode ensures optimum throttle response times as well as safe operation of the jet engine for the use in radio-controlled models/applications. Expected altitude changes on a flight are expected to be less than 1000m.

Setup/adjustment of the operation mode

The operation mode can be changed with the GSU as follows:

1) Connect the GSU to the system and power up.
2) Once ECU has booted press blue “Limits” button on the GSU (this calls up the “Limits” menu)
3) Scroll through the Limits menu just using the +/- buttons until the parameter “Op-Mode” is displayed.
4) Now press and hold the “change value/item” button and select the desired Op-Mode with the +/- keys.

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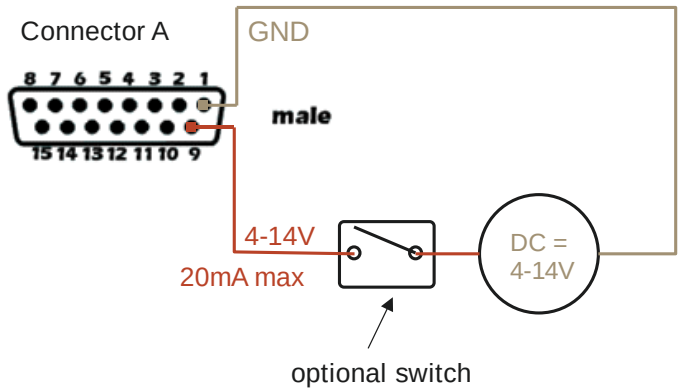
Engine Power ON/OFF

Engine is powered on when a positive control voltage (4-14V) is applied to pin 9 of the 15pin SUB-D connector, with Pin 1 connected to GND.

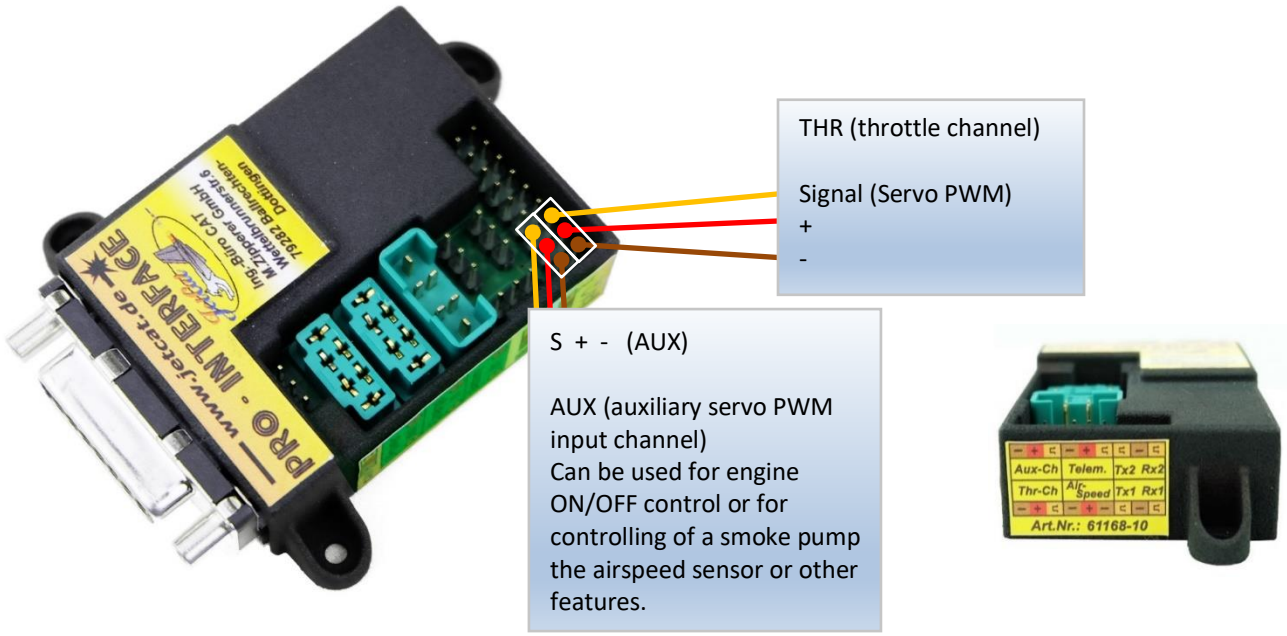
Engine power ON control signal



When using the JetCat PRO interface this can be accomplished like this:

Power on via RC-signal from receiver

Whenever a voltage is applied to at least one of the RC-PWM inputs (between the "+" and "-" pins), the engine will power up. In a typical RC-model configuration this will happen automatically whenever the receiver system is turned on.



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Engine control

Control Options

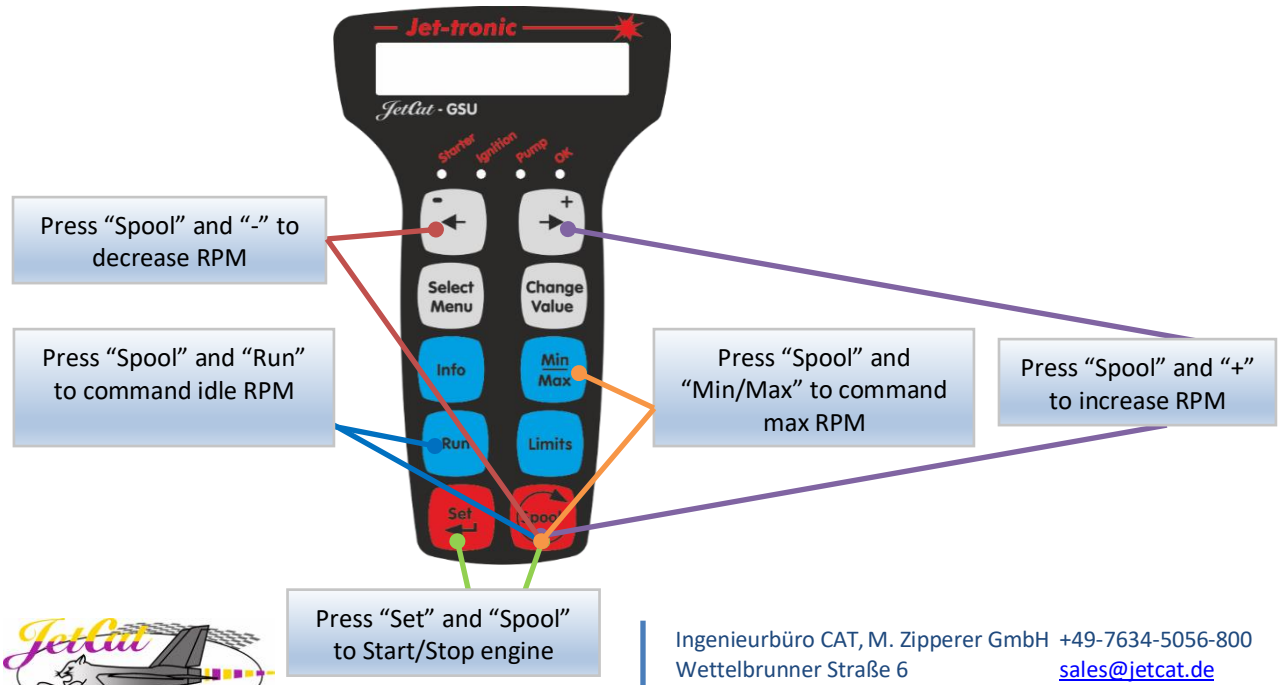
Engine control (on/off/throttle commanding) can be done in various ways:

- Control via GSU (manual)
- Control via analogue Signal (0-2,5V) fed into Airspeed input
- Control via Servo-PWM signal(s)
- Control via serial communication protocol (COM1)
- Control via CAN-Bus
- Control via Switches/Potentiometer connected to PRO-Interface

Control via GSU

With the GSU connected, the engine can be controlled with the following keys:

Action	Buttons to be pressed	Comment
Engine Start/Stop	Press and hold “Set” and additionally press “Spool”	If engine is Off, engine will be started If engine is running, engine will be shut off
Increase Rpm	Press and hold “Spool” and additionally press “+”	Only if engine is running and green “OK” LED is on
Decrease Rpm	Press and hold “Spool” and additionally press “-”	Only if engine is running and green “OK” LED is on
Go to idle Rpm	Press and hold “Spool” and additionally press “Run”	Only if engine is running and green “OK” LED is on
Go to full Rpm	Press and hold “Spool” and additionally press “Min/Max”	Only if engine is running and green “OK” LED is on



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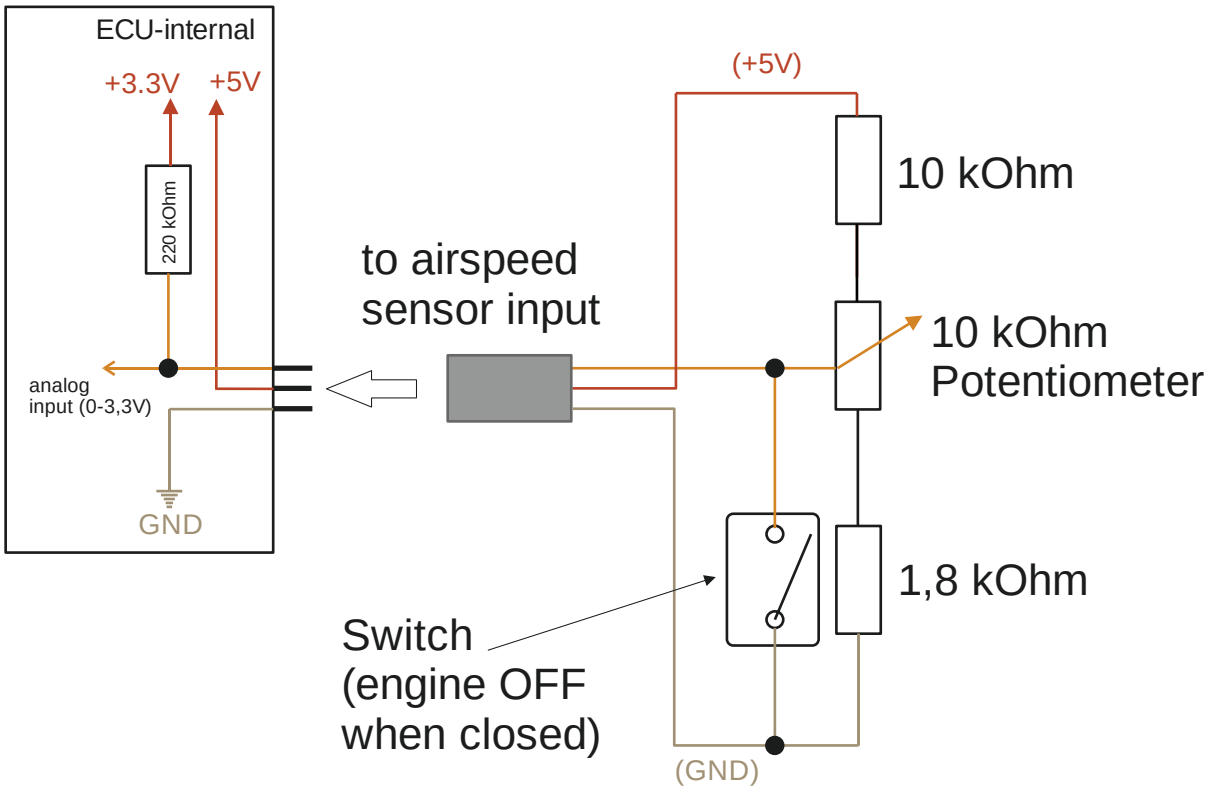
Control via analogue signal (0-3,3V) fed into Airspeed input

The ECU allows to use the analogue input, normally used for the airspeed sensor, to be used for the throttle control signal.
For this special mode, the engines "Operation mode" needs to be set to one of the "Industrial" modes and the parameter "THR-Ctrl Input" needs to be set to "Airspeed Signal". Both settings can be found in the Limits menu. If set like this, obviously the airspeed signal is no longer available.

A suggested typical wiring of e.g., a potentiometer for engine thrust control to this input would then look like this:



Potentiometer Position	Switch Position	Action	Resulting approx. control voltage
Left (min) position	Closed	Engine OFF	0V
Right (max) position	Closed	Engine OFF	0V
Left (min) position	Open	Engine idle	0,41V
Right (max) position	Open	Engine full power	2,7V
Potentiometer/switch circuitry disconnected	---	Error → Off	>3.13V treated as error/failure

If the potentiometer circuitry should accidentally be disconnected to the analogue input, the signal would internally be pulled high (3,3V), allowing the ECU to detect this as a failure and shutting down the engine.

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For the system to work correctly, the input needs to be "teached in" one time prior to be used. For "teach in" please follow the instructions given in chapter "*Teach the ECU to the R/C System*" (page 40 step 2).

Control via Servo-PWM Signals

Single or two channel Operation?

The engine may be operated with either one or two channels from your RC receiver (throttle only or throttle and an auxiliary channel). If single channel is selected, starting, stopping, and controlling the power is all accomplished with just the throttle channel. If two channel operation is selected, an auxiliary channel can be used to start, stop, or optionally control other special features of the ECU like the smoke pump and airspeed control explained later in the manual. Most commonly, one channel is used.

How to set your ECU for single channel operation

Single channel operation can be selected automatically by not connecting the auxiliary channel cable to the receiver. When you are in the **learn R/C** mode, it will detect the auxiliary channel is not plugged in and will automatically change to single channel operation (auxiliary channel = **Not Used**).

To manually select one or two channel operation, follow the instructions below. This is required for changing from single to two channel operation.

- Plug in the GSU and power up the system.
- Press the **Limits** key.
- Using the ►+ key, scroll through the selections until **AUX-channel func** is displayed.
- There are three selections in the **AUX-channel func menu**. While pressing the **Change Value** key, use the ◄ - or ►+ key to scroll through these selections.

ON Turb Ctrl ON	Aux channel enabled for engine control enabled.
ON Turb Ctrl OFF	Aux channel enabled for speed limiter functions and/or Smoker. Turbine control disabled. You still need to use the AUX channel for speed limiter and/or smoker functions but the engine control will be in Single Channel Mode.
Not Used	Single Channel Mode. Totally disable the AUX channel input for engine control, speed sensor and smoker functions. AUX channel wire does not need to be connected to the receiver in this mode. If Not Used is selected and you have a speed sensor, the Maximum Limit Speed is still active, limiting the maximum speed your plane will fly. You cannot disable this safety function.

Setup failsafe mode

The ECU has the unique ability to shut-off your engine if you have a radio failure. This is accomplished by detecting that the signal from the receiver's throttle output is either missing or outside the values that were learned during setup.

YOU ARE REQUIRED TO USE THE FAILSAFE!

This will not instantly shut off the engine. A timer is started when the failsafe condition occurs, and the engine will immediately go to idle. After 2 seconds (AMA requirements as of March 1, 2004) the engine will then shut off. This 2 second timer is reset back to zero anytime a non-failsafe condition is met. Your R/C signal must be broken for at least 2 continuous seconds before the engine is shut off.

☞	The following failsafe instructions are for PCM or Spread Spectrum receivers only. (PPM Receivers are not allowed under AMA rules.)

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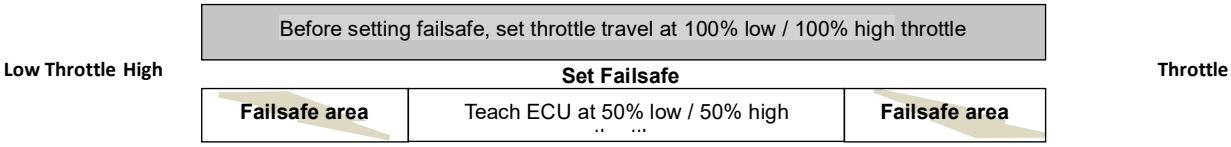
Setting the failsafe

The following procedures are for most radios like JR, Futaba, or Airtronics/Sanwa →
If you look at the following servo travel graph below, you can see how the ECU detects a failsafe condition. The grey bar is the transmitters throttle channel end points set for +/- 100% travel. This is the travel range when setting the transmitter's failsafe. The white bar is a reduced end point travel set for +/- 50% travel. This is the value that will be taught into the ECU. If the throttle input to the ECU is between 50% for low throttle, low throttle trim and 50% for high throttle, then this would be within the ECU's taught range and will operate normally. If a failsafe condition exists, the transmitter's pre-programmed 100% low throttle, low throttle trim will be outputted by the receiver and this value would be outside of the ECU's taught in range. The ECU will now automatically set the engine to idle (after a default 0.1 second **Failsafe delay**) and start a programmable timer. The timer is set to 2 seconds by default. If the timer times out, the ECU will shut-off the engine. If at any time during this countdown the receivers signal is reacquired, the ECU timer will be reset, and the engine will go back to the speed the throttle stick is currently at.
Setting the travel range to +/- 50% does not affect the RPM range of the engine.



☞	If you change your transmitter's failsafe after these steps are completed, you must redo the following instructions again**.**

FOR TWO CHANNEL OPERATION: Do not enable the auxiliary channel in your transmitter for failsafe. Keep it in **hold mode** only. The auxiliary channel is always designed to stop the engine instantly if commanded to do so.

For spread spectrum radios, there are two different ways to set the failsafe. It is either accomplished by the transmitter's failsafe menu or by binding the receiver to the transmitter. Refer to your transmitter's manual on how to set the failsafe.

To set the failsafe, you must execute the following steps. It is **VITAL** that these steps be performed in this order for the failsafe feature to operate properly. **YOU MUST PERFORM THESE STEPS!**

- Inspect the transmitter programming to ensure that dual rates and exponential functions are disabled, and sub trim is set at zero for both throttle and, if two channel operation, the auxiliary channel. Some transmitters have a travel limit menu in addition to travel end points menu. If so, set the limits to its maximum amount >= 100%
- Set your transmitters end point travel parameter to +/- 100% for low and high throttle.
- If you are using two channel operation, position the auxiliary channel to the centre position.
- Set your transmitters throttle stick to low throttle and low throttle trim. Depending on the radio system you are using, either set the throttle channel for failsafe and store/memorize this minimum position or bind your receiver to the transmitter.
- Return to the travel end point menu and now set the low and high throttle end point to +/- 50%.
- Now you must teach in these values into the ECU. Refer to **Learn R/C** section next in this manual.

Additional Failsafe menus are explained in the manual's advanced section.

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Teach the ECU to the R/C System

Before the ECU can be used for the first time you must program the failsafe and learn the throttle stick and optionally the auxiliary control positions of your R/C system.

To accomplish this, complete the following steps:

1. Connect one or both ECU servo cables to the receiver depending on either using single or two channel operation. The "**THR**" cable connects to the throttle channel and if used, the "**AUX**" cable must be connected to a channel capable of three (3) positions or a variable control. Make certain that all other connections are made in accordance with the **Electrical Connection Diagram**.
   Note: Even if you do not use the auxiliary channel for control, you can still plug the **"AUX"** cable into an unused receiver channel for a redundant power signal connection. However, if this is done, you must manually disable the auxiliary channel in the limit's menu.
2. While pressing the **Select Menu** key on the GSU, switch on the receiver/engine.
   Note: Instead of the **Select Menu** key on the GSU, the small button switch on the LED I/O board may be pressed instead. This key can also be used to advance through the **learn R/C** sequence (described below). This feature is useful when the GSU is not available. Keep in mind that the LED's on the I/O board are the same as the GSU for **Standby**, **Pump running** and **OK**.

   Release Select Menu only after the three LED's display the following blink sequence:

LED	Blink Sequence							
Standby/Man.	Yellow	⊙	○	○	⊙	○	○	
Pump runningRed	○ ⇨	⊙ ⇨	○ ⇨	○ ⇨	⊙ ⇨	○		
OK	Green	○	○	⊙	○	○	⊙	....

   The GSU screen will display:

   Release button to memorize/teach the positions of the throttle and AUX channels…

3. This procedure enables a system mode, whereby the ECU can learn the stick positions. When **Select Menu** is released, only the green **OK** LED should illuminate. If the pulse width number is ":0 us" and the green **OK** LED is flashing rapidly, then there is a problem with the receiver output. Test with a servo and ensure the transmitter / receiver are working correctly. To test the connection, move the throttle stick and the pulse width number should change. If not, the **THR** cable is not connected to the correct channel.

   The GSU screen will display:
   ➔ Move throttle stick to idle position and throttle trim to minimum/off position!

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Next, press **Select Menu** or the LED I/O board button switch. This will store the R/C system's pulse width for immediate shutdown of the engine. The green **OK** LED will turn off and the red **Pump running** LED will illuminate for the next step.

4. Next step: Teach in of the throttle stick idle position

The GSU screen will display:
→ Move the throttle trim up to the idle position (keep throttle stick at idle)

Next, press **Select Menu** or the LED I/O board button switch. This will store the R/C system's pulse width for engine idle. The yellow **Starter** LED will turn will illuminate for the next step.

5. Next step: Teach in of the throttle stick max position

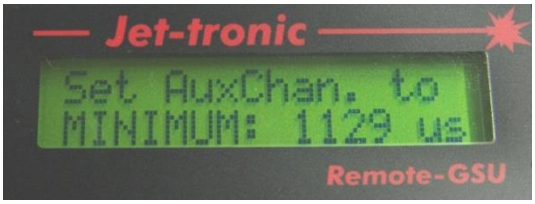
The GSU screen will display:
➔ Advance the throttle trim lever to maximum (keep throttle trim at idle).
(Throttle channel "**Full Power**" position)

Press **Select Menu** or the LED I/O board button switch again to store the R/C system's pulse width for the engine full throttle position.

Depending on the parameter "AUX-channel func" (Limits menu) is not set to "disabled", the teach-in procedure for the AUX channel would follow in the next step. In case the "AUX-cannel function" should be set to "Disabled", the teach in process will end here / continued with step 12, as with this setting the ECU is setup for single channel operation.
In case there would be no PWM signal detected on the AUX input, the parameter "AUX-channel func" would be automatically set to disabled and process would terminate/skipped to step 12.

6. Next step: Teach in of the AUX-channel position „0/OFF":

The GSU screen will display:
→ Set AUX channel to minimum "**Off**" position.



Next, press **Select Menu** or the LED I/O board button switch. This will store the R/C system's pulse width for AUX switch position 0/Off.

7. Move the auxiliary channel to the minimum position for **Off** and press **Select Menu** or the LED I/O board button switch again to store the R/C system's AUX pulse width for AUX position "0/Off". The green **OK** LED will turn off and the red **Pump running** LED will illuminate.

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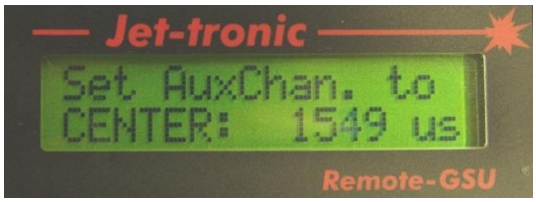
8. Next step: Teach in of the AUX-channel position „1/Center“:

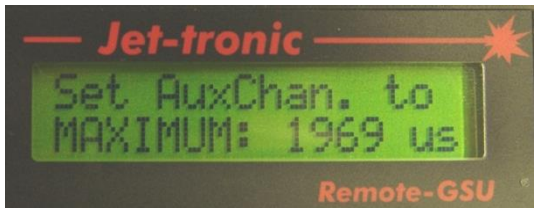
   The GSU screen will display:
   → AUX channel centre “**Start/Standby**” position



   Next, press **Select Menu** or the LED I/O board button switch. This will store the R/C system’s AUX pulse width for AUX switch position 1/Center. The red **Pump running** LED will turn off and the yellow **Standby** LED will illuminate.

9. Next step: Teach in of the AUX-channel position „2/Maximum“:

   The GSU screen will display:
   → AUX channel maximum “**Auto-Off/Maximum** ” position



10. Set the auxiliary channel to the maximum position for e.g., **Auto-Off** and press **Select Menu** or the LED I/O board button switch again to store the R/C system’s pulse width for a normal auto shut-off of the engine. The yellow **Standby** LED will turn off.

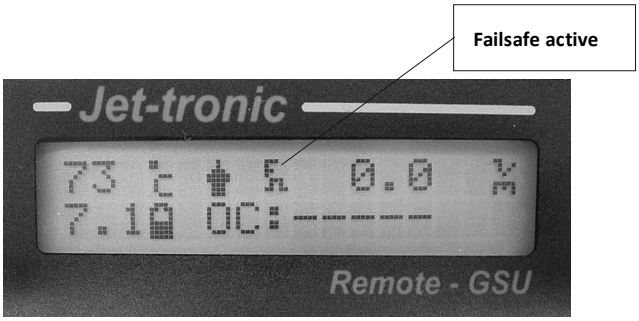
11. The green **OK** LED will flash and the display will briefly show “SAVING SETUP DAT“ and then return to the normal default **RUN** screen. Return the throttle stick and trim to the minimum position and the auxiliary channel (if used) to **Off** and the green **OK** LED will turn off. This completes the programming. The ECU will now permanently store the data. Repeating this procedure is only necessary when the R/C system is changed or adjusted.

    Note: This data is permanently stored in the engine. If you change ECUs, the engine data will be copied into the new ECU and the “**learn R/C**” will not need to be redone

Verify failsafe programming

You can verify the failsafe function in the default **RUN** screen with the GSU. With your receiver and ECU on, turn off the transmitter. After about two seconds a F should display on the screen.

Turn your transmitter back on and the F should clear from the screen. **The failsafe must function to operate the engine in a safe manner.**



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Throttle Curve

The translation function from “throttle command” to effective engine rpm can be defined via the parameter “Throttle curve” in the Limits Menu (page: 62).

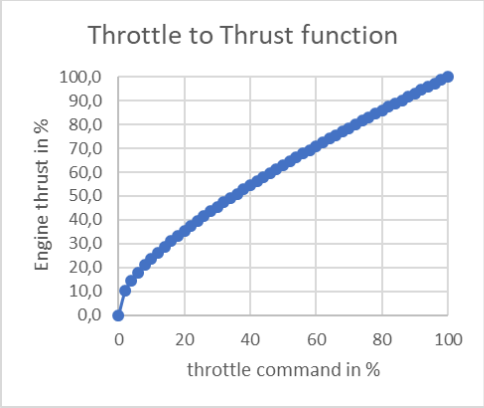
The throttle command input (from 0-100%) is derived from one of the following inputs/sources:

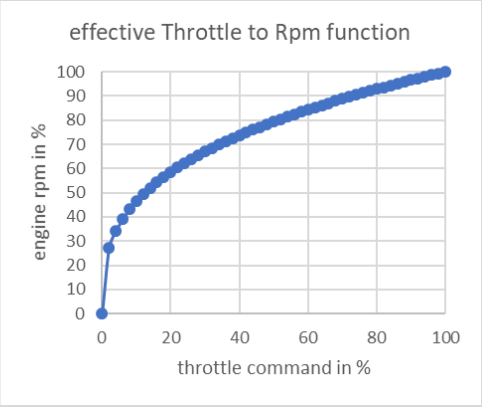
- Servo-PWM
- Analogue input
- Any commands coming in via RS232 or CAN-Bus which are commanding throttle percent values.

Per default the parameter “Throttle curve” is set to a value of **3.0** which in result gives a slight logarithmic relation between throttle command and effective engine thrust. For most applications this gives a good handling of the engines response versus throttle command. In case a perfect linear relation between throttle position and engine thrust is desired, the “Throttle curve” parameter can be set to a value of 2.0 (see example 2 below).

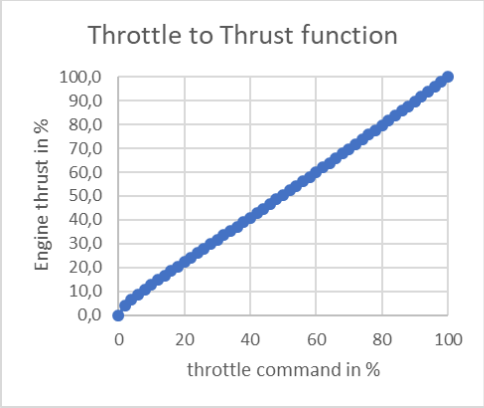
Examples:
In the following examples the transfer functions from throttle command to thrust and engine SetRpm are shown for different settings of the “Throttle curve” parameter. The 0% thrust point is referring to the engines thrust at idle; 0% Rpm point is referring to the idle Rpm of the engine.

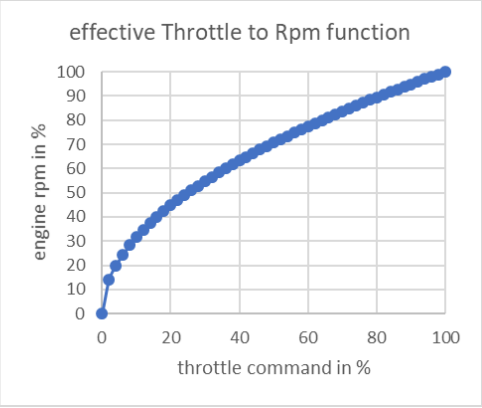
Example 1; Parameter „throttle curve“ set to **3.0** (default) gives the following relation:





Example 2; Parameter „throttle curve“ set to **2.0** gives the following relation (→ linear throttle to thrust curve):





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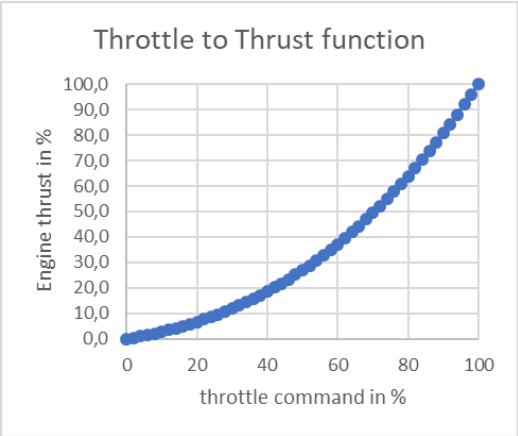
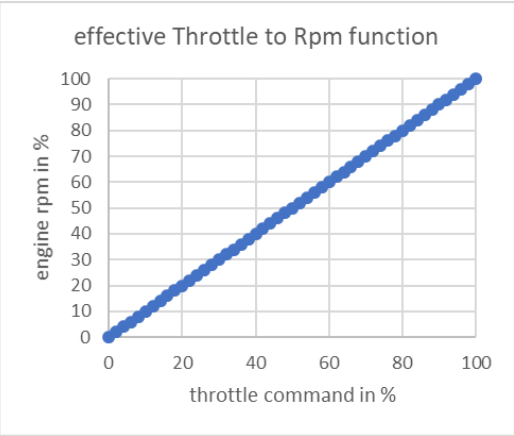
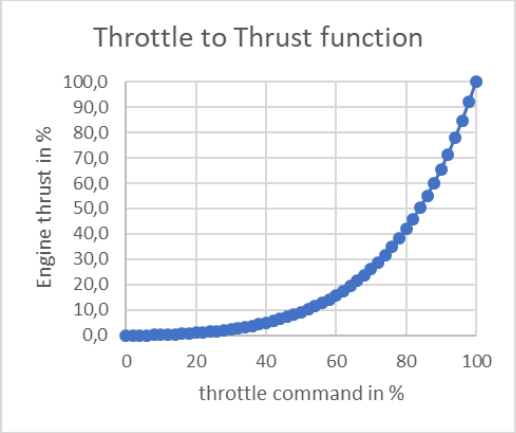
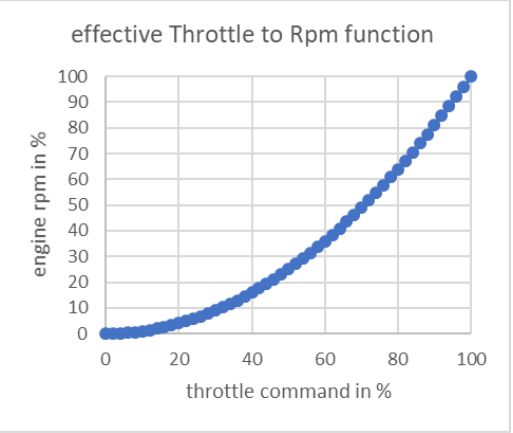
Example 3; Parameter „throttle curve“ set to **1.0** gives the following relation (→ linear throttle to rpm curve):



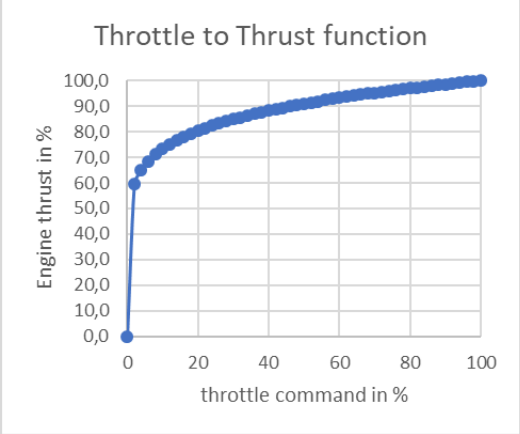


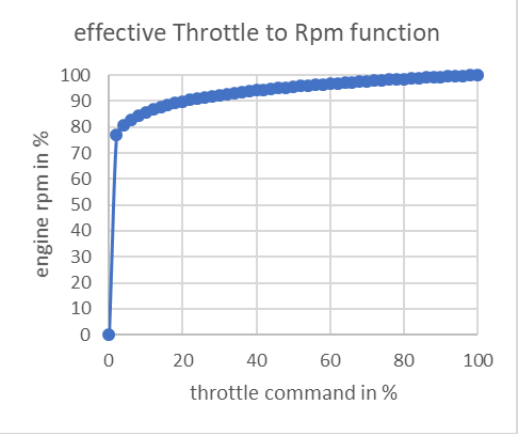
Example 4; Parameter „throttle curve“ set to **0.50** gives the following relation (exponential throttle to thrust curve):





Example 5; Parameter „throttle curve“ set to **15.0** gives the following relation:





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Control via serial Bus (COM1)

Please refer to our separate available documentation on the serial control interface.

Control via CAN-Bus

Please refer to our separate available documentation on the CAN-bus protocol.

Preparing fuel and fuel system

	**Warning!** Obey local laws for the transportation and storage of fuels. **Fire warning!** When mixing the fuel with oil or when operating (fuelling, defueling, etc.), never handle near an open flame. Please do not spill or empty fuel to the ground.

The ***JetCat*** engine can use deodorized kerosene, 1-K kerosene or Jet-A1 for fuel. Fuel must be mixed with 3-5% synthetic engine oil.
Example formula: 1 quart of oil in 5 gallons of fuel.
JetCat recommends low toxicity ***JetCat*** oil with anti-static additive or Aeroshell 500 engine oil although any engine oil that conforms to MS23699 standards will work.

To reduce static charges from the fuel system, we recommend adding our anti-static additive (Part# 61198-0000) or ***JetCat*** Turbine Oil (Part# 61197-0000) with anti-static additive already blended in.

	**Please note:** Fully synthetic **2-stroke oils or Mobil DTE** are not suitable and must not be used.

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Prime the pump and system

To prime the fuel pump and fuel lines (or for fuel pump test purposes), it is necessary to open the fuel solenoid shutoff valve and run the fuel pump manually. For this purpose, use the **Test–Functions Menu** selection, **Fuel Pump Test (Purge Fuel)**. This test opens the fuel valve and acts as a speed control for running the pump. **Note:** PRO engines have internal solenoids so the valve function is irrelevant.

	**Before activating the purge pump mode, ALWAYS remove the fuel feed line connected to the engine.** Pump Test / Purge Fuel allows the fuel pump to operate without the engine running. However, if the fuel feed line is not removed from the engine during this procedure; it will become flooded with fuel. When this occurs, the next engine start can become highly combustible!

Use the select menu key and select the **Test-Functions** menu.

	**Remember** when the **Select Menu** key is pressed and held, the ◄ - / ►+ keys are used to select another menu. When a desired menu is reached, release the **Select Menu** key, and your selection becomes the currently displayed menu.

Press the Change Value/Item key to run the pump. If you want to change the voltage the pump runs at, press either the ◄ - or ►+ while pressing the Change Value/Item key. It is best to lower the pump voltage back down to the 0.5V default amount when finished.

Note:
The priming function on the PRO engines should typically only be used to fill the fuel lines after initial installation of the engine. Make sure to stop the pump latest 2 seconds after the fuel has arrived on the input port of the engine, otherwise engine will be flooded with fuel (this can lead to fire and/or malfunction).

In case the engine should be de-installed, it is possible to run the pump in reverse direction by selecting negative pump values when priming the pump (via ◄ - key).
It is also possible to directly switch between forward/reverse operation by pressing the “Set” button alone. Pressing “Set” will toggle between positive (forward) and negative (reverse) pump voltage values.

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Running the engine for the first time

Initial Adjustments:

- Set-up operation mode:
  Before the engine is run the first time please check that the desired operation mode is set first.
  Per default the engine is set to “Industrial High altitude” operation mode. This might not be desired if the engine is to be used in an RC-controlled model, as throttle response times would be fairly slow then! See page: 34, Operation modes
- Set correct battery type:
  Check that the correct battery type is set/ matches the attached battery.

The Checklist

Before Running the engine

- Charge ECU Battery. **You must read and obey warnings on the LiPo/LiFePo battery pack.**
- Prepare CO2 fire extinguisher
- Check fuel lines. Make sure they are clean with no restrictions
- Check that the fuel tank vent is unobstructed
- Mix 5 % oil in fuel (i.e.: 1 quart per 5 gallons of kerosene)
- Fill fuel tank(s). Make sure the main and header tanks are full
- Turn on receiver switch
- Place the engine with nose into the wind

After Stopping the engine

- Turn engine into the wind. Stop engine.
- During the cooling process the receiver switch can be shut off at any time. When the cooling process is complete, the ECU will automatically shut off
- After each flying session, defuel the tanks before storing.

	**WARNING!** **In case of a mishap, fire extinguishers should be on hand at all times. *JetCat* recommends the CO/2 variety. Powdered extinguishers will corrode the precision components inside the engine and void your warranty.**

Starting and stopping the engine

1. Prepare to start by completing the start-up checklist.
2. Single Channel Mode start/stop procedure.
   a. To start the engine, place the throttle stick and trim to their minimum positions. Next, move the trim to its maximum position. Finally, move the throttle stick to its maximum position.
   b. When the throttle stick is set to the maximum position, the ECU will begin a fully automatic starting sequence. This starting sequence can be immediately stopped at any time by moving the throttle stick and trim to the minimum positions.
   c. To stop the engine after it is running, throttle up just above idle and let it stabilize for a couple of seconds, then move the throttle stick and throttle trim to their minimum positions. The auto-cool down mode will start when the engine has nearly stopped rotating.
3. Two Channel Mode start/stop procedure.
   a. Set the throttle stick and trim to their minimum positions and the AUX switch to the **Off** position.

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b. Move the throttle trim lever to its maximum position.
c. Set the AUX switch to the middle **Start/Standby** position. The engine is now ready to start!
d. Advance the throttle stick to its maximum position and the engine will start.
e. Once the engine begins to accelerate, the throttle stick can be returned to idle position.
f. When the throttle stick is set to the maximum position, the ECU will begin a fully automatic starting sequence. This starting sequence can be immediately stopped at any time by moving the AUX switch to the **Off** position and/or reducing the throttle stick and trim to the minimum positions
g. To stop the engine after it is running, set the AUX switch to the **Auto-Off** position. The engine will increase RPM above idle, stabilize and then shut off. The auto-cool down mode will start when the engine has nearly stopped rotating.

4. As soon as the engine stabilizes at idle speed, the green **OK** LED will illuminate, indicating that thrust control is now handed over to the pilot. The throttle stick must be in the idle position for the green **OK** LED to illuminate.

	When initiating a start, the LED's will blink in a continuous sequence of green to red to yellow. If the throttle stick is above minimum position when initiating a start sequence, the LED's will blink in a continuous sequence yellow to red to green indicating an error. Bring the trim to the maximum position and the throttle stick to the minimum position and this will correct the error condition.

After the start process is initiated, the following occurs:

1. The Kerosene-Igniter is pre-heated for approximately 5 seconds (the starter motor is not running).
2. Next, the starter motor spools up the engine to a constant speed and then starting fuel pulses into the engine until the combustion chamber rises above 120 degrees C. The yellow **Standby** LED will illuminate when the starting motor engages. Should ignition not occur, after a 30-second period, the process is aborted, and the green **OK** LED will blink.
3. Turbine RPM will progressively increase until achieving stable speed. When the engine speed surpasses the idle RPM value, the starter motor disengages, and the yellow **Standby** LED goes out.
4. As the engine approaches its stabilize RPM, it will briefly dwell, before automatically decelerating to idle RPM.
5. When the engine attains idle speed and the throttle stick is placed at idle position, the green **OK** LED will illuminate, indicating that thrust control is now handed over to the pilot.

Automatic Cooling Process

After the engine spins down from **Auto Off** or **Manual Off**, the starter motor will spin the engine rotor at a slow constant speed until the **E**xhaust **G**as **T**emperature is below 100° C.

	**ATTENTION!** **Two channel control only:** In unsafe situations (e.g.: a fire), the automatic cooling process may contribute additional oxygen. To immediately discontinue the cooling process, bring the throttle stick to idle, throttle trim to the minimum position and the AUX switch to **Off**.

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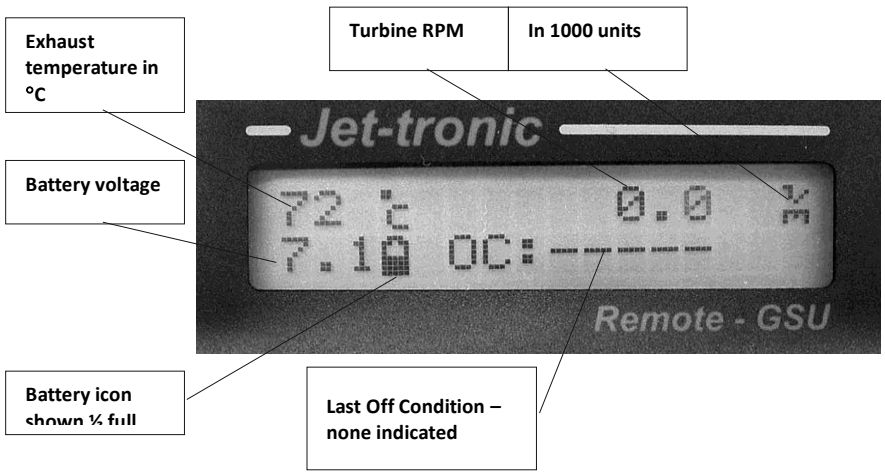
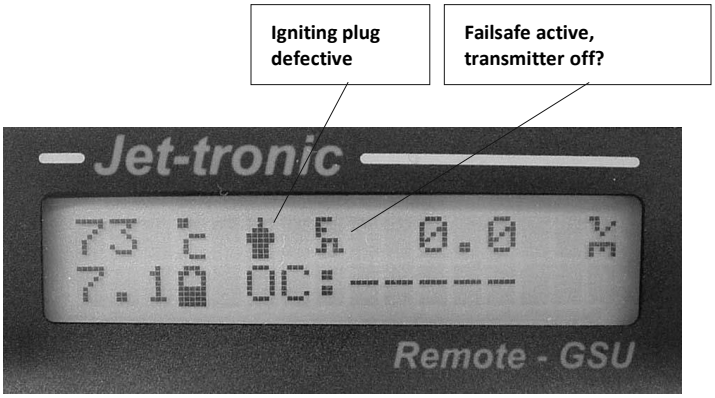
GSU (Run menu default) display symbols

Initial default display screen after power up



After power up – "error condition" display screen



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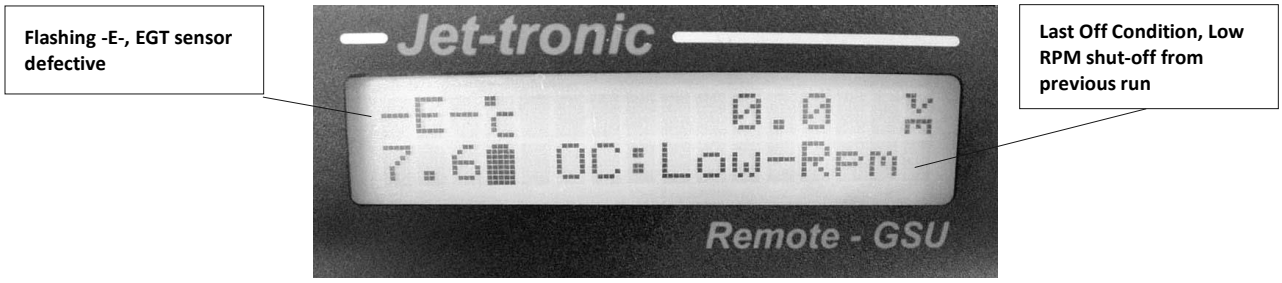
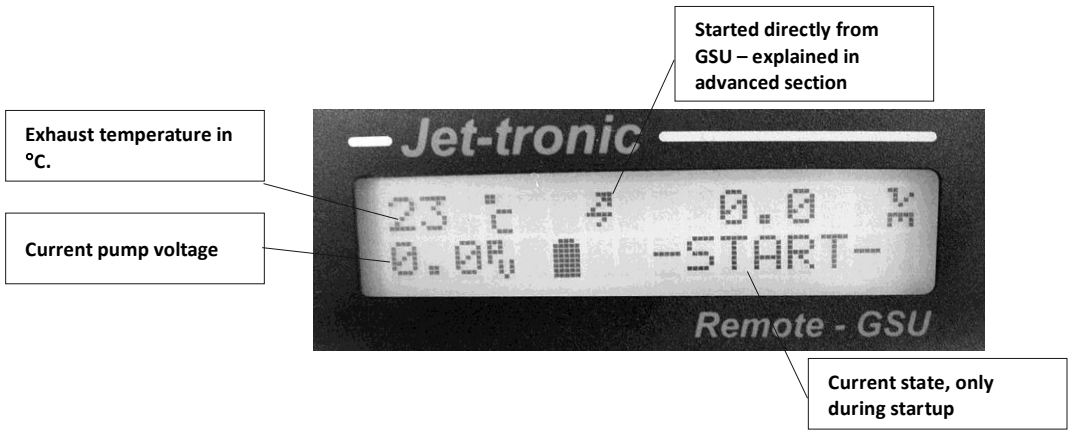
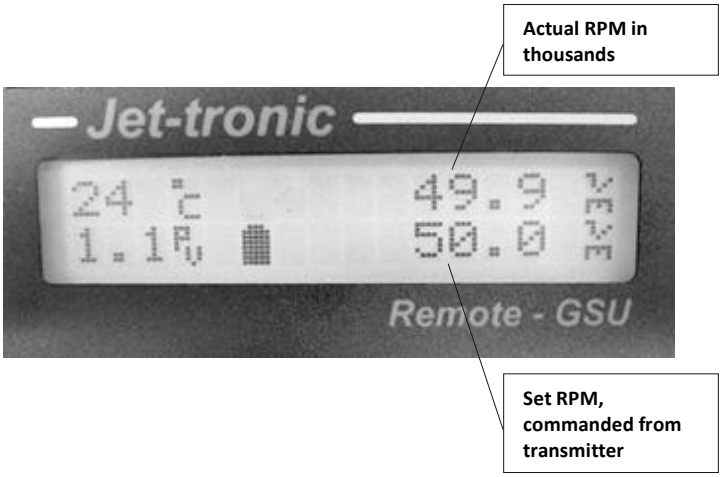


Engine starting display screen



Engine running display screen



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Engine Running States

The ***JetCat engine*** progresses through several operating states, from ignition to the cool down process. The transitions of these states are automatically controlled by the ECU and by user commands. The current value is always displayed on the GSU screen in the **STATE** selection in the **RUN** menu. When the engine is starting, the GSU will also display the current state on the bottom line of the display. Whenever the engine is in cooling mode or the starter is tested with the **Spool** key, the top line of the GSU display will flash "! – Cooling - !".

Explanation of the engine States

Table 1

Value	Explanation
-OFF-	AUX switch in the Off position and/or the throttle trim in the Off position. All LEDs are off. Turbine is off (preventing starting).
Standby / START	AUX switch positioned to the Start / Standby position, throttle trim at maximum and throttle stick at idle. The LED chase sequence is started from green to red to yellow, continuously. When throttle stick is advanced to the maximum position, the starter motor engages to spin the rotor. When RPM reaches a pre-programmed value, the starter motor's voltage is removed and the engine is ready to ignite.
Pre Heat 1	The burner is pre-heated for 3-7 seconds (the starter motor is not running)
Pre Heat 2	The starter motor spools up the engine to its ignition. After another few seconds the ignition of the engine is engaged by injecting kerosene into the Kerosene-Igniter. The pump and the internal starting fuel solenoid will begin pulsing.
MainF-On	Main fuel solenoid opens, and kerosene is modulated into the engine.
AccelDly	Delay while combustion chamber is preheating. Waiting for a rise in EGT.
Ker.Full	Starting fuel solenoid closes and all the fuel is now directed to the main injectors. The red **Pump running** LED turns on and will stay illuminated if the pump operates.
Stabil.	Turbine successfully accelerates to the idle RPM, then automatically increases speed to about 30% higher RPM. When this speed is maintained consistently for at least one second, the engine will proceed to the next state (**Learn LO)**.
Learn LO	In this state, the engine automatically decreases RPM to the idle speed. As soon as idle speed is attained, with the throttle stick in the idle position, the engine will proceed to the next state (**RUN (reg.)**).
Run (reg.)	Turbine in the normal running state; the throttle stick will regulate engine thrust. During this operant condition, the green **OK** LED will illuminate, indicating that pilot has control. (Red LED is already illuminated) **RUN (regulated)** continues, until the engine is switched off.
Auto Off	The AUX switch placed in the **Auto Off** position. Turbine automatically increases RPM if at idle and remains at that RPM for a few seconds before transition to the next state (**Slow Down)**.
Slow Down	During this state, the fuel shut-off valve is closed, and the fuel pump is stopped. The green **OK** LED blinks and the GSU displays !-Cooling-!, indicating **Slow Down** This condition will continue, until all the following parameters are met: • Turbine speed less than 800 RPM • EGT is less than 100 degrees C. • The AUX switch is moved to the **Off** position and throttle trim is moved to the minimum position

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	Once these conditions are met, engine proceeds to **Off**.
Speed Control	Speed Control mode -- only active when the air speed sensor is connected. Regulates model flight speed.

Table 2

Code	Value	Explanation
1	RcThrOff	throttle stick and throttle trim moved to the minimum/OFF position.
2	OverTemp	Turbine running over temperature. Exceeded high temperature parameter and time out.
3	IgnTimOut	Turbine did not ignite within programmed time interval.
4	AccTimOut	Turbine achieved ignition but did not accelerate within programmed time interval.
5	Acc.Slow	Turbine achieved ignition, but acceleration was less than the programmed value, during start-up.
6	Over-RPM	Turbine exceeded the maximum RPM, by 5% and a delay of 0.5 seconds.
7	Low-RPM	Turbine running under the minimum RPM, by 10% and a delay of 3 seconds. Usually triggered by a flame out.
8	BattryLow	Battery pack is dead. Cell voltage is < 1.0V.
9	Auto-Off	Turbine shut down via the AutoOff sequence, using the AUX channel.
10	LowTemp	EGT dropped below the minimum value. A dislodged EGT sensor can trigger this shut down.
11	HiTempOff	EGT exceeded the maximum range (~950 °C).
12	GlowPlug!	Defective kero/glow plug.
13	WatchDog	ECU processor was locked out usually from static discharge or voltage spike in power supply.
14	FailSafe	Turbine was shut down from a failsafe timeout condition.
15	ManualOff	Turbine was shut off by using the GSU.
16	PowerFail	The power failed to the ECU when the engine was running. This will occur if the power was lost because of a defective battery, connection or if the switch is turned off before the engine is shut down. Note: If this state is displayed the Info, Min/Max and Statistics menus retain information from the previous run.
17	TempSensor Fail	EGT sensor failed. Note: This could happen only during start-up.
18	FuelFail	Fuel sensor detected “out of fuel” condition. Only applicable on engines with fuel sensor!
19	Rpm2Fail	Second rpm sensor defective, only for 2-shaft engines
20	2nd EngF	Cross check enabled, and shut down was forced due to 2nd engine shut down
21	2nd Diff	Cross check enabled, and shut down was forced due to thrust differential
22	2nd Comm	Cross check enabled, communication error to 2nd engine.

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23	No-OIL	Not applicable for PRO engines
24	OverCurr	The electrical current to the engine is too high. Starter may be jammed Kero/glow plug is short circuited
25	No Pump!	There is either no pump connected, or the pump cable is defective.
26	Wrong Pmp	Wrong pump type, see pump configuration in the advanced section of the manual.
27	Pump Err	Communication to pump driver disturbed.
28	No Fuel!	Not applicable for PRO engines
29	LoRpmPmp	Pump driver problem
30	LowRpmFB	Rpm measurement subsystem error
31	!Clutch	Clutch of Starter motor does not disengage
32	EngMatch	Not applicable for PRO engines
33	CAN-TO	Engine has been started up via CAN-Bus, but then the CAN Bus has been disconnected (no commands received within CAN-timeout period)
34	NoRcPuls	Engine has been started up via THR channel, but then the THR signal has been disconnected.
35	RotorBlck	Rotor of engine is blocked
36	Kill Sig	The “Kill signal” was activated, which will turn off the power to the fuel solenoids as well as disable power to the pump(s) via an independent secondary hardware circuit. (See also: pinout of 15pin SUB-D connector)
37	ReStartX	AutoRestart was triggered and AutoRestart option is set to “MaxThrottle”. However, throttle stick was not set to max throttle position by user within 6sec timeout period → Restart aborted
38	RcAuxOff	Engine off commanded via AUX channel.
39	RS232Off	Engine off commanded via command received through serial interface.
40	CAN-Off	Engine off commanded via command received through CAN interface.
41	Test-Off	Engine off commanded via internal test cycle termination.
42	RS232-TO	Engine off commanded, as no serial communication was received within timeout RS232-timeout period.
43	PrHeatTO	Timeout during Preheat phase

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Troubleshooting

Most frequent errors. Cause and remedy:

Problem	Cause	Remedy
Turbine doesn't ignite	Fuel supply lines are empty or not purged	Purge fuel system. Use the Test Functions Menu, Purge Pump
	ECU battery weak or empty	Charge ECU battery
	The kero start igniter failed. The automatic glow plug test may not detect a failed igniter!	This is an extremely rare event, but the engine must be returned to ***JetCat***. It may be possible on some engine types to use a temporary external plug. Call ***JetCat*** for information.
Starting process fails	Turbine is still too warm. Cool Down not yet completed.	Wait until **SlowDown** sequence is finished. The green OK LED will stop blinking.
	Low battery or faulty connection.	Charge battery. Check ECU's battery connection.
	Glow plug defective (red **Pump running** LED blinks).	Replace defective glow plug.
	Three-conductor cable for starter motor and glow plug disconnected.	Check cable. Check for proper connection from ECU to the engine.
ECU doesn't follow full commands from the throttle stick	Programming alteration in R/C transmitter	Check alignment with RC-Check menu. Re-align ECU to the R/C system.
Turbine ignites, but the start process is discontinued.	Air in fuel feed lines.	Air leaks in fuel system. Examine all Festo fittings, nipples, clunk, filter, etc. Check for fuel filter clogs.
	Fuel pump not running.	Test the pump in Test Functions menu, (as soon as the red **Pump running** LED illuminates, the fuel pump must run!).
Starter unit slips, makes noise.	Dust and oil sediment on the compressor nut and O-ring.	Clean O-ring and compressor nut periodically, with cotton swab and solvent.
EGT giving erratic temperature or RPM readings.	Transmitter antenna too close to the model.	Keep the antenna away from the model. It may cause false readings.
Turbine quits with Watchdog Failure	Static discharge reset the ECU.	Do not mount ECU directly to the fiberglass body of the plane. Use a plywood mount with a layer of foam tape and Velcro between the body and the ECU. If the plane has a glossy finish and the failure happened directly after the

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		wheels left the ground, spray the tires with an anti-static spray available from electronic or hardware supply stores.

Reason for an unexpected Shut-Down

There are three ways to diagnose why the engine flamed out.

1. In the info menu the "LAST OFF-COND" variable will tell you why. For example, low RPM, high temp, fail-safe etc. **This parameter is non-volatile and will be available until the engine is run again.**
2. You can view the last 8 seconds of the flight before it shut-down. This data is updated every 0.2 seconds. This allows you to see the trend leading up to the shut-down. This mode is entered by pressing the "+" key of the GSU while powering up the ECU. You can scroll through the data using the (+ or -) keys and scroll forward and backward through time using the (info or min/max) keys. **This parameter is non-volatile and will be available until the engine is run again.**
3. You can download and view the entire flight using the optional serial adapter Part# A1028-USB and a PC.

If the off condition is "POWER-FAIL" then the data is not valid. This occurs if the ECU or receiver battery was disconnected or was intermittent or if the receiver power goes lower than 3 volts. In this case, the data in the system would be for the previous run.

Sample of displayed values

Tim: Time	**R:** RPM	**S:** Set-RPM	**EGT:** Temp	**Pmp:** Pump V	**Sta:** State	**Th:** Thr. pulse	**Au:** Aux. pulse	**Bat:** Batt volts	**AirS:** Air Speed	**SetS:** Set Air speed
-4.0	0	0	0	0.0	0	0	0	0	0	0

See the **Explanation for Turbine Shut Down** for a description of each state code.

How to diagnose a shut-down from the saved data

Symptom	Engine shut-off state	Possible Reason
Engine quits with a trail of white smoke.	Low RPM or Fuel Fail	This is normally caused by air in the fuel system. Make sure there is no leaks in the fuel system and most importantly, get all the air out of the fuel filter. The fuel filter should not be hard fixed to the plane but allowed to hang free. It is best mounted vertically. When you purge the fuel system, tap the filters while the pump is running to get all the air out them. **USE A BVM Ultimate Air Trap!**

	If the engine fails to ignite, you **CAN** get excess kerosene in the engine. **YOU CANNOT REMOVE EXCESS KEROSENE BY TILTING THE PLANE WITH THE NOSE UP IN THE AIR**. The kerosene will be captured by the exhaust guide vanes and will not run out of the engine. The nose must be tilted down towards the ground. The excess kerosene will then run out the intake. You may need a towel around the intake to absorb the kerosene. Clean off the starter O-ring afterwards since it may get kerosene on it as well.

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Manual advanced section

Smoker pump

The ECU can directly control a smoker pump for injection of smoke fluid (e.g. diesel oil) in the exhaust blast.

The function of the smoker pump can be defined in the “Limits menu”
(Parameter: „SmokerValve Ctrl“)

The possible option for the parameter „SmokerValve Ctrl” are:

Option	***Description***
DISABLED	The smoker pump/valve is not used, → always off!
Open if AuxSw=0	Smoke pump is activated if the AUX-Switch (3-Pos. switch) is brought into the **lower** position (“OFF”-Position) and the engine is running. To be able to use this function it is necessary, that the AUX-channel is activated, this is the parameter „AUX-channel func“ (see below) must not be adjusted to „NOT USED“.
Open if AuxSw=2	Smoke pump is activated if the AUX-Switch (3-Pos. switch) is brought into the **upper** position (“AUTO-OFF”-Position) and the engine is running. To be able to use this function it is necessary, that the AUX-channel is activated, this is the parameter „AUX-channel func“ (see below) must not be adjusted to „NOT USED“.

Attention!
Inject the smoke fluid rear the thrust tube to avoid flash fire of unburned fuel.
A one way valve inserted downstream of the smoker pump can help to avoid leaking of smoke fluid when the smoke pump is not running.

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Menu Structure

All similar data and running parameters are grouped in separate menus. Menus can be displayed, and their values modified (where accessible), by using the GSU.

Menu Selections

- RUN menu
- MIN/MAX menu
- RC-Check menu
- INFO menu
- STATISTICS menu
- LIMITS menu
- TEST menu

Selecting a Menu

The corresponding buttons (hot keys) can directly select the “Run”, “Info”, “MIN/MAX”, or “Limits” menus. An alternate method is to press and hold the **Select Menu** button and use the **+ / -** buttons for selecting. **Note:** this method is the only access to all menus.

Change Values / Items

To change an indicated value, press and hold the **Change Value/Item** button while using the **+ / -** buttons to alter its value. An arrow (→) will appear in front of the value, if it can be changed.

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The RUN Menu

As soon as the ECU is switched on, the **Run** menu is displayed.
In the lower display line, the actual engine RPM is indicated.
In the upper display line, the following selections can be monitored. Use the **+ / -** buttons alone for selecting the different parameters.

Value	Explanation
Temp.	Current EGT (**E**xhaust **G**as **T**emperature). The units, °C or °F can be selected in the LIMITs menu.
OffCnd **SetRpm**	Last Off command (reason for shut down). See table on page 28
State	Current engine state.
U-Pump	Current pump voltage.
Airspeed	Current Air speed (km/h) this readout is usual for function check of the speed sensor. Note: This readout is only supported by connected airspeed sensor.
Set Speed	Target state-air speed (km/h). This readout is for checking at the “speed control” mode the set target state-airspeed of throttle stick. Note: This readout is only supported by connected airspeed sensor.

The Min/Max Menu

The Min/Max menu is used primarily for diagnostics purposes. All the following variables may be sampled manually by pressing the **Change Value/Item** button on the GSU.

Value	Explanation
Upump-Max **Upump-Min**	Maximum pump voltage. Minimum pump voltage.
MaxTemp **MinTemp**	Maximum EGT. Minimum EGT.
MaxRpm **MinRpm**	Maximum engine RPM. Minimum engine RPM.
MaxAirSpd **AvgAirSpd**	Maximum Airspeed (*) Average Airspeed (*)
Flight Distance	Flight distance in km (*)
AvgRpm **MaxRTmp**	Average-RPM Average temperature at full throttle
AvgPump **AvgTemp**	Average pump voltage Average temperature

(*) Only by connected air speed sensor!

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The Min/Max values can be reset by pressing "Change Value „key.
The values are only valid during and after the actual run. By switching on the ECU they are reset

The R/C Check Menu

All parameters in this menu are for informational purposes only and will vary in accordance with R/C input.

Value	Explanation
Throttle% **StickPulse**	Position of the throttle stick (by percentage, 0-100%). Position units of the throttle stick.
AuxInp% **AuxPulse**	Position of the 3-position AUX channel (by percentage, 0-100%). Position units of the AUX channel.
Aux.Position	Position of the AUX channel control (0=**Off**; 1=**Start/Standby;** 2= **AutoOff**).
Fail Safe Count F	Indicate the numbers of Fail Safes since the ECU is active
Fail Safe Time **In seconds**	Indicate Fail Safe-time (sec.) the ECU recognized since it is active

Menu parameters are for informational purposes only and cannot be changed.

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The INFO Menu

Info menu displays the following information:

Value	Explanation
Rest Fuel	Remaining fuel in tank. Tank size can be entered using the **LIMITs** menu. Value is reset every time the ECU is switched on (or can be reset manually by pressing the **Change Value/Item** button on the GSU).
Fuel Flow ml/min	Actual fuel consumption in ml/min. Also specific fuel consumption is displayed in gr/N/h
BattCnd **Ubattery**	The condition of the battery is indicated in the upper line: **1. --OK--** **2. !WEAK!** **3. --EMPTY--** 1. If the battery voltage is 1.1V/Cell or higher "**—OK--**" will be displayed. 2. If the battery voltage drops under 1.1V/Cell, the display will read "**!WEAK!"**. Red **Standby/Manual** and green **OK** LED's will blink simultaneously (at a rate of twice per second). Starting the engine is not possible, until the battery is recharged. If the engine is already running and the battery warning function is enabled, the warning function will be activated. 3. If the battery voltage drops under 1.0V/Cell "—**EMPTY--**" is displayed. Starting the engine is not possible until the battery is recharged. If the engine is running, it will be immediately shut off, to avoid a malfunction of the ECU. Current voltage of the battery. Displayed on bottom line.
Baro **Temp**	Indicate the current barometric pressure. Temperature indicator (C°) in range of ECU
PressureAltit(m)	Current pressure altitude
LastAltitude(m)	Highest altitude reached during last flight (referenced to the altitude were the engine has been powered on)
Inlet Temp.T0 °C	Air Temperature at compressor inlet. Only on engines with T0 sensor (e.g. P1000)
Last Run Time	Last engine run time.
Last Fuel Count	Quantity of fuel consumed, during the last engine run.
Last-Off PmpVolt	Volts applied to the pump when it was switched off.
Last Off RPM	RPM of the engine, when it was switched off.
LAST-OFF TEMP	Temperature of the engine when it was switched off.
Last-OffCond	Last stored Off condition.
Last MaxTemp	Maximum temperature during the last engine run
Last MinTemp	Minimum temperature during the last engine run
Last AvgTemp	Average temperature during the last engine run
Last MaxR AvgTmp	Average full throttle temperature during the last engine run
Last StartTemp	maximum EGT during last engine start
Last MaxRPM	Highest rpm during the last engine run
Last MinRPM	Lowest rpm during the last engine run

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Last AvgRPM	Average rpm during the last engine run
Last Max Pump	Maximum pump voltage during the last engine run
Last Min Pump	Minimum pump voltage during the last engine run
Last Avg Pump	Average pump voltage during the last engine run
Last FailSafeCnt	Number of Fail Safe during the last engine run
Last FailSafeTim	Fail Safe Time in seconds during last run
Last-Max AirSpd	Maximum reached flight speed during the last flight (Only with connected Airspeed sensor!)
Last AvgAirSpd	Average flight speed during the last flight (Only with connected Airspeed sensor!)
Last Distance	Flight distance travelled during the last flight (Only with connected Airspeed sensor!)
Last MaxProp	Highest Rpm of second shaft (only on 2-shaft engines) during last run
Last MinProp	Lowest Rpm of second shaft (only on 2-shaft engines) during last run

Menu parameters are for informational purposes only and cannot be changed.
All “LAST” values show the results of the last flight, even if the ECU is switched off in the meantime. These results kept stored up to the next run of engine.

The Statistic-Menu

Value	Explanation
Total Run-Time	Total engine running time.
TimeSinceService	Total engine running time since last service.
Runs-OK	Number of successful engine runs, without errors.
Runs aborted	Number of engine shut downs, caused by the ECU’s safety system.
Ignitions OK	Number of successful ignitions.
Ignitions FAILED	Number of failed ignitions.
Starts FAILED	Number of failed starts.
Total fuel count	Total fuel consumption of engine
LoBatt Cut-Outs	Number of cut off due weak battery voltage
Serial No	ECU serial no

Menu parameters are for informational purposes only and cannot be changed.

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The LIMITs Menu

The LIMITs menu allows the operator to adjust the following parameters of the engine, within the allowable values, according to the performance requirements of a particular model.

Value	Explanation
Minimum RPM	Turbine idle speed (If **IdleRPM-SET** or **Idle&Ramp-Set** is enabled by **Barom.Auto Tune** it will further appear **(Auto)** in the display and the RPM is set by ECU).
Maximum RPM **F**	Turbine maximum speed Indicate the thrust at full throttle. By varying the RPM this value calls the related thrust of the engine. This provides a save and easy way to limit the maximum thrust.
LowIdle RPM	Reduced idle speed. This function is activated if the throttle stick is in idle and the throttle trim is set to half. The Idle speed will be decreased to the programmed value. The acceleration time to get back to the common idle speed can take 2-5 seconds according the used engine type.
Ignition-Mode	Version of ignition type: Kerosene-N JetCat kerosene start. This parameter is for informational purposes only and can't be changed
Battery Type	Kind/chemistry of connected Battery**: LiPo / LiFe / NiCd / Pb / LiIon**
Cells	Number of battery cells
BatterySize(mAh)	Capacity of the connected supply battery. This option is only present on engines with integrated charging system/alternator. On engines with alternator function, this information will also be used to limit the max. charging current to the supply battery (also depending on the selected battery chemistry).
Barom.Auto Tune	Enables the ECU to align the control system according the barometric pressure. The possible settings are: **Disabled:** No auto tuning by ECU **IdleRPM-Set:** Optimize of idle RPM only **Ramp-Set:** Optimize of acceleration only **Idle&Ramp-Set:** IdleRPM and acceleration are optimized
Smoker Flow	Only available when a bus-smoke pump is connected. The smoke flow can be adjusted in a range of 0-100%. Additional is shown the quantity of flow in millilitres (ml).
Bleed fuel lines	This function allows to automatically aspirate fuel up to the engine. The system automatically stops the pump as soon as fuel has reached the engine sided fuel pump. One of the following options can be selected: **DISABLED**: Turns function off **Always**: Before every start, it is checked if fuel is present at the pump. **Automatic**: Only after a prior false start or a failed engine run, the bleeding function will be executed upon the next engine start. **Manual:** If this option is selected the bleeding function is executed once as soon as the "Change value" button is released.
Fueltank size	Actual capacity of the fuel tank in ml
LowFuel Limit	Fuel level (ml) to activate the fuel warning function.

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Value	Explanation
TelemAdap.	Defines the type/address of the Telemetry Adapter to be used. Options are: "NOT USED", "Intern, A=1" "Extern, A=2" "Extern, A=1"
Telemetry	Select type of telemetry protocol, only applicable in conjunction with PRO-Interface Options are (see also instruction manual of "JetCat telemetry adapter"): • NOT USED • Futaba SBUS-2 • Graupner HOTT • MPX M-Link1 • Jeti • MPX M-Link2 • Jeti-NoAlarms • Mikado Vbar (Telem V8.7 of higher only) • PowerBox (Telem V8.8 or higher only) • Spektrum (Telem V8.9 or higher only) Depending on actual telemetry system present, only some of the above options might be available!
AUX-channel func	The AUX-channel (3-step switch) can be used for optionally special features or disabled even for single-channel operation. **ON,TrbCtrl ON**: Aux channel enabled for engine control **ON.TrbCtrl OFF**: Aux channel enabled for additional functions like speed limiter functions, Smoker control etc. Turbine control disabled. The Aux channel is used only for additional control functions. The engine control is only via the throttle channel (Single Channel Mode) **NOT USED**: Single Channel Mode. Totally disabled AUX channel input for engine control, speed sensor and smoker functions. AUX channel wire must not be connected to the receiver in this mode. In case of a connected air-speed sensor the Maximum Limit Speed is still active and limits the maximum speed of the plane. This safety function can't be disabled.
AUX-SW0 Action	Only if the parameter "AUX-channel func" (see above) has been set to "ON, TrbCtrl OFF" this option is visible. In this case, the AUX-channel (3-step switch) can be used for optional controls or can be disabled. This option defines the action taken if the 3-step switch is be set to the "SW0" position (backwards position) **DISABLED/NONE** No Action

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Value	Explanation
	LowIdle active Idle rpm will be reduced to the value set by the "LowIdleRpm" parameter **Turbine-OFF** The following options are only present with an airspeed sensor connected: **LrnSpeed Lo/Hi** **LrnSpeed Lo** **LrnSpeed Hi** **Hold-Speed**
AUX-SW2 Action	Only if the parameter "AUX-channel func" has been set to "ON, TrbCtrl OFF" this option is visible. In this case, the AUX-channel (3-step switch) can be used for optional special controls or be disabled. This option defines the action taken if the 3-step switch is be set to the "SW2" position (forward position) **DISABLED/NONE** No Action **LowIdle active** Idle rpm will be reduced to the value set with the "LowIdleRpm" parameter The following options are only present with an airspeed sensor connected: **LIN-SpeedCtrl** **3-StepSpdCtrl** **Hold-Speed** **SwitchSpeedLim**
FailSafe delay	Delay in seconds before Fail-Safe function will be activated. While this time the engine speed run on the last valid stick pulse **(→HOLD**) adjustable range = 0.1 -20.0 seconds. After expiration of this term the Fail-Safe Time Out starts. (see next point)
FailSafeTimeOut	Delay in front of Fail Save cut off. While this time the engine speed is set to the Fail Save RPM (next point) Is there no valid pulse after the expiration of this term the engine will be cut off by the ECU. Range 0.1-20 seconds.
FailSafeRPM	Programmable engine speed for the Fail-Safe Time Out procedure. Range from minimum RPM to maximum RPM.
SpoolUp Time	Time from idle to max rpm. Only available for helicopter engines!
Operation mode	See page: 34, Operation modes
THR-Ctrl Input	The following options are available: **ServoPWM direct**: Engine control via Servo PWM Signal **AirSpeed Signal**: Engine control via analogue Signal on "AirSpeed" input
IdleThrResponse	Adjustment of the throttle response (acceleration) by idle (up to average speed) **Fast** default setting **Normal** average acceleration **Slow** acceleration for excessive warm weather or for operate more than 1000m sea level

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Value	Explanation
FullThr Response	Adjustment of the throttle response by full throttle (from average speed to full) **Fast** default setting **Normal** acceleration (for operation above 1000m)
StartUp Mode	This function allows to select different start procedures for the THR-input (PWM or analogue signal) You can select between following settings: **[SEQUENCE]:** Default setting: Throttle trim to maximum, throttle stick to idle, AUX switch to centre and now move the throttle stick to maximum to start the engine. By using the Single Channel Mode (devoid of the AUX switch) start the engine by set the throttle trim to maximum and then move the throttle stick to maximum. **THROTTLE MAX:** Throttle trim and throttle stick to maximum. Turbine starts if the AUX-switch is set to centre. By Single Channel Mode (devoid of AUX switch) the engine starts by move the throttle stick more than 95% of maximum. **THROTTLE MIN:** Throttle trim to maximum and throttle stick to minimum. Turbine starts if the AUX-switch is set to centre. By Single Channel Mode (devoid of AUX switch) the engine starts by move the throttle stick more than 95% of maximum. **IMMEDIATE:** The engine starts direct by move the throttle trim to maximum and set the AUX-switch to centre. By Single Channel Mode only move the throttle trim to maximum for start. **Suggestions to start a multi-engine model** **Two channel Mode:** Program one ECU to **THROTTLE MAX** mode but the second to **SEQUENCE** mode. The “Throttle max engine” starts by move the throttle trim and throttle stick to maximum and set the Aux switch to centre. To start the “Sequence engine” you now must move the throttle stick first to minimum and back to maximum. **Single channel mode:** Program one engine to **IMMEDIATE** mode, the other to **SEQUENCE** mode. Throttle trim and throttle stick must be set to minimum. To start the “immediate engine” just move the throttle trim to maximum. The “sequence engine” starts by move the throttle stick to maximum.
THR-Transfer (%)	After the engine has been started up via PWM command on THR channel, the system will stay in the “LearnLo” state until the throttle stick is brought to idle/backwards.

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Value	Explanation
	This parameter defines the threshold to which the throttle stick at least must be lowered to transfer throttle control to the user and switch to “Run” mode. A value of 100% means that the engine will directly go to the commanded throttle setting after it has been started up, no matter where the throttle stick is set at. Default setting: 5%; range 0-100%
Throttle Curve	Throttle stick curve, factory setting is 3.0. Herewith the thrust and the throttle stick position proceed slightly logarithmic (higher response at the idle range compared to the full throttle range of the throttle stick/commanding). At the value of 2.0 the thrust will proceed exactly proportional to the throttle stick position. This parameter can be used to tune the throttle command to thrust curve in a very wide range. See also page: 43
AutoRestart	In case the engine would flame out during normal run, the system can be programmed to automatically try a restart of the engine and resume operation. Per default the Auto restart feature is disabled for safety reasons. A restart always can be interrupted via the normal controls which stop the engine. The following options are selectable: **Disabled** (Default, recommended) **Enabled** (engine will be restarted in case of flame out) **ThrottleMax** (engine will be restarted instantly, but operator must bring throttle stick to full throttle position within 6 seconds (after the flameout happened) in order not to interrupt/stop the restart attempt.
AUX-ch SmokeCtrl	To be able to use this function its necessary that the ***AUX-channel func*** is activated by ***ON,TrbCtrl Off*** (see above). This option defines the smoke pump control option for the 3-step switch. The ECU can directly control a smoke valve or a Smoke pump for injection of smoke fluid into the exhaust blast to generate smoke. You can use the shut off valve (Part# 61106-0055) as smoke valve. For smoke pump, you can use any JetCat Smoker pump AUX-channel programming for smoke function (3-step switch) Settings: **DISABLED** Smoke solenoid is not used → valve is constantly closed **Open if AuxSw=0** Smoker-valve is open if: Turbine is running and the AUX switch (3-Pos. switch) is brought to lower position (“off” position) That is to say the Aux switch is enabled for smoke function but not for engine control.

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Value	Explanation
	Open if AuxSw=2 Smoker -valve is open if: Turbine is running and the Aux switch (3-Pos.switch) is brought to upper position ("AUTO-OFF" position) To be able to use this function its necessary, that the ***AUX-channel func*** is activated by ***ON,TrbCtrl Off*** (see above). The Aux switch is enabled for smoke function but not for engine control.
Smoker WarnFunct	If this function is activated, the smoke-valve will pulse in a sequence of 0,2 secs on and 0,4 sec off –time if following conditions are complete: **BATTERY LOW:** The valve will pulse if the ECU battery is weak/empty. **FUEL LOW:** The valve will pulse if the fuel level is low the programmed ***LowFuel Limit*** **BATT or FUEL LOW:** The valve will pulse in any of these conditions **FAIL- SAVE**: The valve will pulse if the ECU detect a fail safe **BATT,FUEL,FAILS:** The valve will pulse in any of these conditions **ENABLESmokePmp:** Enables signal for smoke pump only if engine is running. The pump can't run without a running engine (only useful by operate a JetCat Smoke pump) **High-Temp.** The valve will be pulse in case of excessive exhaust temperature. **MaxRPM-reached:** The valve will be pulsed if the engine has reached its maximum RPM. **Disabled:** No function, off. **Note:** The smoke warn function is switched off while the throttle stick is in idle position.
AirSpeed units	Displayed flight speed unit in ***km/h*** or ***mph***
ThrustReduFactor	This parameter allows to automatically reduce the engines thrust in relation to the weight of fuel burned. At a programmed value of 1.0 the engines thrust would be reduced such that it exactly compensates for the weight (force) of the amount of fuel burned up to this moment. For hovering applications, this function can help to automatically reduce thrust and compensate for the weight loss of the system by fuel burned/consumed. Per default this value is set to 0, which effectively disables this function (recommended setting!). The lower the value is set the lower the effective thrust reduction will be computed. Values higher than 1.0 will result in an overcompensation.
Simulate engine	Enable or disable Simulation mode. If set to "enabled" engine will not be run in real, Rpms / EGT etc. is internally simulated. Pump/Starter/valves are disabled in this mode. This allows e.g. to test the serial communication without hot running the engine. Only available if operation mode is not set to "RC-model"!

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Value	Explanation
Engine CrossChk	This function allows to interchain two engines with each other via the secondary serial interface (→Tx2/Rx2, null modem cross over connection). In this configuration every engine then "knows" the operation state/rpm/thrust etc. of its "partner engine" and vice versa. Typically, this is used to synchronize two engines and/or to keep their thrust differentials within a pre-set safe margin. For this option to work correctly it must be ensured that the "Slave-address" value (see below) is set to different values on the two engines communicating with each other (e.g. engine #1 Slave-address set to 1, engine #2 Slave-address set to 2) Also, it will be ensured that the control would only be handed over to the pilot if both engines are started up and running at idle. **"DISABLED":** This disables the cross-checking function, default **"ON; OFFOnFail ":** This enables the crosschecking function, if the other engine should turn off by any reason, the "partner engine" would also be switch off. Also, if the communication cable should be interrupted, this would result in an engine shut down. **"ON; ContOnFail":** This enables the crosschecking function, if the partner engine should turn off by any reason, the engine would not be turn off, but would be auto limited on thrust according to below setting of the "**Max-ThrustDiff"** value. **"Heli-Syncronis":** This option is used to synchronize a pair of two-shaft engines which are connected/driving to the same output shaft and have the shaft regulator function activated (typical twin-engine helicopter configuration). This option will avoid that one of the two engines, over time might take a larger portion of the load, whilst the other one is getting lazy (=applying less power). Only applicable for two-shaft engines!
Max-ThrustDiff	Desired maximum thrust differential value in Newtons for the cross-check function The engine which produces more thrust than its linked partner engines thrust plus the differential value would be de-rated such in rpm to match the condition. Only available if "Engine CrossChk" is not set to "Disabled"
ThrustDiffOffDly	Allowed time in multiples of 0,1s where the thrust differential compared to other engine in Newtons is allowed to be higher than the programmed window. A setting of 0 disables the shut down due too high differential thrust, the limiter function stays active though. Only available if "Engine CrossChk" is not set to "Disabled"
Generator-Charge	Generator function Enabled or Disabled; only on engines with generator functionality This effectively will turn on/off the internal AC/DC converter and charging circuitry.
SelfPower funct.	Normally the engine is powered on/off via the control input on pin 9 of the 15pin Sub-D connector. This option allows to optionally keep the ECU powered on under certain conditions, even if this control signal should be removed. This option is only available if the operation mode is not set to "RC-model"; See also page: 34 • OFF • run & cooling • cooling
CAN-Ctrl-Address	CAN control offset address. See CAN-bus documentation
CAN-Report-Adr	CAN report offset address. See CAN-bus documentation.
CAN-Bus Mode	"CAN 2.0A, 11Bit" or "CAN 2.0B, 29Bit"

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Value	Explanation
CAN-Bus Speed	"125kHz", "250kHz", "500kHz","1 MBit/s",
CAN-Timeout	Option to check if CAN communication link is working/present. If a value unequal to zero is set, and the engine has been started via a command sent through the CAN interface, the ECU will expect commands to come in via the CAN interface within the set timeout interval. Timeout value is in multiples of 0,1 seconds. In case communication is lost, engine will be shut down. A value of zero disables the timeout check.
RS-232 Baudrate	"2400", "4800", "9600", "19200", "38400", "57600", "115200"
Slave-Address	Address to be used for serial communication addressing (RS232 interface)
COMM-Timeout	Option to check if serial communication link is working/present. If a value unequal to zero is set, and the engine has been started via a command sent through the serial interface, the ECU will expect commands to come in via the serial interface within the set timeout interval. Timeout value is in multiples of 0,1 seconds. In case communication is lost, engine will be shut down. A value of zero disables the timeout check.
Serial Protocol	ASCII (standard) or Binary serial control protocol (not available on all engines)
AirSpeedSensor	This option allows to disable or enable the optional Airspeed Sensor input and to select its type.
SpdCtrl SW0 Act.	See chapter “Air Speed Control” of the manual
SpdCtrl SW2 ACT.	See chapter “Air Speed Control” of the manual
MAX LimitAirSpd	See chapter “Air Speed Control” of the manual
Max.AirSpeed	See chapter “Air Speed Control” of the manual
Min.Air Speed	See chapter “Air Speed Control” of the manual
SpeedRegVal-P	See chapter “Air Speed Control” of the manual
SpeedRegVal-I	See chapter “Air Speed Control” of the manual
SpeedRegVal-D	See chapter “Air Speed Control” of the manual
MinRPM SpdCtrl	See chapter “Air Speed Control” of the manual

Possibly not all of the above options are displayed in your effective engine system. Some of the above given parameters might be omitted depending on your specific engine configuration!

TEST Menu

	**<u>Before activating the purge pump mode, understand that fuel will/might be pumped into the engine if the user is not stopping the pump when fuel has arrived at the engines fuel inlet.</u>** Pump Test / Purge Fuel allows the fuel pump to operate without the engine running. However, if the fuel feeding is not stopped once fuel arrives at the engine, the engine will become flooded with fuel. When this occurs, the next engine start can become highly combustible!

Value	Explanation
Purge FuelSystem	Enable to prime the fuel pump and lines.

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	By pressing the "Change Value" key the fuel valve opens, and the fuel pump starts to run. To change the voltage the pump runs at, press either the "+" or "-" key while the "Change Value " key is pressed. Depending on engine type, the fuel pump can also be run reverse. Negative values for the pump voltage then result in reverse operation of the pump.
BurnerTest	By pressing the „Change Value" key the Burner glow with the appointed voltage. The left number displays the burner voltage the right shows the current battery voltage. The burner voltage can't be changed.
BurnerValve Test	Pressing the "Change Value" key opens the burner valve
Smoker Test	Pressing the "Change Value" key opens the smoke valve
FuelValve Test	Pressing the "Change Value" key opens the fuel valve
PurgeValve Test	Pressing the "Change Value" key opens the purge valve. This function is not available on all engines!
OilPump Test	Pressing the "Change Value" key will start the oil pump. This function is not available on all engines!
LCU-Test	This allows to test the LCU. Only available if LCU is connected/present.
Temp. **AD**	Displays the data of the temperature sensor. The upper left value indicates the exhaust gas temperature, the right value calls the measured value of environment. These values are the according internal values of the AD-converter. If appears a "F" in the upper right edge the temperature-sensor is faulty or the data cable in not connected or faulty, too.

Special Functions

Temperature calibration

After a replace of a temperature sensor (EGT sensor) it might be necessary to run a temperature calibration

The engine must be at ambient temperature (approx. 21°C)!

Press and hold the „Select Menu" key on GSU, then **switch on ECU** (receiver). Instead of „Select Menu" key of GSU, it's possible to press the little key on the LED-board.

The LED´s indicate the following blink sequence:

LED	**Blink Sequence**						
Standby	⊙	○	○	⊙	○	○	(yellow)
Pump running	○ ⇨	⊙ ⇨	○ ⇨	○ ⇨	⊙ ⇨	○	(red)
OK	○	○	⊙	○	○	⊙	(green)

The display of GSU indicates simultaneously: **Release Key to „Learn RC"**

While this sequence hold the key „SelectMenu" <u>don't</u> release it !!!!

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Release the key if the three LED´s indicate this blink sequence:

LED	**Blink Sequence**						
Standby	⊙	○	⊙	○	⊙	○	(yellow)
Pump running	○ ⇨	⊙ ⇨	○ ⇨	⊙ ⇨	○ ⇨	⊙	(red)
OK	⊙	○	⊙	○	⊙	○	(green)

The display of the GSU indicate simultaneously: **“Release Key to Calibrate Temp“**

after releasing the key on the GSU the temperature calibration is executed.

Reset to Default Values

The ECU can be reset to default values by following:

Press and hold the „Select Menu“ key on the GSU, then switch on the ECU (receiver).
The LED’s indicate the following blink sequence:

LED	Blink Sequence						
Standby	⊙	○	○	⊙	○	○	(yellow)
Pump running	○ ⇨	⊙ ⇨	○ ⇨	○ ⇨	⊙ ⇨	○	(red)
OK	○	○	⊙	○	○	⊙	(green)

The display of GSU indicate simultaneously: **Release Key to „Learn RC“**

While this sequence keep „SelectMenu“ button pressed, don’t release it !!!!

After a while (approx. 15 seconds) the LED’s indicates the following blink sequence:

LED	Blink Sequence						
Standby	⊙	○	⊙	○	⊙	○	(yellow)
Pump running	○ ⇨	⊙ ⇨	○ ⇨	⊙ ⇨	○ ⇨	⊙	(red)
OK	⊙	○	⊙	○	⊙	○	(green)

While this sequence hold the key „SelectMenu“ don’t release it !!!!

Release the key not before the LED’s indicate following sequence:

LED	Blink Sequence						
Standby	⊙	○	⊙	○	⊙	○	(yellow)
Pump running	⊙ ⇨	○ ⇨	⊙ ⇨	○ ⇨	⊙ ⇨	○	(red)
OK	⊙	○	⊙	○	⊙	○	(green)

Simultaneously the display of GSU indicates: **“Release key to Reset System”**

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Now release the key to execute the reset.

After a reset, it is required to:

- Learn in RC

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Firmware Update

JetCat PRO engines allow for online update of the ECU´s firmware.

For the update process a JetCat USB-adapter (USB to serial) is required.

First you need to install the "JetCat ECU-V12 Updater" program (for Windows PC)

To install the software, type the following in the address line of your Internet browser:

http://www.cat-ing.de/jetcat-hexfiles/JetCatUpdaterV12.htm

then follow installation steps….

After the utility program has installed you are ready for the following steps:

1) Connect JetCat USB interface adapter to the PC and GSU.
2) GSU must also be connected to the PRO-Interface.
3) Power on engine system

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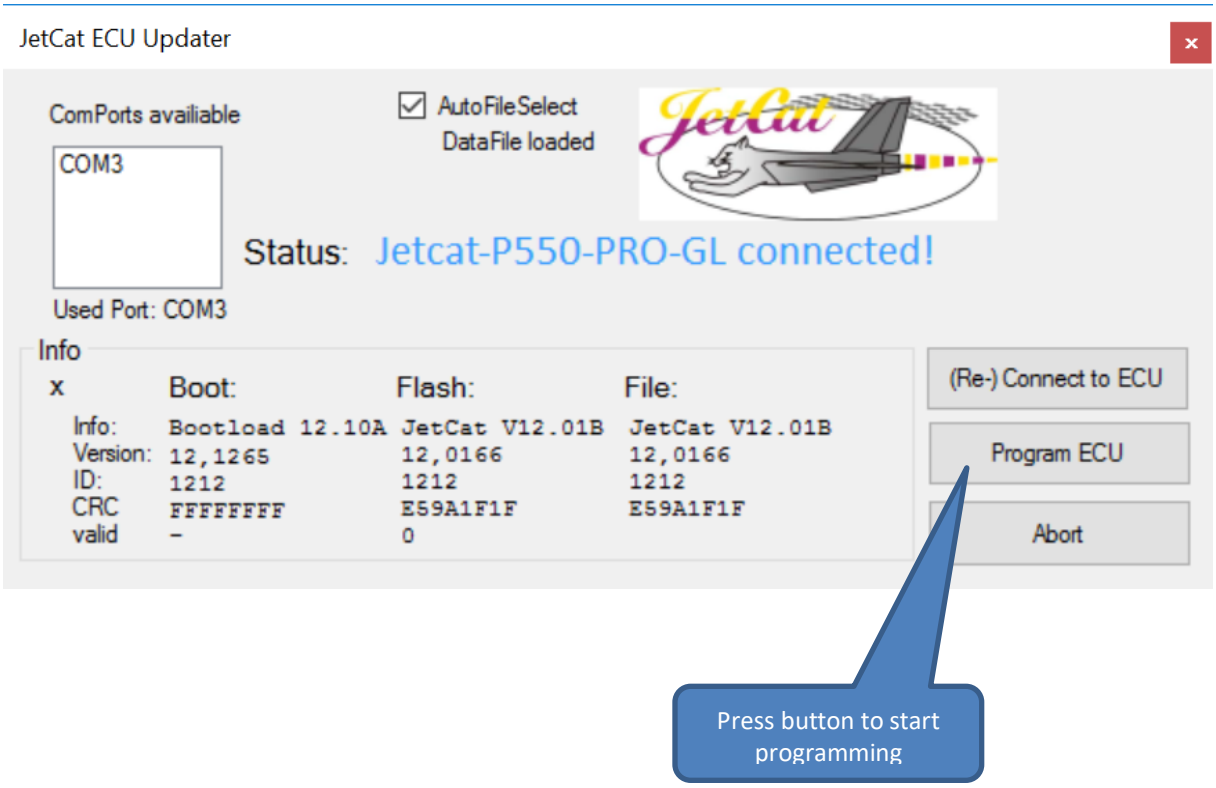
Make sure that the PC has live connection to the Internet!

On ECU-Firmware's higher or equal 12.01S also make sure the Baudrate of the serial Interface is still set to the default 9600kbit/s (→ check settings in Limits menu).

Now start the previously installed application **"JetCat Updater-V12"**

After some seconds the following screen should come up:



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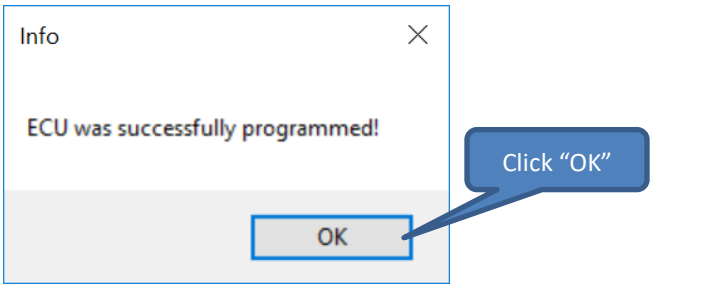
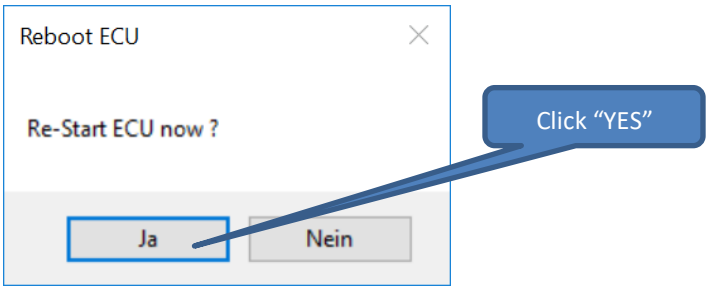
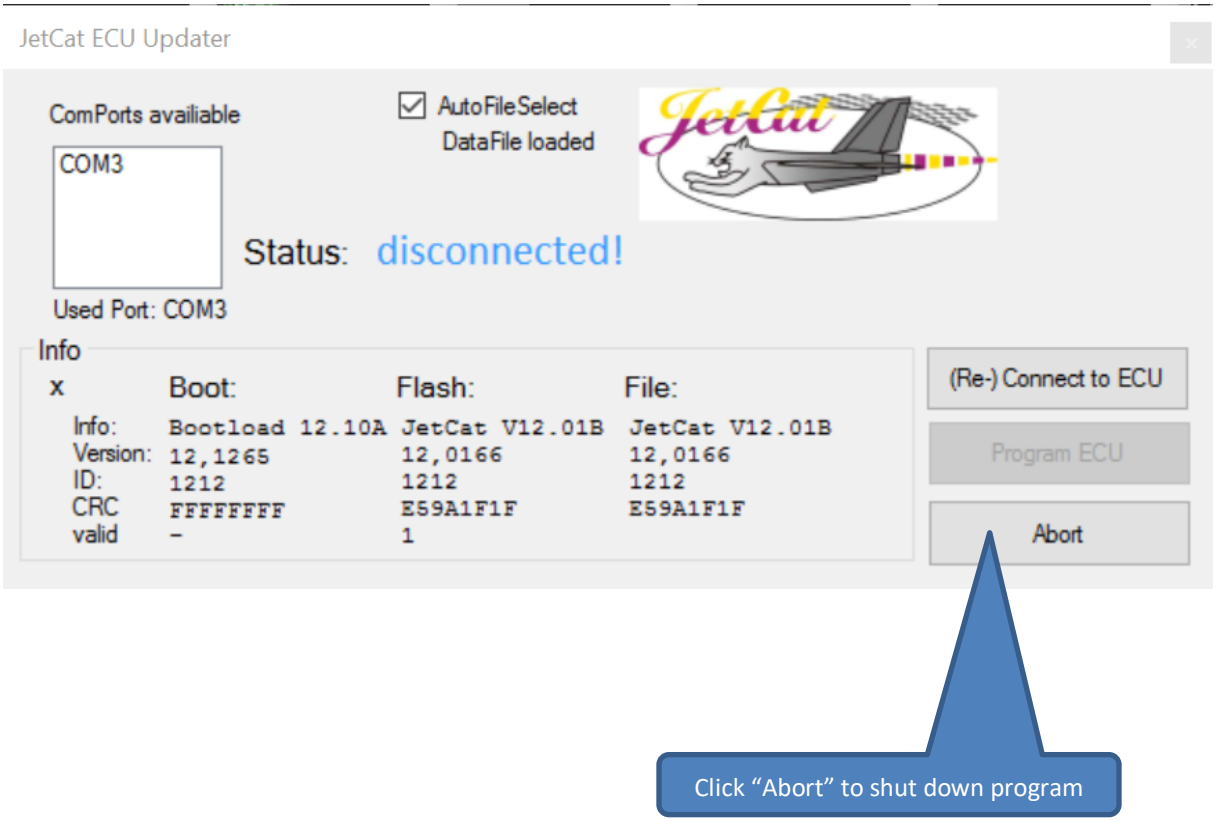




ECU will reboot, and after some seconds will be ready to run!



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JetCat three Year Limited Warranty.

Ingenieurbüro CAT, M. Zipperer GmbH, Wettelbrunner Straße 6, 79282 Ballrechten-Dottingen, Germany hereafter called JetCat warrants that this MINATURE TURBOJET ENGINE for model aircraft, cars or boats ("Model Engine") enclosed with this warranty statement is free from defects in materials and workmanship during normal usage, according to the following terms and conditions.

1) The limited warranty extends to the original purchaser ("Buyer") of the Model Engine and is assignable or transferable to any subsequent purchaser /end-user.
2) Upon request from JetCat, the Buyer must prove the date of the original purchase of the Model Engine by a dated bill of sale or dated itemized receipt.
3) Warranty coverage begins the day you buy the Model Engine. For 3 (three) years all labour and parts except for the glow plug and battery will be repaired or replaced free of charge. All parts, including repaired and replaced parts are covered for the original warranty period. When the warranty on the Model Engine expires, the warranty on all replaced and repaired parts also expires.
4) During the limited warranty period, JetCat will repair or replace, at JetCat's option, any defective parts with new or factory rebuilt replacement items if such repair or replacement is needed because of Model Engine malfunction or failure during normal usage. No charge will be made to the Buyer for any such parts. JetCat will also pay for the labour charges incurred by JetCat in repairing or replacing the defective parts. The limited warranty does not cover defects in appearance. JetCat shall not be liable for any other losses or damages.
5) The Buyer must operate and maintain the Model Engines in accordance with the Model Engine manual. The Model Engine must be returned to JetCat for maintenance on or before the TBO (Time Before Overhaul) interval of every 25 hours. lf Buyer fails to return the Model Engine within the. TBO interval, any damaged parts affected by this negligence will be subject to additional repair costs.
6) The Buyer shall have no coverage or benefits under this limited warranty if any of the following conditions are applicable
   a) The Model Engine has been subject to abnormal use, abnormal conditions, improper storage, unauthorized modifications, unauthorized repair, misuse, neglect, abuse, accident, alteration, improper installation, or other acts which are not the fault of JetCat, including damage caused by shipping.
   b) The Model Engine has been damaged from external causes such as crash damage, foreign object damage, weather, Act of God, improper electrical connections, or connections to other products not recommended for interconnection by JetCat.
   c) The Model Engine is operated for commercial or institutional use.
   d) The Model Engine serial number has been deliberately removed, defaced, or altered.
7) If a problem develops during the limited warranty period, the Buyer shall take the following step-by-step procedure:
   a) The Buyer shall ship the Model Engine prepaid and insured to JetCat.
   b) The Buyer shall include a return address, daytime phone number, complete description of the problem and proof of purchase.
   c) The Buyer will be billed for any parts or labour charges not covered by this limited warranty.
   d) If the Model Engine is returned to JetCat during the limited warranty period, but the problem with the Model Engine is not covered under the terms and conditions of this limited warranty, the Buyer will be notified and given an estimate of the charges the Buyer must pay to have the Model Engine repaired, with all shipping charges billed to the Buyer. If the estimate is refused, the Model Engine will be returned freight collect. lf the Model Engine is returned to JetCat after the expiration of the limited warranty period, JetCat 's normal service policies shall apply, and the Buyer will be responsible for all shipping charges.
8) The Buyer must bear the cost of shipping the Model Engine to JetCat, Germany. JetCat shall bear the cost of shipping the Model Engine back to the Buyer after the completion of service under this limited warranty. The Buyer must pay for any other shipping charges.
9) The Model Engine consists of newly assembled equipment that may contain used components that have been reprocessed to allow machine compliance with Model Engine performance and reliability specifications.
I0) JetCat shall not be liable for delay in rendering service under the limited warranty, or loss of use during the period that the Model Engine is being repaired.
11) JetCat neither assumes nor authorizes any other person or entity to assume for it any other obligation or liability beyond that is expressly provided for in this limited warranty.
I2) This is the entire warranty between JetCat and the Buyer, and supersedes all prior and contemporaneous agreements or understandings, oral or written, and all communications relating to the Model Engine, and no representation, promise or condition not contained herein shall modify these terms.
I3) Buyer must fully accept all conditions of the PURCHASE AGREEMENT, FULL ASSUMPTION OF LIABILITY AND INDEMNITY AGREEMENT
I4) lf the Buyer is not prepared to fully accept the liability associated with the use of this Model Engine, the Buyer is advised to return this Model Engine immediately in new and unused condition to the place of purchase.
I5) This limited warranty allocates the risk of failure of the Model Engine between the Buyer and JetCat. The allocation is recognized by the Buyer and is reflected in the purchase price of the Model Engine.
I6) Questions concerning the warranty may be directed to:

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