ProJET
electronic components

Instructions manual / Bedienungshandbuch

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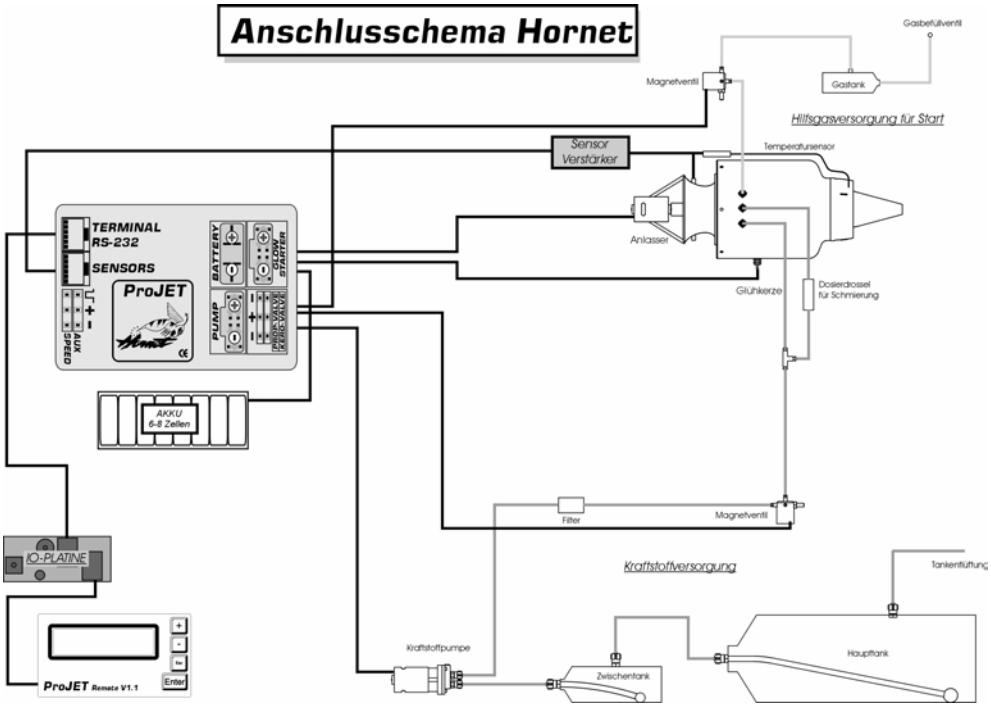
About Hornet

The Projet Hornet is an engine control unit (ECU) that controls all the important parameters during turbine operation. The connected kerosene pump and valves are regulated by the ECU to avoid an over/under run of the preset temperature and RPM values. The engine will always run within the set limits, and the safety functions include an engine shut down if the detected values are not within these limits, caused by a loss of transmitter signal and/or damage to the temperature and RPM sensors.

Attention :- A successful operation of the Hornet ECU requires a perfect running turbine. The ECU will not rectify incorrect assembly procedures resulting in a high exhaust gas temperature and/or an unbalanced rotor assembly.

Connection Diagram



Components

The following components are required for turbine operation using the Projet Hornet:

Projet Hornet Engine Control Unit (ECU)
Projet Data Terminal (ground support unit/GSU)
I/O Board (input-output) with optical and acoustic engine status indicators
Sensor Amplifier
Sensors (RPM and temperature)
Kerosene Pump
8 Cell Battery – 1600 MAH minimum capacity

Power Supply

All connected components such as the fuel pump, starter motor, glow plugs and valves are powered by a single 7 to 8 cell battery (8 cells recommended.) The capacity should be high. 1600 MAH or higher is recommended. The battery should be observed during your first flights to find out when it has to be recharged. The GSU shows the battery voltage in the lower right portion of the display. (See page .) It should be noted that the minimum voltage per cell is 1.2 volts. Faultless engine operation is only guaranteed by using fully charged batteries ! e.g. An 8 cell battery should have at least 9.6 volts (8 x 1.2 volts) and should be charged if the ECU is detecting this value.

NOTE. If you are worried by the weight of the onboard battery, then a smaller one can be substituted and a larger capacity battery outside the model can be plugged into the system for start ups.

Sensor Installation

The sensors are connected to an eight lead AMP-plug that is compatible to the Jettronic System (Jetcat). As an alternative, the sensors can be ordered together with a half round sensor amp board (type A80 or A130.) These electronic boards are screwed to the front face of your turbine. The two versions are prepared for Behotec turbines but fit most homebuilt turbines as well.

RPM Sensor

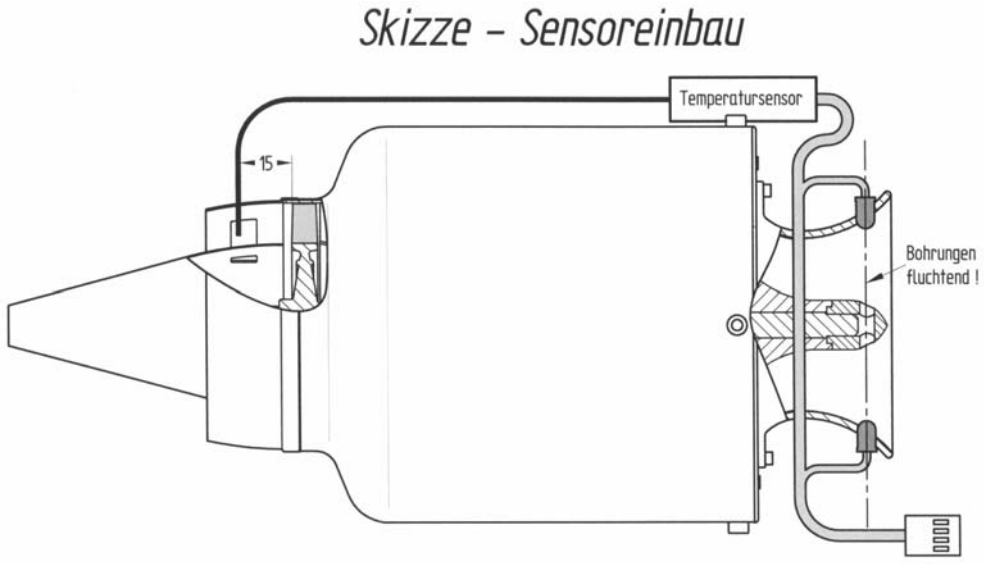
The RPM sensor consists of two infrared diodes (send and receive diode.) The type of RPM sensoring requires the diodes to be in a straight line as shown in the figure. The spinner has to be drilled with a 3 – 4mm hole (4mm recommended.) A perfect alignment of the two diodes and the spinner hole is vital! Any misalignment will cause an incorrect RPM detection especially at high RPMs and the system will also react to sunlight. If possible, protect the diodes from direct sunlight during operation. The black (receiver) diode should never be subjected to sunlight. This can be avoided by twisting the turbine to bring the diode to the up position.

The ECU is also designed to work with Hall Effect magnetic pick up sensors

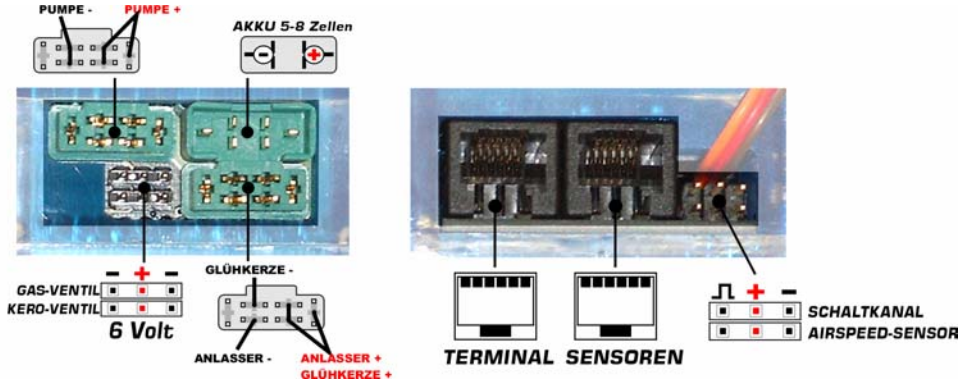
Temperature Sensor

The temperature sensor is able to detect temperatures up to 1100 degrees centigrade. It should be mounted 15mm behind the turbine (see figure.) Most turbines have a hot spot at the five o'clock position viewed from behind. Avoid this position for the temperature sensor. The one or two o'clock positions will give a medium exhaust gas temperature.

Figure - Sensor Installation



The Power Plugs – Polarity



Starter Motor

Depending on turbine type, different starter motors are used. The parameters in Menu 50 (Auto Start) have to be adjusted to your starters requirements

Glow Plug

Use a Rossi 3 or a four stroke plug as these have heavier elements and will last longer. The element will have to be prised out of the plug case approximately 3mm. To do this, the element must first be annealed by applying 2 volts to the plug. A pin can then be used to prise out the coils.

Note. If you have old plugs that do not work well in 2/4 stroke engines, these can be used, but will not last as long as the above.

Valves

A Kerosene and Propane valve is required for a full automatic start. The use of these valves is highly recommended as being part of the safety functions, protecting your turbine from serious damage caused by incorrect handling. If different valves are used make sure they will work with 6 volts.

The I/O Board

The input/output electronic board is connected to the "TERMINAL" port and should be placed in your model at a position where you have good visual access. The board gives acoustic and visual information about the engine status. This makes the permanent use of the GSU during starting unnecessary.

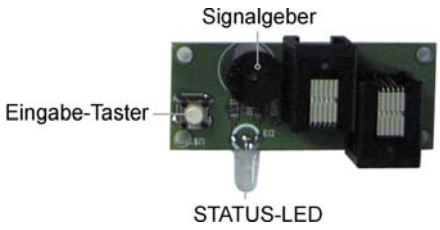
Alarm Buzzer

Short beep	-	ECU is switched on
Long beep	-	Auto Start sequence begins
Short interval	-	Battery low, temperature sensor defect, glow plug defect
		See additional error messages on GSU.

Status LED

Green	-	Off status
Orange	-	Ready
Red	-	Turbine running in automatic mode

To manually pump Kerosene, you can press the push button on the board. (RX off, ECU Battery connected.) The Kerosene valve opens and the pump is powered by the programmed voltage (Menu 41 – Pump Start Voltage) as long as the button is pressed.



Handling:

The GSU is used to programme the Hornet ECU and to show all the important turbine parameters. Programming is done with the four push buttons on the GSU.

↑	Up arrow	-	used to increase values or move Menu upwards
↓	Down arrow	-	Used to decrease values or move Menu downwards
X	Button	-	Escape button, if you want to escape from an unwanted value change

The (**X**) button will make the change ineffective.
Example: You changed the maximum RPM from 100,000 to 105,000 RPM. After pressing the (**X**) button, you leave the new setting and the old value will be effective (100,000.)

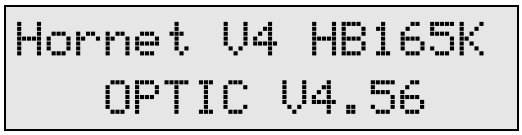
√	Button	-	(Enter) button or (Yes) button – a value change will only be accepted (stored), after the (enter) button has been pressed.

Additional terminal function – Starting the Engine:

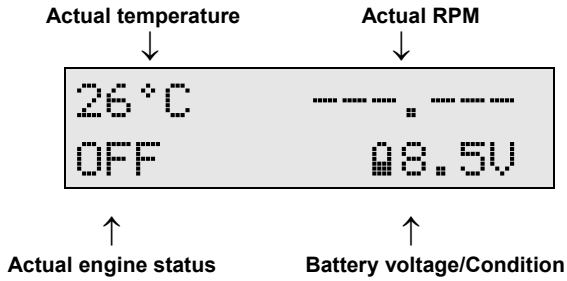
An engine can be started by the GSU simultaneously pressing the (↑) and (√) buttons**. The throttle and trim have to be in the max. position (= ready)** this function is necessary to operate two or more engines if connected to the same receiver channel.

The Display

After switching on the ECU, the display shows the software version first.



Then the display shows the following :



Note: The battery voltage will change over to the pump voltage after the turbine start has been activated.

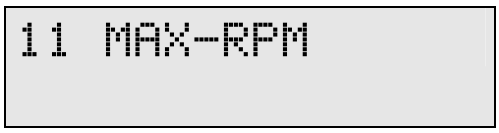
Display Symbols

- Battery full
- Battery in normal condition
- Battery empty
  Note: The battery condition monitoring can only work perfectly if the number of cells is programmed correctly (Menu 90 – preset is 8 cells).
- Glow plug damaged or disconnected
- Temperature sensor damaged or disconnected
- Pump running – symbol changes to actual pump voltage
- Switch mode (only if separate switch channel is used to operate the ECU - digital trim)

The above mentioned error messages are accompanied by acoustic signals from the I.O. board.

* SETUP *

To step through the menu, use the up and down arrow buttons. Confirm the chosen menu with the enter button to check or to change the programmed values. The menu is numbered and integrated in groups. For a better understanding, a menu structure sheet is added to the manuals. It is recommended to have this sheet on hand if you are not completely familiar with the ECU menu structure.

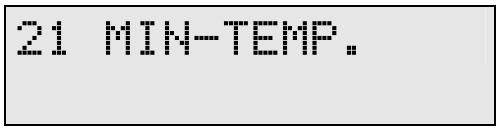


120.000
---/---
Preset Value / Your Value

It is recommended that you fill in your value if you have changed the preset.
Adjusting the max. RPM (full throttle) of your turbine – consider turbine manufacturer's limits!!!

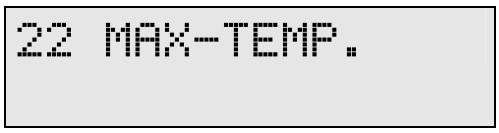
35.000
---/---
Preset Value / Your Value

Minimum RPM adjustment (Idle)
Consider Manufacturer's recommendation!



200 °C
---/---
Preset Value / Your Value

Minimum temperature, if the turbine temperature falls under the programmed value, the ECU will shut down the engine.(The ECU will also close the Kerosene valve). This function avoids the turbine flooding with Kerosene after a "flame out".

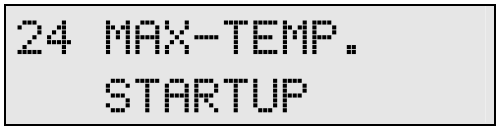


1000 °C
---/---
Preset Value / Your Value

Accepted maximum temperature. If the turbine temperature rises above the programmed value, the ECU will shit down the engine and close the Kerosene valve.

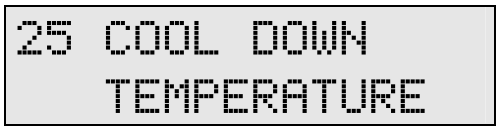
700 °C
---/---
Preset Value / Your Value

The programmed temperature is the limit during acceleration. Higher temperatures will cause a slower acceleration.



1000 °C
----------/----------
Preset Value / Your Value

This is the start up temperature limit. The start up procedure will be interrupted if the programmed temperature is exceeded.



120 °C
----------/----------
Preset Value / Your Value

The starter motor will cool down the turbine to the programmed temperature

This menu gives you the opportunity to program the four acceleration ramps. Each range can be ramped after the enter button has been pressed.

The four deceleration ramps can be programmed in the same manner as the acceleration ramps.

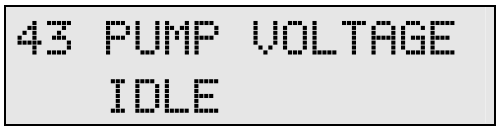
0.25 V
----------/----------
Preset Value / Your Value

This is the minimum voltage to start the pump. Too low values can cause malfunction in the start up procedure. You can check the voltage by pressing the push button on the I/O board (only if Menu 41 is activated.) Increase or decrease the value to obtain the ideal voltage. Quit the procedure by pressing the enter button.

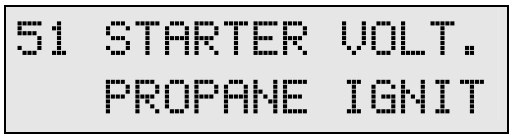
The very first turbine run has to be a run calibration. This is necessary to teach the ECU (pump voltage in relation to RPM.) A run calibration is also required if anything in the fuel system has changed (different fuel line length, new tank or filter etc.) The procedure is as follows :

1. Bring the trim to the max. position and activate the run calibration by pressing the enter (√) button
2. The full automatic start begins
3. The ECU will idle the turbine (and store the required voltage)
4. The turbine accelerates slowly to max. RPM (ECU stores pump voltages in relation to the corresponding RPM.)
5. The turbine idles again and is now ready for use

Note: During the run calibration, the procedure can be interrupted by bringing the trim to the minimum position. (This will stop the turbine.)



Menu 43 to 47 shows you the pump voltages that have been determined during the run calibration.



1.5 V
----------/----------
Preset Value / Your Value

This is the starter voltage during the propane ignition. When the menu is activated, the starter runs with the voltage shown on the display.

6.0 V
----------/----------
Preset Value / Your Value

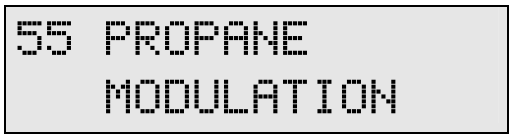
This value should be set to the maximum voltage that is allowed for your type of starter motor. (Manufacture's recommendation.

2.5 V
----------/----------
Preset Value / Your Value

This combustion chamber can be pre heated after propane ignition. The starter spools the rotor with the programmed voltage.

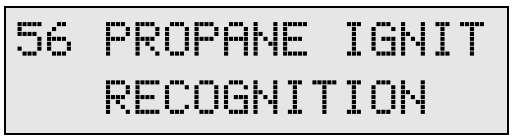
28.000
---/---
Preset Value / Your Value

The starter will be switched off when the turbine RPM exceeds the programmed RPM.



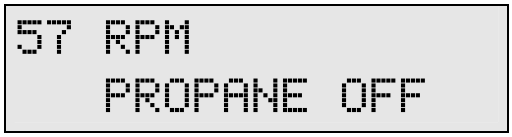
70 %
---/---
Preset Value / Your Value

The amount of propane can be adjusted. This can be necessary under changing weather conditions. 100 % means that the valve is permanently opened . Anything less than 100% will cause the valve to pulse (frequency 20 Hz.)



120 °C
---/---
Preset Value / Your Value

The ECU will switch to Kerosene after the programmed temperature has been reached.

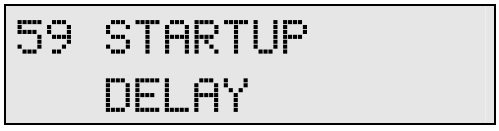


20.000
---/---
Preset Value / Your Value

Propane will be switched off after the turbine has reached the above RPM.

1.0 sec.
---/---
Preset Value / Your Value

Time to preheat the combustion chamber (consider Menu 53.)



15.0 sec.
---/---
Preset Value / Your Value

This menu is to program the time between prime ignition and idle RPM.

Note: A too short start up delay can cause overheating of your turbine! In this case it can happen that the ECU will interrupt the start up procedure (temperature above limit – Menu 24.)

```
* ADJUST *
```

```
70 GLOW PLUG
   POWER
```

```
2.0 V
----------/----------
```
Preset Value / Your Value

After Menu 70 has been activated the glow plug will be switched on (powered with the adjusted voltage.) Increase or decrease the voltage with +/- buttons. (**Note:** It is important that the element of the glow plug is pulled out (about 2 to 3 mm) to get a reliable propane ignition.

```
71 R/C TIMING
   4044 18% ON
```

The left number shows the transmitter pulse width, the right one represents the throttle position 0% = idle, 100% = full throttle = maximum RPM.) The words “ON” or “OFF” show the trim position. Start the signal calibration by pressing the enter button. Bring the throttle and trim to the idle position and press the enter button. Bring the trim to the maximum position, press the enter button. Now move the throttle to maximum and press the enter button again. (Reverse the throttle channel in your transmitter. If an error message occurs) leave the Menu with the (X) button.

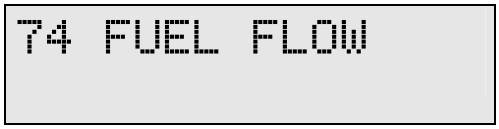
```
72 TEMPERATURE
   SENSOR
```

It is important to calibrate the temperature sensor when the ECU is used for the first time.
If you have made a SYSTEM RESET
If the Sensor Element has been replaced

Enter the ambient temperature and press the enter button.

```
73 AIRSPEED
   SENSOR
```

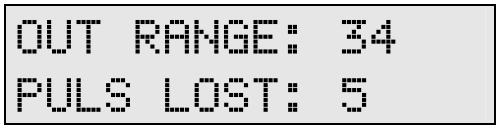
This menu is for the calibration of an airspeed sensor. Additional information can be found in the attachment



The ECU can monitor the actual fuel consumption (alarm function.) To use this function, you need to programme – fuel consumption at idle, fuel consumption at max power and tank size.

* INFO *

The information menu shows you all the minimum and maximum data of the last turbine run (temperatures, RPM etc.) Only the transmitter signal check needs a short explanation:



"OUTRANGE" shows the number of wrong transmitter signals.
"PULS LOST" shows the number of transmitter signal losses (total loss of signal)

* TEST MENU *

The Hornet's Software includes extensive test and diagnosis functions to check all components.

Attention: It is important to detach fuel and Kerosene tubing from the turbine if you test the pump or the Propane valve – danger of fire!

Pump: The pump voltage can be adjusted with the up and down arrow buttons, the enter button starts the pump, the (X) button is used to stop the pump.

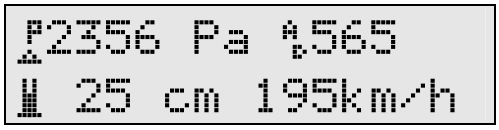
Propane Valve: The up and down arrow buttons adjust the pulse width, the enter button switches the valve on and the button switches off (valve closed.)

Fuel Valve:

Smoke Valve:
(√) button switches ON (Valve opened).
(x) button switches OFF (valve closed).

Temperature Sensor :
TMP : detected ambient temperature
AMB : Compensated ambient temperature

Speed Sensor



Δp: Differential pressure (Pascal)
ADC: Analogue/digital converter value
: Water level
km/h: corresponding speed (Kilometers per hour).

Rpm Sensor:
Shows the measured rpm

RC Timing:
Shows the pulse duration of the throttle and switch channel.

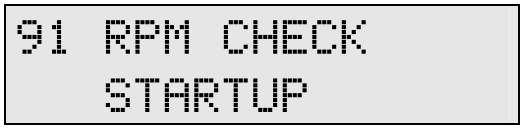
* MANUAL *

The turbine can be operated manually without the need for a radio.
It is controlled by the GSU.
The (√) button is to start the turbine, the (x) button shuts the turbine off.
The (↑) (↓) buttons increase/decrease the rpm.
If the (√) button is pressed simultaneously with the (↑) or (↓) button, the turbine will accelerate to full power and then decelerate to idle.

* SYSTEM *

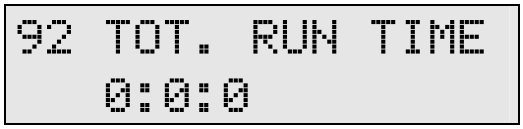
8 CELLS
----------/----------
Preset Value / Your Value

Give the number of cells in your battery pack, this is important as it activates the “Low battery alarm” function.

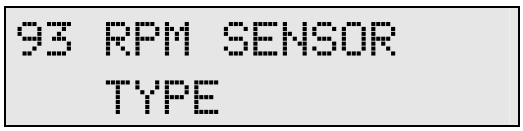


ON
----------/----------
Preset Value / Your Value

If your turbine is started with the full automatic starter, the RPM check should be activated. It can be necessary to deactivate this function when the start up is done manually. (eg, Hand starter, compressed air etc.)



Menu 92 shows the total running time of your turbine. This is not a default that you can reset.

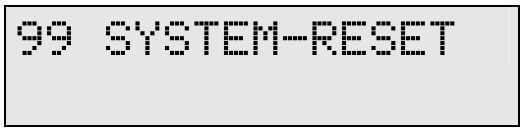


You can adjust your type of RPM Sensor : Optical = 2 pulses per revolution
Magnetic = 1 pulse per revolution

If you change your RPM measurement system pay attention to this value ! Wrong adjustment means that the ecu measures only half of the turbines real rpm - this will destroy your turbine immediately !

0.5 V/sec.
----------/----------
Preset Value / Your Value

During start up the starter voltage increases smoothly. The increase of volts per second value can be adjusted
The preset should not be changed under normal circumstances.



You can reset all the settings back to the manufactures defaults (Preset Values) except the total running time.
After resetting to defaults you will have to recalibrate the Transmitter and Temperature Sensor again.

* LAST SHUT OFF *

User Break
This shows when the turbine is shut down by the operator, moving the Throttle stick and trim to minimum position.

Under run RPM Min.
If the RPM falls below the preset Idle Speed by 10%. (Menu 12)

Over run max.
The RPM has exceeded by more than 5% the programmed Max RPM.(Menu 11)

Over Temperature
The permitted maximum temperature has been exceeded (Menu 22)

Flame Out.
The turbine temperature dropped below the programmed minimum temperature. (Menu 21)

R/C Timing Fail.
Caused by the loss of the Radio Transmitter signal.

RPM Sensor Fail.
Loss of the RPM sensor signal.

Max Pump Voltage Exceeded.
The maximum pump voltage of 6 volts has been exceeded during the calibration run (Menu 42)

Power Failure During Operation.
Power has been cut to the ECU during operation. (cables damaged, loose fit of plugs, flat battery)

Startup interruption

Over temperature
Temperature during start up higher than 1100 deg C.

Flame out heat.
Temperature during preheat too low.

Flame out fuel ignition.
Temperature during Kerosene ignition too low.

No propane ignition.
No propane ignition detected, (Is the gas ON?, Glow plug OK? ,Battery charged?, Too much /too little gas. Air temperature too cold-warm gas canister, Starter speed too high)

RPM < 4000 propane heat.
Starter was unable to accelerate the turbine during preheat (RPM lower than 4000).

No acceleration.
Turbine did not accelerate during start up.

Battery low.

Battery less than 1 volt / cell. (charge the battery)

RPM < 12,000 during start up.
RPM during acceleration (Kerosene) was less than 12,000.

Userbreak.
Start up interrupted by the operator.

The Radio

Most modern jets require a lot of receiver channels. Therefore the HORNET only requires one channel
(The Throttle in combination with the trim).
A separate channel (ON/OFF switch) can be used if so desired for shut down of the turbine.
If you are using a modern radio with digital trims, you will need to set the rate at which the trim moves to the highest setting on your transmitter, or use a separate channel with the AUX on the ECU

The Throttle function is as follows :
Throttle stick and trim fully open----------READY.
Throttle stick and trim fully closed---------OFF (immediate shut down of the turbine)

The ProJet Hornet does not require a switch between the battery and the ECU.
The ON/OFF function of the ECU works automatically when the battery receiver is switched ON/OFF.

ATTENTION: Check the Throttle programming in your transmitter.
The Throttle channel must not have Expotential or Dual Rate functions activated.
The movement must be set to 100%.

The GSU will monitor the engine status---depending on Throttle and trim position---after the has been switched ON (See page 4).

Additional switched channel
Some digital trim radios may require a separate switched channel, as the trim rate may not be adjustable on the Throttle channel (Futaba can be rate adjusted).
Ready made cables can be purchased from ProJet or you can make your own with JR servo connectors.
The cable has to be connected to the AUX channel on the ECU and a switched channel on the receiver
The polarity is - + - (see drawing)

As with the Throttle channel, the switch channel must not have any Expo, or Dual Rate functions programmed in.
The AUX channel does not need any calibration

NOTE: The only difference to the single channel version is that the trim is always in the UP position when using the ECU(after calibration has been carried out)

The auto start is activated as follows :

- Throttle and trim in the Up (fully open) position and the switch in the ON position.
- Bring the switch to the OFF position.

- Now bring the switch to the ON position.
- Auto start is now activated.
- When the turbine is running the Throttle can be returned to the Idle position, and after two seconds you have control.

Switching OFF the turbine does not require any trim movement when the AUX channel is used---just bring the switch to the OFF position.
The ECU will normally cool down the turbine after it has been switched OFF.

The auto start

- The Throttle stick and trim is in the UP (fully open) position.
- Throttle stick ONLY is moved to the IDLE position and then back to the OPEN position within three seconds.

After a successful Auto start, the ECU will change to the “AUTO” mode (see display).
All, important parameters such as RPM, temperature, acceleration and battery condition display, are now controlled by the ECU.
As a safety function, the THROTTLE has to be moved to the IDLE position for a least two seconds, before the operator has the full authority over the turbine RPM.

Description of the start up procedure

- Throttle and trim to the max position.
- Status LED—**ORANGE**—READY.
- Throttle to IDLE and back to MAXIMUM within three seconds. LONG BEEP---LED---**RED**
- Propane valve opens, starter motor and glow plug are switched ON. (see menus 55,51,and 70)
- Propane ignites.
- The turbine will be preheated (see menus, 58 and,53).
- Kerosene injection/ignition (see menu 41).
- Turbine accelerates to IDLE speed (pump voltage as programmed in menu 43 calibration run values) - Acceleration is dependant on the temperature.
- Turbine IDLES.
- ECU switches to AUTO.
- Throttle back to the IDLE position (for a least two seconds)
- You now have control of the turbine RPM.

The First Start – Short instructions

Note: If you want to operate a homebuilt turbine and your starter has not been tested before, compressed air should be on hand to assist the starter motor if too weak.

- Do not operate the turbine indoors.
- Wear ear protection.
- Remove loose parts from around the turbine(nuts, screws, bolts, cables or anything that might be sucked into the intake)
- Never work on the turbine during operation.
- Always have a fire extinguisher on hand (CO2 is recommended).
- Before starting the turbine, make sure the turbine is not flooded with Kerosene.
- Never allow spectators to stand in the plane of the turbine wheel, ---a safe place is in front but at a safe distance.
- Use a helper who is familiar with procedures.

OPTIONAL MANUAL START

If your turbine does not have a starter motor (controlled by the ECU) it will be necessary to deactivate the RPM CHECK START UP (Menu 91).

- To activate the manual start, make the Throttle and trim movements as described before.
- When you hear the long “BEEP” from the I.O.Board, crack open your manual propane valve and put your manual starter to the spinner ,or blow the rotor with compressed air, or spin the rotor with your fingers just enough to mix the air with the propane, ignition will occur with a “POP”, now keep the rotor spinning with short bursts of the starter motor and the temperature will begin to rise.
-
- When the propane ignition has been recognised you will hear a short “BEEP” from the I.O.Board. Now is the time to spin up the rotor to full speed, at the same time the Kerosene will begin to flow and burn.
- Turn OFF the propane.
- The ECU will control the acceleration up to IDLE RPM.
- After reaching IDLE RPM the ECU will change over to “AUTO” mode (LED-- **RED**)

SHORT INSTRUCTIONS

The following short version of the manual is divided into three steps :

1. Connection of components.
2. Necessary adjustments
3. Operation

STEP 1 - Connection of the components.

The following components have to connected to the ECU.

1. The sensor amplifier
2. Input/output board (I.O.board)
3 Starter motor
4. Kerosene pump
5. Propane valve
6. Kerosene valve
7. Battery

The ECU switches automatically with the receiver, it does not require a separate switch.
The ECU has a small power consumption in the OFF switched mode. Therefore disconnect the battery from the ECU when not being used for a while.

STEP 2 - Necessary adjustments.

The Hornet is programmed with the Ground Support Unit (GSU). The (+/-)buttons are used to increase /decrease values, (√) button is to confirm, and the (X) button to escape. (value will not be stored).

The following values have to be programmed before the first operation of the turbine.

- Calibration of transmitter signal (Menu 21).
- Minimum/maximum RPM (Menu 11 and 12)
- Pump start voltage – Important ! – (Menu 41)
- Glow Plug Power (Menu 70)
- Calibration of temperature sensor – important ! (Menu 72)

Transmitter calibration:

Use + button to get “Adjust” - menu, Confirm with √. Go on with + button until you see (Menu) 71 R/C timing.
Confirm with √ , follow the instructions and confirm with √.

If the GSU monitors an error message, reverse the throttle channel in your transmitter. When ready leave the menu with X (do not press √ again!)

You can now check the correct function:

Throttle and trim to idle	0% OFF
Trim to maximum	0% ON
Throttle to maximum	100% ON

NOTE: A transmitter calibration has to be done after each system reset and when the receiver has been changed!

Calibration of temperature sensor:

Go to Menu 72, enter the ambient temperature and confirm with √.

RPMs:

Go to: - Set up – RPM, then √, adjust the RPMs and confirm with √.

Pump Start Voltage:

Go to Menu 41, confirm with √. Your transmitter should be switched on, throttle and trim in minimum position (idle.) Now press the button on the I/O board and Icheck that the pump starts safely. If not, increase the voltage with the + button until you are satisfied, confirm with √.

Glow Plug:

Go to Adjust – Glow Plug Power, then √. The glow plug is now powered by the ECU (with the adjusted voltage.) Increase or decrease and confirm with a √.
Note: The adjusted voltage (preset) of 2 volts should be OK for most glow plugs.

Step 3 --- Operation.

It is very important that the very first turbine run with the Hornet ECU is a calibration run!!!

The ECU measures and stores all important parameters (pump voltages for corresponding RPMs.)
Do the run calibration as follows:

Go to: Set up – Pump Set up – Run Calibration (Menu 42), the trim on your transmitter has to be in the maximum position!
Start the calibration with √.
The turbine will start automatically, it will stabilise the IDLE RPM and then accelerate to the maximum RPM (slowly.) After that the turbine idles again and the ECU switches over to the AUTO mode.

The Projet Hornet requires only the throttle channel for all functions, this means:
Throttle and trim in minimum position = OFF position (turbine switches off when running)
Trim in maximum position = ON position/READY.
The only exception with the throttle and trim positions is during the full automatic start procedure.
This works as follows:

Throttle and trim to maximum	{Ready}
Throttle to minimum	{Wait for start up}
Throttle back to maximum)	{Autostart}

Attention: As a safety function, the throttle movement between step 2 and 3 has to be done in within 2 seconds!!