ProJET
electronic components

V2.0

Hornet III

Instructions manual
Bedienungshandbuch

LIST OF CONTENTS

INTRODUCING

The HORNET-III is a modern engine control unit for model aircraft turbines to controll and regulate the engine in a safety operation area.

Additional all important engine data are observed and the engine is shut down if an error occures, i.e. overtemperature or rc-signal failure. Description of error conditions look at apendix.

☞ ATTENTION !!!

A perfect running engine is required for unproblematic operation. Bad running engines could not be operated successfully and reliable by an electronic control unit.

LIABILITY

By using this product, you agree to hold ProJET electronic components GmbH free from any type of liability either directly or indirectly while using this product.

WARRANTY

This product is warrantied for 24 months. ProJET electronic components GmbH, Buchäckerweg 27, 95689 Fuchsmühl, Germany guarantees this product for a period of 24 months from date of purchase. The guarantee applies only to such material or operational defects wich are present at the time of purchase of the product. Damage due to wear, overloading, incompetent handling or the use of incorrect accessories is not covered by the guarantee. The user´s legal rights and claims under guarantee are not affected by this guarantee. Please check the product carefully for defects before you are make a claim or send the item to us, since we are obliged to make a charge for our cost if the product is found to be free of faults.

Anschlussschema Hilfsgasstart
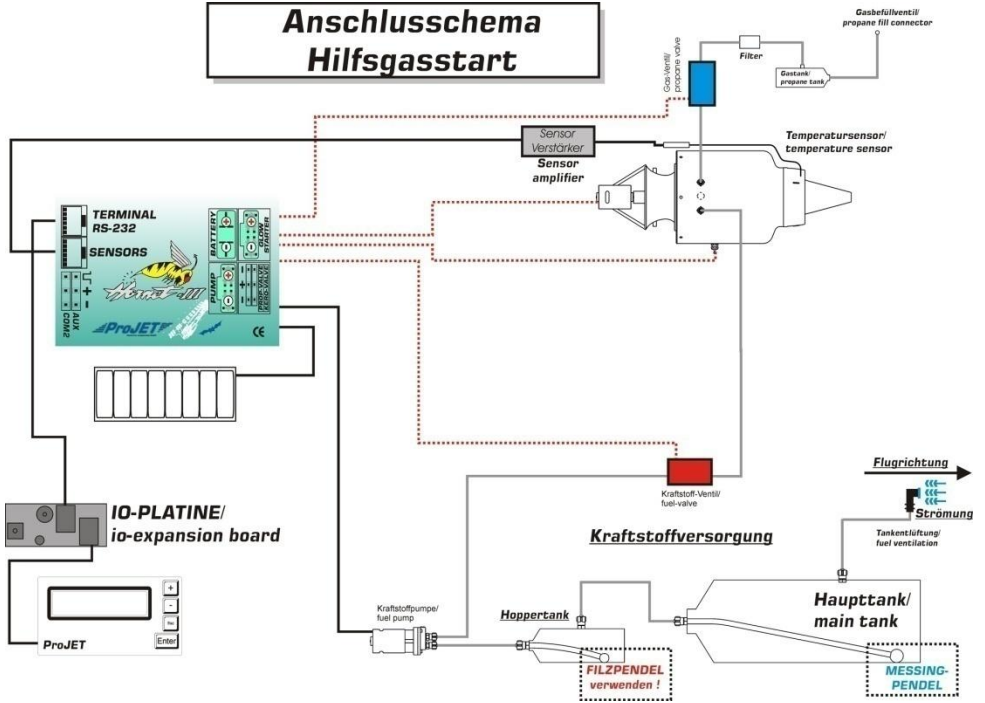
Anschlusschema
Kraftstoffstart
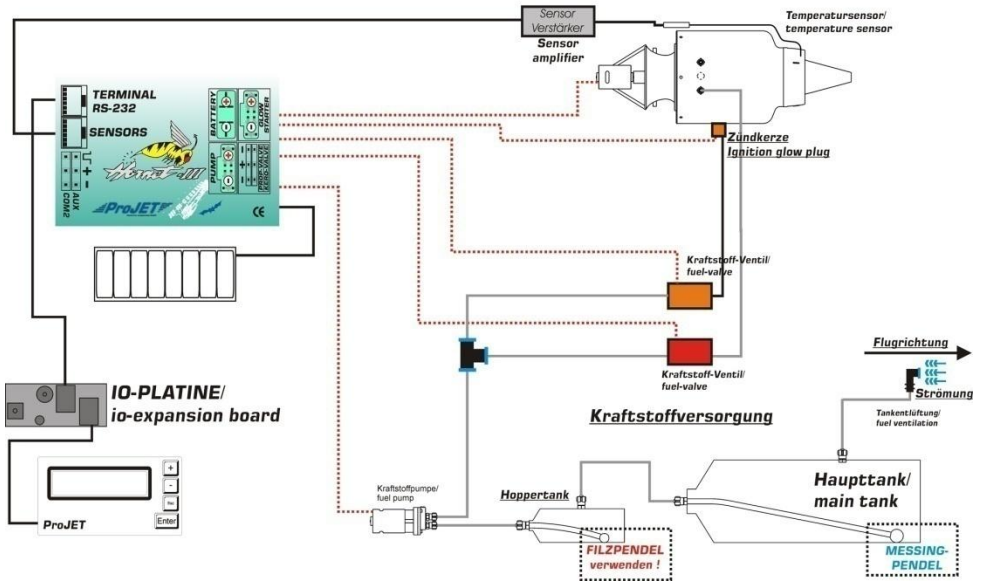
COMPONENTS

Listed accessories are needed for engine operation:

- HORNET ECU
- GSU
- I/O BOARD (with LED and buzzer)
- Sensor – amplifier pcb
- Sensors (rpm and temperature)
- Fuel pump
- Power supply battery

POWER SUPPLY

Al components are supplied by one battery. The capacity should be at least at 2500 mAh. If the ecu is not operated more than a week, the battery must be disconnected.

FUEL SUPPLY

The whole reliability of the running engine system depends on a perfect fuel supply.

- Using a high quality fuel pump
- Using high quality valves
- Hopper Tank
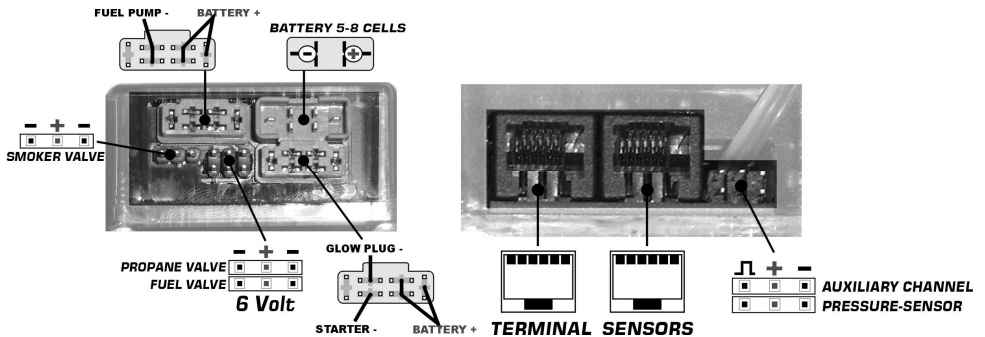- No filter before fuel pump
- Largest cross-section of the fuel pipeline

ELECTRICAL CONNECTION DIAGRAM

STARTER

To start the engine you can use a fan or an electrical motor.

GLOWPLUG

Propane ignition

A modified conventional (hot range, non-idle bar) glow plug (Rossi #3) is appropriate. The glow plug is installed on the engine without a washer. The glow plug is modified, so what to turns of the element extend beyond the bottom of the plug. Using a pin, turn out two turns of the element. Make sure the plug glows brightly red. The glow plug voltage is adjusted at Menue „Adjustment".

Kerosene ignition
The glow plug voltage has to be adjusted to the burner-plug voltage.

VALVES

To realize the automatic start you could connect a propane /kerosene valve.

Further there is the opportunity to plug in a smoker valve.

IO-BOARD:

To lengthen the in-and output port and the serial port the io-board could be plugged in between the ECU and GSU. The board should be mounted on a good accessible position.

Buzzer:

- Short signal   : Power on message – GSU connected
- Long signal   : Begin autostart (open propane supply)
- Short interrupted signal   : Battery power alarm/Temp.-Sensor fault/Glow plug fault

(Symbol at GSU)

Status-LED:

- Green   : OFF
- Orange   : READY
- Red   : Engine in auto-mode

Button:

- By pressing the button in OFF-mode the pump is turned on manually.
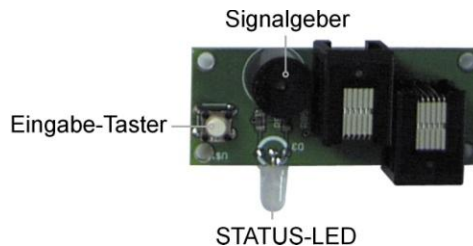
GROUND SUPPORT UNIT (GSU)

OPERATION

All important settings are transmitted from the GSU to the ECU. The following diagram shows a menu overview.

The input is done by four buttons UP(↑), DOWN(↓), ESC(✗) and Enter(✓).

The GSU can be connected during operation to change or show adjustments.

With ↑↓-button the menu is scrolled up and down or adjustments are in/ decreased.

With ✗–button inputs can be escaped, without saving adjustments.

With ✓-button adjustments are saved.

ADDITIONAL FUNCTION – STARTING ENGINE

If you operate two engines simultaneously, it could be necessary to start the engines manually. Push the throttle stick and trim to maximum position - by pressing [ESC] and [UP) buttons at the same time the autostart is executed.

☞*ATTENTION !The GSU must not be mounted inside the model aircraft, because of electric magnetic disturbances!*

POWER ON MESSAGES

After connecting the GSU to the ECU two messages appear.

```
HORNET-III V1.4a
   HOMEBUILDER
```

ECU-Version

```
SENSOR: OPTIC
IGNIT : KEROSENE
```

RMP sensor (optical/magnetic), Ignition System (Propane/Kerosene)

STATUSDISPLAY

With ↑↓ -bottons the different status displays could be showed.

STATUSDISPLAY 1 – ENGINE STATE

The status display appears with following information :

<p align="center">Temperature   –   RMP x 1000   –   Throttle position (%)</p>

```
26°C      ---/---
0FF       †0. 0V
```
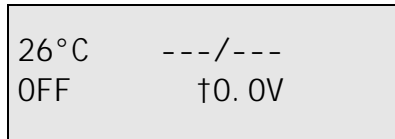
<p align="center">Operation state   -   pump voltage</p>

Temperature	: current egt
RMP	: RMP x 1.000
Operation state	: current state (OFF, READY, AUTOMATIC etc...)
Pump voltage	: current pump voltage

Display Symbols

- **Battery full**
§ **Battery normal**
¶ **Battery weak**
¢ **Glow glug faulty**
† **Pump running/pump voltage**

If an error condition occurs (Battery weak, glow plug faulty...)an alert tone sounds.

STATE MESSAGES

OFF
engine off, standby

STANDBY
standby – waiting for start sequence (throttle stick to 0% and next to 100%)

PROP IGNIT
Start engine– propane ignition

BURNER ON
Kerosene ignition– Burner plug on

FUELIGNIT
Kerosene ignition

FUELHEAT
Heat – Engine will be heated with constant rmp and pump voltage

RAMP DELAY
Starter will accelerate slowly without increasing pump voltage

RAMP UP
Increase engine to idle rpm

WAIT ACC
Waiting for acceleration gets steady

STEADY
Waiting for stabilize rpm

CAL IDLE
Teach in idle rpm

CALIBRATE
Teach in calibration rpm

GO IDLE
Stabilize idle rpm

AUTO
Engine in automatically operation

AUTO-HC
Engine in automatically operation – max. rpm is teached in – Necessary for carry out emergency programs

EMERGENCY
Emergency program – engine will be regulated over pump voltage

SLOW DOWN
Engine turned off – waiting for still stand

COOL DOWN
Cool down engine with constant starter rpm

DEV. DELAY
The engine speed could not follow the increasing pump voltage – Acceleration ramp too fast!

STATUSDISPLAY 2 - KEROSENE

Status display 2 informs about kerosene consumption and remaining fuel.

STATUSDISPLAY 3 - POWERSUPPLY

Status display 3 informs about battery state.

STATUSDISPLAY 4 – ERROR MESSAGES

Status display 4 show last turn off reason.

ERROR MESSAGES START-PHASE:

RPM < 2.000 DURING HEAT
REASON: Engine felt short of 2000rpm during heating time
EXPLANATION: Starter voltage to low(Menu 9.16), Starter broken, Stucking engine

RPM < 5.000 DURING INCREASING
REASON: Engine could not reach 5000 rpm during ramp-up to idle rpm
EXPLANATION: Starter voltage to low(Menu 9.16), Starter broken, Stucking engine

FLAMEOUT DURING HEAT
REASON: Temperature felt of short 200 degree during heating time
EXPLANATION: Starter voltage to high (Menu 9.16), Fuel intervals (Menu 1.8) to low

FLAMEOUT DURING INCREASING
REASON: Temperature felt of short 200 degree during ramp-up.
EXPLANATION: Starter acceleration to high (Menu9.19), Fuel supply interrupted

ERROR MESSAGES AUTO-CALIBRATION

FLAMEOUT DURING CALIBRATION
REASON: Temperature felt short of 250 degree during calibration-run.
EXPLANATION: Fuel supply interrupted -> User error

FELT SHORT OF MIN. CALIBRATION RPM
REASON: Necessary rpm felt short of to ramp up engine
EXPLANATION: Disturbance at speed sensor (Light, electrical error), Fuel supply interrupted (Bubbles) -> User error

ERROR DURING CALIBRATION
REASON: Calibrations rpm could not stabilized
EXPLANATION: Calibration time to fast (Menue 9.4), Fuel supply interrupted -> User error

CALIBRATION VOLTAGE EXCEEDED
REASON: Max calibration voltage was exceeded
EXPLANATION: Max. calibration voltage to low (Menu 9.5), Fuel supply interrupted , Pump broken (Loosing power) -> User error

Calculated fuel pump voltage too high
REASON: Necessary pump voltage exceeded the max. permitted voltage of the ecu to reach the max. rpm (Menu 1.6)
EXPLANATION: The max. allowed fuel pump voltage exceeds the adjusted volte in pump max volt (Menue 1.6)

ERROR MESSAGES ENGINE RUN

FAILURE GASTHROTTLE PULSE
REASON: Break down throttle pulse during engine run,
EXPLANATION: Disturbance at input signal of PPM receivers, Loosing contact at connection receiver/ecu, Broken throttle-channel

FAILURE SPEEDSENSORSIGNAL
REASON: Speed-impulse fail
EXPLANATION: Bright light, Broken speedsensor,Disconnected speedsensor

MAX. RPM EXCEEDED
REASON: Exceeded max. rpm
EXPLANATION: Wrong settings at control loop -> Overshot, Disturbance at speedsensors (Light, electrical error,losing contact)

MIN RPM UNDERRUN
REASON: Minimum rpm felt short of

EXPLANATION: Disturbance at speedsensor (Light, electrical error,losing contact), Fuel supply interrupted (Bubbles)

FAIL TEMPERATURE-SENSOR
REASON: Incorrect temperature measurement
EXPLANATION: Temperature-sensor broken, Disturbance at sensors(electrical error, losing contact)

MAX. TEMP EXCEEDED
REASON: Max temperature of 800 degrees was exceeded
EXPLANATION: Mechanical problem of engine

FLAMEOUT DURING RUN
REASON: Temperature felt short of 200 degree during run.
EXPLANATION: To fast delay, Bubbles at fuel supply, tank empty

MENU

Access main menu by the ✓ – button.

1-SETUP

1.1   MAX. RMP
Setting the max. rmp of the engine
1.2   IDLE RMP
Setting the idle rmp
1.3   FLOWDYNAMIC
Setting of acceleration and delay – FAST – MIDDLE - SLOW, it depends on the weather how to adjust the acceleration and delay ramps.
Fast response characteristic results in overheating or exhausting engine.
1.4   STARTING PUMPVOLTAGE
Min necessary voltage to start pump. If pump voltage is too high it could result in a flame formation during starting engine, is the value entered to short fuel could not be ignited.
1.5   PUMPVOLTAGE IDLE RPM
After ignition engine pump voltage will be ramped-up to reach idle rpm. The ECU teaches in the idle rmp autonomous. For inquiring start ramp must entered only an estimated value.
1.6   MAX. PUMPVOLTAGE
Not to confuse with pump voltage at max. rpm. The entered voltage is for detection some errors at pump. Is this value exceeded, engine will immediately be stopped ! The voltage should be entered a little higher than the voltage at max. rmp. Pleas note: If voltage is too less, engine will not reach max. rpm !
### 1.7   PROPANE-VALVE PULSE
Quantity of propane to start engine depends on ambient temperature and propane pressure .
If fuel ignition is used, valve will be smooth pulsed.

1.8 FUEL-VALVE PULSE

After successful ignition, the fuel supply will regulated with the entered value. Engine will exhaust with less values.

1.9 GAS-EXPO

Setting of throttle stick – RPM-Curve. 0% = Linear (no EXPO) 100% = max. EXPO.
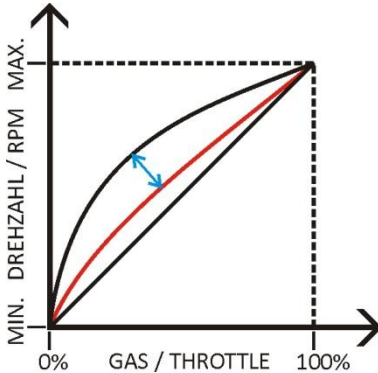
1.10 TEST GLOWPLUG

Glow plug test can be switched on or off during starting phase.

1.11 COOL DOWN TEMPERATURE

Engine will be cooled down to the entered temperature.

2-ADJUSTMENT

2.1 TEACH IN TRANSMITTER

The ECU has to learn the used transmitter. Listen to the following instructions:
1. THRO. LO/TRIM LO (THROTTLE/TRIM MINIMUM) Throttle-Stick and trim to minimum -> ✓
2. THRO. LO/TRIM HI (THROTTLE MINIMUM/TRIMMING MAXIMUM) leave throttle-Stick at minimum, Trimming to maximum -> ✓
3. THRO. HI/TRIM HI (THROTTLE MAXIMUM/TRIMMING MAXIMUM) push Throttle-Stick to maximum, leave trimming at Maximum -> ✓
➔ Ready.
➔ If AUX-Channel is active (plugged in), the aux channel positions must be tea ched.
➔ The plausibility will check up after adjustments. If an error message with a sound signal appears, solve the problem and carry out the procedure again. The reason is mostly a wrong programming of the transmitter.

2.2 ADJUSTMENT GLOW PLUG

Setting the voltage of the glow plug

2.3 ADJUSTMENT TEMPERATURE

Adjustment of the temperature element

2.4 FUEL CONSUMPTION

To use the fuel gage the characteristic pump curve is necessary. Set in the fuel-flow at 1 Volt (FUEL-FLOW @1.0V) and 2 Volt (FUEL-FLOW @2.0V) pump voltage. For calculating the remaining fuel set in the size of the fuel tank.

3-SYSTEM

3.1 BATTERY VOLTAGE

Set in the min. and max. voltage of battery.

3.2 LANGUAGE

Choose your language .

3.3 COUNTER

Shows the effective running time of engine

3.4 FAILSAFE FUNKTIONS

Necessary if receiver fail safe or error impulses arises (see chapter distance control)

3.5 SWITCH CHANNEL FUNCTIONS

If a switch channel is used, the functions must be filled in. Choosing possibilities :

- Without function   : Switch channel is not used
- ON/OFF Switch   : Switch channel replaces trimming
- SMOKER VALVE   : A Smoker valve can be used. Notice, that the output will switched off not before egt exceeds 300°C

Notice, the channel has to be teached in before using.

3.6 WIRELESS TELEMETRIE

Activating a telemetry transmitter (TRX-2400). The count of data is specified (OFF/1x/2x/3x) and channel (COM-CHANNEL 0-10) and the address of telemetry-Terminal (0-10000). More detailed information see on telemetry-system instructions manual.

3.10 SETTING RESET

ATTENTION! Choice sets the ecu in condition of delivery date!

9-EXPERTE MASTERMODE

The menu 9 can only be used in a self-build version, in a producer version this menu is not available.

ATTENTION ! Setting of all necessery parametres for the runnig behaviours of engine. Settings must be carried out by an expert!

9.1 MAXIMUM UPM INPUT

Max. adjustable speed (MENU 1.1)

9.2 MINIMUM UPM INPUT

Min. adjustable speed (MENU 1.2)

9.3 CALIBRATION SPEED

This speed will reached for calibration run after starting engine. This speed fix a crossing point between slow /fast acceleration resp. delay(Menu 9.8 – 9.11)

9.4 CALIBRATION RATE

Input of pump voltage increasing rate during automatically calibration. If voltage is too high, flaming results and calibration speed could be exceeded (9.3). This should be avoided! Is the adjusted value too low, the automatic calibration is delayed.

9.5 CALIBRATION MAX. VOLTAGE

This max pump voltage must not be exceeded during auto. calibration. Engine will shut down -> see error messages

9.6 CORRECTION FACTOR MAX.

To calculate the desired pump voltage at max., set in a multiplication factor.
ATTENTION ! Is this value to low, the max rmp will be reached verry slow at first attempt, overshoot if the value too high.

9.7 CORRECTION STEP MAX

Are the differences in normative-actual state rpm the pump voltage will re-adjusted with this value. The input happens in volt/sec.
ATTENTION ! If this value is choosen too low, the re-adjustment happens verry slow, is this value too high, the closed loop regulator can swing, turbine could be shut down.

9.8 ACCELERATION SLOW

Time to accelerate engine from idle to calibration speed (Menu 9.3).

9.9 ACCELERATION FAST

Time to accelerate engine from calibration speed to max. rpm (Menu 9.3).

9.10 DELAY SLOW

Time to delay engine from calibration speed to idle (Menü 9.3).

9.11 DELAY FAST

Time to delay engine from max. rpm to calibration speed (Menu 9.3).

9.12 ACCELERATION / DELAY TEMPERATURE

If temperature rise per 1/10 per second is higher than the declared value, the fuel injection is delayed to avoid overheating engine.

9.13 SPEEDSENSOR

Used sensor optical/magnetic – one or two pulse/rotation

9.14 IGNITION

Choice fuel or gas ignition

9.15 STARTER-V IGNITION

Starter Voltage to ignite engine

9.16 STARTER-V HEATING

Starter voltage during heating time

9.17 STARTER-V MAXIMUM

Max. starter voltage.

9.18 SPEED STARTER OFF

Rpm to decouple starter.

9.19 STARTER ACCELERATION

Value which starter voltage will increased per second, too high values could blow out engine.

9.20 HEATING TIME

After fuel ignition the combustion chamber will be heated up for this adjusted time.

9.21 FUEL DELAY

After heating the starter will rise up slowly in adjusted time, without increasing pump voltage. (STATUS: RAMP DELAY)

9.22 RAMP-UP TIME

Engine will increased to idle rpm in adjusted time. Thereby pump voltage will increase. Menu 1.5 PUMP VOLTAGE IDLE

9.23 RAISING PUMP VOLTAGE

To ignite fuel, the pump voltage will increased with this value.

9.24 PROPANE/BURNER SWITCH OFF SPEED

After exceeding the adjusted rpm the propane resp. the fuel supply will stop.

9.25 ACCELERATION CURVE

Choice of an acceleration curve (chapter functions and program flow).

9.26 DELAY CURVE

Choice of a delay curve (chapter functions and program flow).

9.30 RESET OPERATING COUNTER

Reset operating counter.

9.98 PUMP-OFFSET

To compensate fabricating tolerances adjust a normative-actual state of voltage of the pump power amplifier. It is not allowed to change this value.

9.99 PRESETTING ENGINE TYPE

Used engine could be preset. The list of types is permanently expanded, ask your producer of your engine about settings for your engine.

RUN AUTO-START
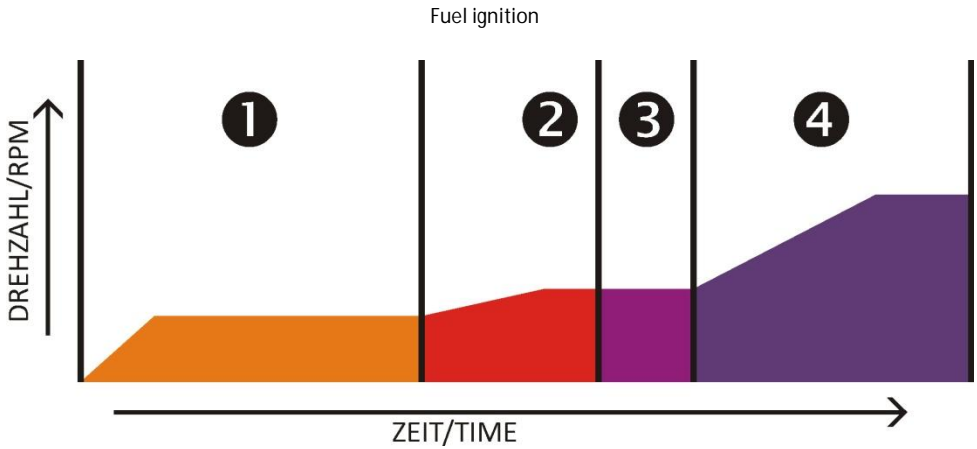
Fuel ignition

1. BURNER ON –Burner on for 8 seconds
2. FUEL IGNIT – Pushing burner valves– Starting fuel pump
   FUELHEAT – Heating time (Segue from burner supply to fuel ignition)
3. RAMP DELAY – Slow starter acceleration with constant fuel supply
4. RAMP UP – Increasing to idle
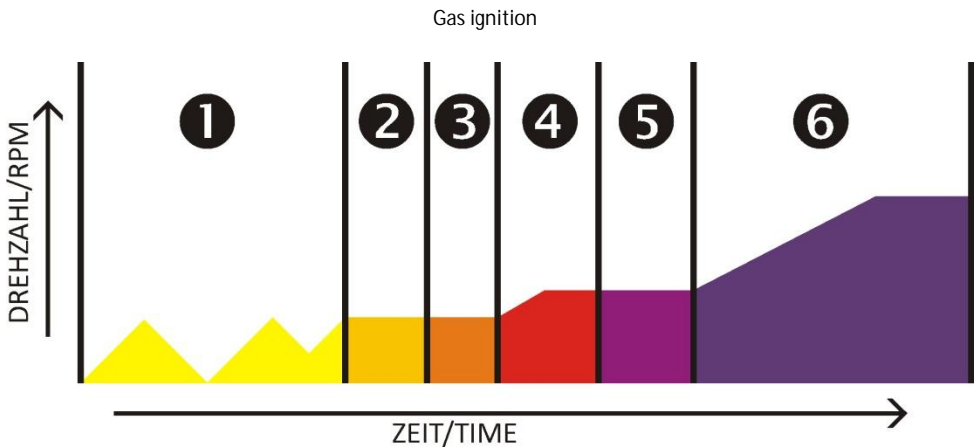
Gas ignition

1. IGNITION – Glow plug on / starter , gas valve open
2. PROP HEAT – Heating with propane
3. FUEL IGNIT – Fuel ignition
4. FUELHEAT – Heatin time(Segue from gas supply to to fuel ignition)
5. RAMP DELAY – Slow starter acceleration with constant fuel supply
6. RAMPUP – Increasing to idle

RUN AUTO-CALIBRATION

1. Accelerate engine to calibration rpm
2. Stabilize
3. Approach idle rpm
4. Calculation the characteristic curve of engine

PROCEDURE OPERATION

Characteristic features for automatically operation:

- Fuel supply depend on temperature and speed
- Controlling of speed and temperature limits
- Recording all relevants engine data (BLACKBOX)
- Telemetry transmitting

EMERGENCY OPERATION

The ECU disposed of an emergency program. In case of temperature or speed sensors failure a emergency program occur (State: EMERGENCY). In this modus the engine is controlled only over the characteristic curve of the pump. A precondition for activating this the AUTO-HC state must be reached one time.

Restarting engine is only possible after correction the error cause.

SAFETY FUNCTIONS

- Speed: Exceeding-fall below-failure
- Temperature: Exceeding-fall below-failure
- Power supply: Min. voltage
- Output fuel pump: Failure/Bypass
- Input receiver: Failure –Disturbance –FailSafe

RADIO CONTROL

THROTTLE

The throttle controls the engine:

- Initiation starting sequence
- Speed / Thrust controlling during flight
- Shut-off

Before starting the engine, the radio control has to be teached in. (see Menu 2-Adjustments).

STARTING ENGINE:

1. Triming + throttle to maximum -> STANDBY
2. Throttle to minimum
3. Within 3 secs throttle to full -> STARTSEQUENCE

SPEED/THRUST CONTROLLING

After successful start-sequence and calibration the gas throttle controls the thrust of the engine.

SHUT-OFF

Engine is switched off to minimum by pushing back trimming (throttle idle).

RADIO CONTROL WITH DIGITAL TRIMING

To react very fast with digital trimming it is recommended to mix a switcher on the throttle channel or to use a motor cut off switch. The switch replaces trimming, in this case trimming is without function and has to be left on the maximum position.

FAIL SAFE

The incoming throttle channel pulses are permanent checked, if they are in valid limits. Upper and lower limits will fixed in by teaching in the throttle channel. If a pulse is above or below this limits the fail safe function is working.

In status display 1 the message „FAIL" appear.

FAILSAFE DELAY:
Time between error impulses and depressing to fail safe rpm (Menu FAILSAFE THRUST).

FAILSAFE TIMEOUT:
Engine will shut off, if there is no valid impulse recognized or the receiver is already in fail safe modus.

FAILSAFE THRUST:
When „FAILSAFE DELAY" is runned over, engine will decreased to the stored value.

Disabling FAIL SAFE function:
Fail safe function is disabled, if the value 0,0 sec. is entered.

AUXILIARY

Function as ON/OFF switch:

On/Off switch (Replacement for trimming):
The switch replaces trimming, switch ON = trimming ahead / switch OFF = trimming backward. Notice: using switch the trimming has to be left at the max. position.

Smoker-Valve:
A smoker valve can be turned on and off. The valve is activated at 300°C and is automatically shut off below 300°C.

Radio control and ecu will connected on AUX-input patch cable. It is located directly below to the throttle channel cable.

AUX-ECU   **EMPFÄNGER**

APPENDIX

FIRST START – NECESSERY SETTINGS

To use the ECU with a turbine some settings are necessary. Basic steps:

1. MAX/IDLE-speed (Menu 1.1, 1.2)
2. Pump voltage during start (Menu1.4)
3. Adjustment radio control (Menu 2.1)
4. Setting burner voltage (Menu 2.2)
5. Adjustment temperature (Menu 2.2)

6. Battery voltage (Menu 3.1)

TECHNICAL DETAILS

- Efficient RISC Microcontroller
- Easy update by FLASH-MEMORY
- Modern USB PC-connection
- Gas-/Fuel Start
- Operation with only one receiver channel
- Starting by GSU (Models with more engines)
- Integrated logger: Dates will be recorded from the last 30 operating minutes. Recording resolution are 5 points per second
- Telemetry: Data could be transmitted to an local groundstation (Laptop)
- Emergency operation: In case of an sensor error (speed/temperature) engine run can safety finished
- Controlling power amplifiers (Fuelpump – Starter – Burner)

MAXIMUM TECHNICAL DETAILS

- Max. speed 175.00 RPM
- Pump output 6 A continuous / 10 A 200mS
- Starter output 6 A continuous / 10 A 200mS
- Burner output 6 A continuous / 10 A 200mS
- Output valves 250 mA continuous / 500 mA 1000mS
- Power supply: max 12,6 V continuous
- Receiver input 5 cells / max. 7,5 V / Pulse-amplitude min. 2,7 V

ACESSORIES

TRX-2400: 2.4 GHz Telemetry transmitter
Telemetry transmitter 2.4 GHz for transmitting data to a ground station

TelJET: 2.4 GHz Graphical telemetry display unit
Graphical display unit with serial data output, Real-time display of all relevant engine parameters

ENGINE DATA – SELF SELECTION

Fill in here your individual settings.

1-SETTING

1.1 MAX SPEED   *RPM*

1.2 IDLE RPM   *RPM*

1.3 DYNAMIC BEHAVIOUR ☐ *FAST*   ☐ *MIDDLE*   ☐ *SLOW*

1.4 PUMP VOLTAGE START   *VOLT*

1.5 PUMP VOLTAGE IDLE   *VOLT*

1.6 MAX. PUMP VOLTAGE   *VOLT*

1.7 PULSE GAS-VALVE   *%*

1.8 PULSE FUEL   *%*

1.9 GAS-EXPO   *%*

9-EXPERTE MASTERMODUS

9.1 MAXIMUM RPM   *RPM*

9.2 MINIMUM RPM   *RPM*

9.3 CALIBRATION RPM   *RPM*

9.4 CALIBRATION RATE   *VOLT*

9.5 MAX. VOLTAGE CALIBRATION   *VOLT*

9.6 MAX. CORRECTION FACTOR   *X- FACTOR*

9.7 MAX. CORRECTION STEP   *VOLT*

9.8 ACCELERATION SLOW   *SECONDS*

9.9 ACCELERATION FAST   *SECONDS*

9.10 DELAY SLOW   *SECONDS*

9.11 DELAY FAST   *SECONDS*

9.12 ACCEL./DELAY TEMPERATURE °C

9.13 SPEED SENSOR ☐ *OPTICAL* ☐ *MAGNETCAL*

9.14 IGNITION ☐ *FUEL* ☐ *GAS*

9.15 STARTER-V IGNITION *VOLT*

9.16 STARTER-V HEAT *VOLT*

9.17 STARTER-V MAXIMUM *VOLT*

9.18 SPEED STARTER OFF *RPM*

9.19 STARTER ACCELERATION *VOLT*

9.20 HEATING TIME *SECONDS*

9.21 FUEL DELAY *SEDONDS*

9.22 RAMP-UP TIME *SECONDS*