

# FADEC system-Autostart version

## Users guide.

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### Description of the FADEC.

The FADEC (Full Authority Digital Engine Control) is a total system for the control of a model gas turbine engine. Its main function is to control and regulate the fuel pump, providing to the turbine engine the necessary amount of fuel for safe and controlled operation. The FADEC measures the exhaust gas temperature, the relative position of the throttle stick and the rotor speed. It monitors all of the controls necessary to guarantee that the engine stays between the user defined parameters of operation, also providing failsafe shutdown of the engine when it has detected any important anomaly. In order to make this assessment, the FADEC has a rpm sensor, a thermocouple input, a throttle servo input, power connections for the fuel pump, starter, glow plug, fuel and gas valves and the battery and a digital (RS232) serial port to program and read the data in real-time to a PC.

The measurements made by the FADEC are:

- Temperature of the exhaust gas
- Pump battery voltage
- Width of the throttle pulses from the radio transmitter
- Engine rotor RPM
- Engine run time.
- External analog signal.

All of these measurements can be read into and displayed on the Handheld Data terminal (HDT) that is connected to the FADEC by a RJ-45 connector, or into a personal computer through a RS232 adapter. The configuration/setup parameters are stored in the FADEC by the terminal of hand or the PC.

### Features:

- RPM input: Magnetic sensor up to 250.000 R.P.M.
- Temperature range up to 1000°C using a "K" type thermocouple
- PWM control of 1024 levels for pump, glow plug and starter motor.
- Adjustable power for the starter motor
- Build-in electronic brake for the starter motor to help the clutch to disengage.
- Blown glow-plug detector
- Adjustable glow-plug power
- Glow-plug temperature independent of the battery voltage
- Adjustable gas off temperature
- Adjustable rpm starter switch on and off.
- Elapsed engine run timers
- Status LED on the unit
- RS232 interface to interface to a PC.
- Black box function. Record the engine measures each 0.5sec up to 52 minutes.

### Adjusting the parameters:

On this software version there are 2 sets of parameters that can be changed.

The "user" parameters are adjustable through the Data Terminal using normal menus. The "manufacturer" parameters are accessible by a special procedure and in some software versions, are only accessible by the manufacturers.

The user parameters are:

- Radio throws adjust.
- Maximum rpm
- Idle RPM
- Stop RPM
- Minimum temperature
- Maximum temperature
- Acceleration time
- Deceleration time
- Stability time
- Pump start point
- Pump start ramp
- Glow plug power
- Start gas flow

From these parameters, the readings of the engine and the position of the throttle control, the FADEC adjusts the power to the fuel pump in the following way:

First, the FADEC verifies that the control pulse of the transmitter is correct, that is to say, is between the limits set by the user. If the pulse is not correct, or the pulses are not received during 1.5 seconds, the system assumes that there is a trouble with the radio link and shuts down the engine (fail safe). During this time of delay, the system assumes that the throttle is at idle and decelerates the engine to this power.

Once verified that the pulse is correct, the relative position of the throttle stick determined by the limits programmed by the user is calculated. This calculation gives a value between 0% and 100% that can be read on the HDT or a PC. This value is transformed into a value of equivalent rotor speed from the values of full power speed and idle speed programmed by the user. For example, if we programmed a idle speed of 30.000 rpm and a full power speed of 100.000 rpm, this speed will be reached with the throttle control at 100%. With the throttle stick at 50%, the equivalent speed would be 65.000 rpm (half way between 30Krpm and 100Krpm). This calculated equivalent speed is compared with the one read from the engine and the power to the pump is corrected/adjusted until reaching the desired speed, in this case 65Krpm.

The speed of the slope of spool up is a parameter programmed by the user. To accelerate the engine the FADEC has to raise the power to the pump. The system monitors the exhaust temperature, reducing the rate acceleration if the temperature approaches to the maximum programmed temperature. In case of arriving at this maximum temperature, the system reduces the fuel flow until restoring the motor within its limits of operation, being able to stop the pump if it can not lower the temperature. With this system it is guaranteed that the engine accelerates in the minimum time possible without exceeding the max. temperature or speed, adapting itself to the variations of the engine, room temperature, pump, fuel pressure etc.

With this system, called closed loop, the rotor RPM of the engine tracks linearly with the position of the throttle control, independently of the type of pump, batteries or engine. This benefit is very useful in multiengine aircraft, since the thrust of the engines is always in balance.

Aside from the safeguards of speed out of limits, temperature or radio failure, the system also incorporates two additional safeguards. First is pump shutdown in case that the temperature of the exhaust is lower than the minimum, protecting the engine from flooding itself of non-burned fuel in case of flameout. The second is fuel pump shutdown due to a too low rotor speed. The system stops the fuel pump in case that the rotor speed is less than the programmed stop speed. This safeguards the engine from continued running in case that rotor speed is less than that required to self-sustain the engine, or in a rpm sensor failure.

The engine can be started manually (semiautomatic) or full autostart system.

In order to start the engine in manual mode, the user must first raise the transmitter throttle trim and leave the throttle stick in idle/minimum position. The green Light Emitting Diode (LED) on the FADEC illuminates, indicating the system is "ready for start". Once in this position, the operator must 1) turn/spin up the engine with the starter motor / blower etc, 2) open the butane/propane gas, and ignite it. When the FADEC registers an exhaust temperature higher than the programmed start/minimum temperature and the rotor turning, the LED begins to blink and, 3) the system begins to pump fuel to the motor, raising the fuel pump power slowly until the idle speed is reached. This final condition is signaled by the system extinguishing the LED. The manual start is only possible after power-on the unit. If the throttle is cycled, the system enters in AUTO mode, and cannot be started in manual until it is switched off/on again. "Auto Mode" can be read in the screen in this mode.

To start the engine automatically, the user should cycle the throttle from idle to full power and back to idle again. In this moment the start procedure is triggered and the autostart sequence progress until the engine is at idle. The user can abort the start process by lowering the trim.

In the case that the measured exhaust temperature is higher than the start/minimum programmed temperature, the throttle stick acts a switch, allowing the starter to be energized and too cool down the engine after a aborted start.

A pump prime system is added. When, in the start phase, the throttle stick is set up to 100% during 5 sec, the pump is switched on at 25% of power for 1 second maximum. This allows to prime the pump and the fuel tubes before the start. To protect that this function be activated remotely inadvertently, it is necessary that the Data terminal be connected and it display the second screen. ("Pulse=...")

#### 4. Installation of the FADEC.

##### Connections:

- Throttle input JR type connector receptacle.
- Propane/butane valve: JR type connector receptacle
- Fuel valve: JR type connector receptacle. The central cable is positive and the two of the sides negative.
- RPM sensor: JR type connector receptacle
- Thermocouple: JR type connector receptacle
- Battery input/ Pump output: MPX male plug
- Glow plug / Starter output MPX Female plug

- Aux 1 and Aux 2 inputs: JR type connector receptacle, used for pitot tube measure and Rotor speed measure in helis.

Connect all of the cables in his places. Note that some of the JR type connectors used can be connected in wrong place or inverted. Use the coloured labels on the FADEC body to connect all the connectors in his place. The configurations of the pins have done in the way that no damage can be produced to the electronics in the case of a bad connection.

##### Please note that:

- If the thermocouple connector is connected inverted, the temperature will decrease when heated, and the FADEC will fail in to recognize the gas ignition.
- If the RPM sensor is connected inverted, no RPM will be read.
- Use the recommended starter motor and battery. If bigger voltages are used, then the high current from the motor can damage the ECU. If after a start attempt you feel that the FADEC becomes warm, this is a sign that something is wrong. The FADEC should be cold all of the time.
- The glow plug negative cable is connected to the engine body. This means that the whole turbine is connected to the negative of the pump battery.
- NEVER charge the battery of the fadec while connected to it, specially if you charge the batteries of the RX at same time, because some current can flow to one battery to the other trough the fadec, and damage it. The battery should be fully disconnected, both terminals.

#### 4.1 FADEC main unit

Because the FADEC is an electronic piece of equipment, the installation in the model aircraft is similar to that of the radio receiver. It has to be in an accessible location within the airframe, with limited vibration and far from the heat of the engine. Also because the pump motor uses DC power, that can produce sparks in the collector when operating, it is highly recommended that the installation of all of the electrical equipment is done as far as possible from the R/C receiver. Keep the power cables at the minimum possible length and avoid installing the antenna near them. Also anti -spark capacitors must be installed on the pump motor.

#### 4.2 Pump/starter battery.

The FADEC needs for its operation two different power supplies. The main power is taken from the battery that power the pump and starter, while the radio receiver voltage that arrives through the throttle servo connection is only used to switch on the FADEC. **Reversing the polarity of the battery causes the destruction of the semiconductors of the FADEC.**

The nominal voltage for the pump battery is usually 7,2V, but it can be between 6v and 12v. The selection of the number of battery elements is due in consideration of the real needs of the ancillary equipment like starter motor, solenoid valves and pump motor. Use only the recommended battery voltage and capacity.

This battery does not need an on/off switch in the airframe since the FADEC has an internal electronic switch, which disconnects it when the power to the receiver is switched off.

Use good quality sintered fast-charge nicads for the ECU supply with at least 1200mAh, preferably 2000mAh, capacity and charge before each flight. It is possible the use of NiMH and Lipos, but in this last case special care should be taken because the fadec don't will cut the engine when the voltage becomes low, it only will prevent to start, but once running, it will keep running until the bateries be fully discharged.

#### 4.3 Receiver of radio.

The FADEC is connected to the radio receiver like a standard throttle servo, inserted in the channel for the throttle, receiving the information of the throttle control pulses and the receiver battery voltage.

#### 4.4 Thermocouple

The FADEC use a thermocouple of type " K ", apt until 1100°C. The provided standard thermocouple consists of a wire of Inconel of 1.5mm of diameter finished in a connector who fits directly on the FADEC. The recommended installation consists of practising a drill of 1,5 mm in the exhaust nozzle of the engine and inserting the end of the thermocouple so that it be 2-4mm within the flow of exhaust gases.

#### 4.5 Fuel system.

Use 6 mm tubes in the suction side of the pump, and 4 mm from the pump to the fuel solenoid valve, and from this one to the engine.

#### 5. Programming of the FADEC.

Use the recommended parameters for your engine. Some of these parameters are set at factory and can't be modified by the user. The programmable parameters are as follows:

**FADEC user programable parameters:**

Parameter	Function	Range
Full speed RPM	Sets the maximum rotor speed that will be reached by the engine with the throttle control at 100%	0-250.000 RPM.
Idle RPM	Sets the rotor speed at idle	0-250.000 RPM.
Stop RPM	Sets the minimum rotor speed which the engine can run. If the speed is lower, the FADEC will shut down the engine.	0-250.000 RPM.
Start/Minimum Temperature	Minimum temperature at which the engine can work. In the start phase, the FADEC will begin to provide power to the fuel pump. In the running/operating phase, it will stop the engine if the temperature is less this setting.	0-999 °C
Max. Temperature	Maximum Temperature of operation of the engine. The FADEC will try to maintain the EGT temperature below this value, finally stopping the motor in case it can't be obtained	0-999 °C
Acceleration delay	This parameter allows the adjustment of the time of acceleration ramp / delay of the engine. The higher the value, the more slowly the engine will respond. The total time of acceleration is not fixed, since it depends on other parameters as they depend on the present temperature and speed.	0-255
Deceleration delay	Just as the acceleration delay, this parameter defines the time required for deceleration. This parameter must be increased if the motor tends to flame out when going abruptly from maximum power to the idle.	0-255
Stability delay	This parameter allows stabilising the power once the system has arrived at the value set by the throttle control. The value must be increased if the power setting is not stable.	1-255
Pump start point	This parameter sets the minimum pump voltage where the pump just begins to turn. This value is dependant on the voltage of the battery and the pump motor.	0-255
Pump Start Ramp	Sets the rate of increase of fuel flow during the start-up phase. The higher the value, more quickly the motor will accelerate up to idle. High values along with a under-powered starter can cause the engine to blow flames out the exhaust.(Wet/Hot starts) Low values imply a slow starting.	0-255
Stick travel adjusts.	This parameter sets up the throttle limits at the three key points. Stop, Idle and maximum power.	
Glow Plug power	Sets the brightness of the glow plug.	

**5.1 Programming the FADEC with the terminal of data (HDT).**

The HDT has a LCD with 16 characters x 2 rows and four buttons which allow you to move through the various menus and to change the data settings in each menu page. The presentation of data has been organized in screens. The first two displays the engine status readings in real time and the following screens allow you to modify the operating parameters as above table. All of the parameters can be modified while the engine is running, so it is easy to tune the engine without having to start it again to test the new settings. Both left buttons allow you to move through the different screens in an ascending mode (Menu Up) or descending mode (Menu Down). Both right buttons allow you to change the data in increasing value (Up Data) or decreasing value (Down Data).

**Screen 1**

Screen 1 always appears first when starting (switched on/off) the HDT and shows the main primary parameters of operation of the engine. The representation of the screen is as follows:

S	t	a	t	u	s		T	=	y	y	y	°	C	
R	p	m	w	w	w	w	w		P	w	z	z	z	%

The values displayed are:

Status	A eight character word indicating the state of the FADEC. (Ready, Fuel Ramp,...)
Yyy	Temperature of exhaust in °C
Wwwwww	Speed (R.p.m.)
Zzz	Power of the pump. This reading allows to know the power applied to the pump, from 0 to 1000.

**Screen 2**

Screen 2 shows the secondary parameters of operation, they are the information received from the radio transmitter and the voltage

of the battery.

P	U	I	s	e	=	X	x	x	x	μ	S	y	y	%
V	B	=	z	z	.	Z	V	V	e	r	w	.	W	

The values displayed are:

Xxxx	Duration of the pulse of control received from the receiver. This it is a absolute value read from the radio transmitter. The usual values are between minimum 800-1000μS and 2000-2200 μS maximum.
Yy	Calculated value relative to the position of the throttle control. The FADEC uses the programmed values of maximum and minimum along with the real reading to calculate the relative power setting for the control of the fuel pump.
zz.z	Voltage of the battery supplying fuel pump
w.w	Software version

**Following screens:**

The following screens have all the same structure, except they are used of the programming of the FADEC control parameters, and allow you to change the operating parameters, even with the engine running. As an example the first next screen that appears, is the maximum speed.

F	U	I	L		p	o	w	e	r		S	p	e	e	d
					x	.	x	x							

The expression x.xx indicates the value stored in the FADEC. In order to change it is necessary it to use the right buttons " Data Up " to increase the value and " Data Down " to decrease it.

The programming of all the data is made sequentially, changing to the next screen using the button " Menu Up". The programming of the radio transmitter is a special case and needs a different procedure, described next.

**Programming of the radio transmitter setting with the HDT.**

For the programming of the radio you need to have the FADEC and the HDT working with the radio receiver with its battery pack and the transmitter. It is not necessary to install the thermocouple, the pump or RPM sensor.

**Preparation and verification of the transmitter.**

The transmitter must not have programmed any reduction of throw, trim, slow movement, the center value or the linearity modified. In case of doubt it is recommended to connect a servo to verify that the movement is correct from end to end and fast. Once the transmitter is OK, connect the FADEC and by means of the key " Menu Up " change to screen 2. With the trim and stick of the transmitter raised (Full power) the reading of "Pulse = xxx" must be between 1900-2200. With stick and the trim lowered, the reading must be between 800 and 1000. In case that the readings are inverted, like in some Futaba transmitters, it is necessary to change the sense of the movement in the transmitter. (Servo reverse). If the reading does not arrive at these values means that the transmitter has some function of limitation of throw applied to the throttle channel. Once verified the transmitter, the FADEC can be programmed. In order to do it, the HDT has 4 screens.

Move to the screen 'Transmitter programming'. This first menu is only informative and it warns us of the entrance in the screens of programming of the throttle control. Press the button 'Data Up' to enter in the programming menus. Next it appears the screen of programming the full throttle position. In order to program this parameter locate the trim and stick in the superior position. Once located in this position, push the button "Data Up". At this moment the FADEC will record the received order of the radio as the position of full power and, in the HDT, the following phase of adjustment is shown. If it is not wanted to modify this adjustment, is enough with pushing the key "Menu up". This also causes the change of screen but the throw is not programmed.

The following screen allows programming the lower limit (Stop). In order to do it is enough with locating the trim and stick to the minimum and push the button "Data Up ". Also in this case pushing the button " Menu up " will cause the change of screen without varying the previous adjustment.

The last screen of adjustment of the transmitter is the position of the trim that will correspond to the idle of the engine. In order to make this adjustment it is sufficient with locate the stick to the minimum and the trim to maximum and push the button " Data Up". Just as in the previous adjustments, the button " Menu up " will cause the change of screen without varying the last recorded adjustment.

Once finished the programming of the transmitter, this can be verified by means of the second screen of the HDT. To the right of the value of the received pulse of the transmitter appears a value from the 0 to 100%. This value must correspond to the relative position of the throttle stick, corresponding 0% to stick and the trim to the minimum and 100% to stick and trim to the maximum. If it were not arrived at these values, or the limits of the 0 or 100% were reached before arriving stick in the end, the calibration process is due to repeat.

When the superior and inferior limits are verified, the adjustment of the trim can be verified. With the FADEC in start mode, that is to say, just started, locating the trim and the stick at lower side the screen should lead "TrimLow". When raising the trim slowly, the screen should change to "Ready" approximately to half of the throw of the trim. From this point the FADEC considers that the motor must be running and below this, stopped. Ensure that the reading of percentage at the right side of "pulse=xxx" is at least of 10% at

trim-up position.

### 5.2 Radio link failsafe:

The FADEC have a failsafe feature that stop the engine in the case of the radio link failure, but prevents to stop it in the case of short glitches. This system works in PCM/PPM/IPD systems.

#### PPM systems

In the case of radio failure (erratic movement of the servos or pulses out of the programmed values window), the FADEC sets the power to idle during approximately 1.5 sec. If the radio link is regained in this time, the power goes back to normal, but if not the system kill the engine.

#### PCM /IPD systems:

The user should program the failsafe of these systems to cut the engine (trim low-stick low). In the case that the receiver have a radio link failure, it will output the failsafe settings. The FADEC will set the power at idle during 1.5s after receiving the stop command, and if during this time the receiver exits from failsafe the engine will go back to the throttle set power. If not, it will be cut-off. This system allow to fly trough small glitches while retaining the ability to kill the engine in the case of radio failure.

**EVER PROGRAM THE FAILSAFE TO KILL THE ENGINE. NEVER FLY A TURBINE PLANE WITH THE FAILSAFE SET TO "HOLD".**

### 5.3 Special features

#### Timers

The last screen of the HDT shows the 3 timers included in the FADEC. The first is the total engine time in minutes, the second the last run time in seconds, and the third is the start/stop cycles counter. These timers can be only cleared by a special PC software.

#### Last power-down cause:

The FADEC stores in its internal memory the measures of the engine each 0,5s up to 52 minutes. These measures are RPM, Temperature, Throttle position, pump power and a external analog input, usually airspeed. These measure only can be downloaded trough a PC and a RS232 cable, but the user can check trough the HDT the cause of the last power down and the measures of the engine at the moment when the FADEC cut the engine. This feature is useful to track the cause of a flame out in flight. After power up, set the trim low and press the "menu down" button. The HDT will show the cause of the last shut down, and the EGT, RPM and pump power at this moment, the data will be displayed during 2 sec, it is necessary to push the button again to see the data.

#### Airspeed recorder/limiter:

Once the airspeed (pitot) module is connected, it will enable the screen on to check and program its functions. This screen display the maximum airspeed reached in the last flight, and allow to program the maximum airspeed. The fadec will reduce the throttle automatically to keep the airplane flying below the maximum airspeed.

## 6. Tuning the system.

### 6.1 Adjustment of the "Pump start point" value.

The FADEC have the ability of to automatically adjust the pump power to start it at the lowest possible speed, independently of the battery voltage and pump roughness. Also the user have the possibility to adjust the minimum pump power manually.

#### AUTOpump mode:

The values of "Pump start point" from 0 to 8 are in AUTO mode. This means that the FADEC will adjust itself the pump power to start it slowly. The recommended value is AUTO+0, that make that the pump start at the minimum possible speed, but it is possible to start it a faster speed by selecting AUTO+1, AUTO+2 if needed.

#### Manual mode:

From values from 9 to 255 the power applied to the pump is fixed. It is necessary to test with the selected pump and battery the right value to allow the pump to turn at the minimum speed.

### 6.2 Adjustment of the "Pump start ramp" value:

This parameter adjust the speed of the fuel increase during the "Fuel ramp" phase. Higher values mean a faster fuel flow increase. Increase this value if the engine take too long to arrive to idle, and decrease it if the starts are too hot.

### 6.3 Adjustment of the values of speed of acceleration (Acceleration delay), deceleration (Deceleration delay), and stabilization (Stability delay)

Habitually these values do not need adjustment and the recommended values are useful to most of the engines, but with the purpose of being able to use the FADEC with any type of turbine they are included in the parameters adjustable by the user.

#### **Time of acceleration (Acceleration delay)**

The FADEC calculates the speed of acceleration depending of the exhaust temperature, the current rotor speed and this parameter (Acceleration Delay), and therefore, it is possible to modify the global time of acceleration modifying it. Higher values mean longer acceleration times.

#### **Time of deceleration (Deceleration delay)**

For the calculation of the speed of deceleration the FADEC considers the same parameters as in the acceleration, unless the fixed value is this other parameter. Higher values mean longer times.

#### **Stability delay**

Once the engine has reached approximately the power corresponding to the value of the throttle setting, the FADEC adjusts the fuel flow with the purpose of match the exact value of thrust. The speed what the FADEC make this adjustment can be programmed with this parameter. The habitual values vary between 40 and 60, depending on the time of programmed acceleration / deceleration, the temperature and the inertia of the whole system including pump, engine, tubes, etc. If a too low time is programmed, the engine will not become stabilized and will be raising and lowering to the power when correcting the FADEC more quickly than the response time of the turbine. If the time is very long, the FADEC will take more time to adapt itself to the engine in case of change in the batteries, pump, etc.

## 7. Recommended values of the parameters on known engines in Autostart Mode:

Engine:	KJ66	JG100	MW54
Maximum speed:	120.000 Rpm	126.000 RPM	160.000
Idle speed	37.000 Rpm	32.000 Rpm	45.000
Stop speed	25.000 Rpm	20.000 Rpm	30.000
Maximum temperature	800°C	800°C	800°C
Minimum temperature	100°C	100°C	100°C
Pump:	Haüsl 28020	Haüsl 30020	Haüsl 28020
Battery voltage	6V	6V	6V-7,2V
Pump start point	Auto+2	AUTO+2	AUTO+2
Starter type	Speed400 6V or Speed300 or Permax280	Speed400 6V or Permax280	Speed300 or Permax280
Start Ramp	6	6	4

Aplication	First Start	Test bench	Normal fly	Sport fly
Acceleration delay	50	30	20	15
Deceleration delay	30	30	30	15
Stability delay	40	40	50	50

## 8. Limited Warranty:

The FADEC main unit and HDT is warranted to be free from defects in materials and workmanship for a period of one (1) year from the date of original purchase. This warranty is nontransferable. If your unit requires warranty service during this period, we will replace or repair it at our option. Shipping cost to us is your responsibility. This limited warranty only covers FADEC main unit and HDT. This limited warranty does not cover the problems that result from: External causes such as accident, abuse, misuse, polarity reversal, short-circuit, crash damage, servicing not authorized by us, usage that is not in accordance with product instructions and failure to follow the product instructions. OUR RESPONSIBILITY FOR MALFUNCTIONS AND DEFECTS IN HARDWARE IS LIMITED TO REPAIR AND REPLACEMENT OF THE FADEC main unit and HDT AS SET FORTH IN THIS WARRANTY STATEMENT. ALL EXPRESS AND IMPLIED WARRANTIES FOR THE PRODUCT, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES AND CONDITIONS OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN TIME TO THE TERM OF THE LIMITED WARRANTY PERIOD AS DESCRIBED ABOVE. NO WARRANTIES, WHETHER EXPRESS OR IMPLIED, WILL APPLY AFTER THE LIMITED WARRANTY PERIOD HAS EXPIRED. WE DO NOT

ACCEPT LIABILITY BEYOND THE REMEDIES PROVIDED FOR IN THIS LIMITED WARRANTY OR FOR CONSEQUENTIAL OR INCIDENTAL DAMAGES, INCLUDING, WITHOUT LIMITATION, ANY LIABILITY FOR THIRD-PARTY CLAIMS AGAINST YOU FOR DAMAGES TO PEOPLE OR PROPERTIES, FOR PRODUCTS NOT BEING AVAILABLE FOR USE, OR FOR ENGINE OR AIRFRAME DAMAGE. OUR LIABILITY WILL BE NO MORE THAN THE AMOUNT YOU PAID FOR THE PRODUCT THAT IS THE SUBJECT OF A CLAIM. THIS IS THE MAXIMUM AMOUNT FOR WHICH WE ARE RESPONSIBLE.

The user must provide an emergency shut-off (i.e. a servo operated cut-off valve) for increased security. Please read and follow the GTBA code of practice. (<http://www.gtba.cnuce.cnr.it/CODE.HTM>)

## 9. Specifications:

### Measures:

Temperature sensor	K type thermocouple
Temperature range:	0-999 °C.
Temperature resolution:	2 °C
Temperature accuracy:	2%
R.P.M. range:	0-250.000 R.P.M.
R.P.M. resolution:	100 R.P.M.
R.P.M. accuracy:	0.5 %
Pump Battery voltage measurement range	0 to 12,5V
Voltage measurement resolution:	0.1 V
Voltage measurements accuracy:	2 %

### Supply:

Receiver battery voltage:	4 to 10V
Receiver battery supply current:	30 mA.
Pump battery voltage:	6-11.1V (5 to 9 cells).
Pump current:	5 A Max. Continuous.

Remote measures and configuration:	Asynchronous serial digital link
Mechanical measures:	54 x 34 x 22 mm.
Weight:	45 g.

### Autostart & advanced setup.

Other than the operators parameters that are usually set by the users, exist another parameters reserved to manufacturers and advanced users.

These parameters are:

- Temperature calibration
- Timers reset
- Started reduced power (%) in the ignition phase
- Starter RPM window (min and max rpm) in the gas ignition phase
- Starter switch-off RPM. Speed of the rotor were the starter will be switched-off
- Starter switch-on RPM. Speed of the rotor were the starter will be reconnected if the fuel ramp phase if the RPM's decay below this point.
- Gas Switch-off RPM.
- Minimum RPM to start. Minimum rpm that the rotor should have after 1,5s of starter switch on. If the rpm are below this limit, a "bad start" label will appear and the start process aborted. Useful to detect starter/clutch failure.
- Starter power at the beginning of the fuel ramp.
- Rpm were the starter power is at 100%. When the system detects the ignition had occurred, it starts the starter motor at reduced power and this power is increased during the fuel ramp until arrive at the value of this parameter, that is set at 100%. This feature allows to use small/ low voltage rated starter motors without the risk of burning them due at too much power in the low speed phase.
- Starter ramps. The rpm range from 0 to idle are divided in 3 sectors by 2 rpm points. In each sector, a defined fuel/time slope is applied. So the real fuel increase in each rpm range depends on the current rpm, the slope value for this rpm range and the "pump start ramp" parameter, that is added to the ramp value for each rpm sector. For example, if the rpm points are set to 16.000 and 30.000 RPM, the ramp1 at 3, ramp2 at 1, ramp3 at 4 and the "pump start ramp" at 2, then the real fuel ramp applied from 0 to 16.000 will be ramp1 + "pump start ramp" = 3+2=5. From 16.000 to 30.000 will be ramp2 + "pump start ramp" = 1+2=3 and from 30.000 to idle ramp3 + "pump start ramp" = 4+2=6. Adding the "pump start ramp" parameter to all values allow at the operator to modify the whole start time without modifying the "manufacturer" parameters.

### Starting the engine:

Ensure your engine operates correctly before attempting full auto-start operation. You can run the engine using the Autostart ECU in manual mode, by hand starting the engine (ie with a wand or remote starter) after setting the ECU to "Ready".

Keep the magnetic RPM pickup clear of stray magnetic sources such as fuel pump, solenoid valves, glow plug wire, or servo's, as the magnetic field generated can upset the rpm reading.

Ensure your starter operates smoothly and without sticking.

Ensure your glow plug element is well "teased out" to ensure prompt gas ignition.

Gas supplies must be gas only, dip-tube liquid feed types are not suitable. Beware of using too much gas in the belief this will ignite more easily. Keep the maximum gas pressure under 2 bar (25psi) to avoid damage to the solenoid valves.

Problems lighting the gas are mostly related to plug element exposure, ensure the element is pulled clear so the gas can really "see" the element. It needs to glow bright yellow for good ignition, so adjust the "glow power" setting in the main menu as required

**Always** set-up and confirm the operation of your Auto-start installation on the test-stand, before installing into your model.

The present version of Autostart uses only one channel to all of the engine functions: To trigger the autostart cycle, the process is as follows:

- The user raises the trim. "Ready" will appear on the HDT (Hand data terminal) screen when the engine is supposedly to be to idle. If the trim is on "stop" position, "Trim low" will be read on the HDT. If higher than idle, "StickLo!" will be read.
- When "Ready" is displayed, the user raise the stick to full power.
- Once at full power, optionally the user can prime the pump if the stick is left in this position more than 5 seconds and the HDT screen is set in second screen. The pump prime function is triggered, and the pump and fuel valve are energized at the 25% of his power for one second as much. The user can switch off it before this time by lowering the stick. Use this option only to fill the tubes after servicing, but not at each start.
- When the stick is at idle again, the start sequence begins.
- The glow-plug is checked, and if OK, it is powered. After waiting 1 sec, the starter is engaged at reduced power (soft start) and later the gas valve is energized. If the glow test fail, a "Glow Bad" message is displayed, and if the starter fails to arrive a minimum RPM in 2 seconds, a "start bad" message is issued, and the autostart function aborted.
- If the rotor arrives at more than the "ignition max rpm" programmed parameter (default 4000), without detecting ignition, the starter is disconnected and the brake applied.
- When the RPM are lower than the "ignition min. Rpm" parameter (default 1000), the starter is switched on again to raise the rotor speed to the "ignition max rpm" and the cycle is repeated.
- When the thermocouple register a increase of 50°C in temperature or it is higher than the "start/minimum temperature", that mean that the ignition have occurred, the starter is switched on immediately at reduced power, increasing his power accordingly to the real rotor rpm. At the same time the pump is switched on, and the fuel valve is opened.
- The engine begin to accelerate at the rate set by "fuel ramp" values, depending on the real RPM. Once the RPM arrives at a predefined value (usually 20.000 RPM) the gas valve is closed, and when the RPM arrive at the predefined "starter off" value, the starter is switched off and the brake applied to it. The engine continues accelerating alone until the idle RPM are reached.
- The user can finish the sequence in any moment, simply setting the trim to "off" position. If the engine was on "running", a cooling sequence will be triggered, cycling the starter motor until the EGT is below the minimum programmed temperature.
- If the engine is hot (EGT higher than the minimum temperature) at the moment that the user triggers the autostart cycle, then the FADEC will begin a cooling cycle until the temperature is below the minimum programmed temperature. At this moment it will continue with the normal autostart cycle if the trim is left in up position.

### Programming the manufacturer parameters:

- First adjust the "operator" parameters, specially the radio throws.
- Set the trim and stick to "low". "Trim low" readout should appear.
- Switch off and on again the FADEC. When the initial screen appear ("FADEC...") click the "data down" button (-) and then the "menu down" (located first in the left hand). This should be done quickly, and before that the normal screen appear.
- It will appear a screen with a number of parameter and the data. To change the parameter number use the left hand button, and to change the data use the right hand buttons.
- Raise the stick or reset the FADEC to return to the normal screens

**Caution:** The parameters are stored in the same time that are modified, so be careful before to modify any parameter.

The meaning of each parameter is: (These recommended values are for a MW54)

Parameter Nr.	Rec. Value	Units	Mnemonic	Description
1		°C x2	OFFSTEMP	Temperature sensor offset calibration. This value is subtracted from the one read on the FADEC. Factory set, do not change.
2 to 15				Not Used
7	100	Volts/0.05	LowBat	Minimum battery voltage in start phase. If the battery voltage falls below this value, the start is aborted and "lowBatt" message displayed. Only in start phase, in running phase the engine is kept running until the battery is empty. Value= Desired cut voltage multiplied by 100 and divided by 5.
16	2	Rpmx1000	RPMINICI	Minimum safe rpm to begin the fuel ramp phase. Lower RPM than this value than this will abort the sequence.
17	35	0 to 255	POWERSTA	Starter power in the ignition phase. Real power is full power * this value/255.
18	4	Rpmx1000	RPMIGN	Rpm where the starter is switched off in the ignition phase
19	2	Rpmx1000	RPMSTOGA	Rpm where the starter is reconnected in the ignition phase. Minimum 2
20	6	Sec x 2		Preheating time. Time from when the ignition is detected and the fuel ramp is launched.
21	0			Not used
22	100	RPMx1000	T_STOP_G	Start gas switch off RPM.
23	30	Rpmx1000	R_STOP_S	Starter switch off RPM
24	35	0 to 255	POWSTIR	Starter power at the beginning of the fuel ramp. Real power is full power * this value/255.
25	24	Rpmx1000	RPMERAM	RPM where the starter power arrive at 100%
26	18	Rpmx1000	RPM1TRA	First Rpm point in the fuel ramp. From 0 to this value the RAMP1 value will be applied
27	30	Rpm x1000	RPM2TRA	Second Rpm point in the fuel ramp. From the 1st RPM point to this value the RAMP2 value will be applied. Above this value to idle, RAMP3 will be used.
28	2		RAMP1	1st. Fuel ramp. The real value used will be this value added to the "Pump start ramp" value.
29	0		RAMP2	2on. Fuel ramp. The real value used will be this value added to the "Pump start ramp" value.
30	0		RAMP3	3th Fuel ramp. The real value used will be this value added to the "Pump start ramp" value.
31	24	Rpmx1000	RPMONFU	Rpm where the starter is reconnected in the fuel ramp phase if the rpm fall below this point..

#### List of FADEC message codes

Here is a list of possible messages shown on the data terminal screen and their meaning.

**TrimLow:** Indicates that the signal received from the transmitter corresponds to the lowered trim, that is to say, engine OFF.  
**Ready:** Indicates that the engine is ready for starting, and that the transmitter signal corresponds to IDLE, (green LED lit)  
**StickLo!** This indicates that the throttle stick is in a position above IDLE, the engine will not start with the stick in this position.  
**Glow Test:** Verification of glow plug  
**StartOn:** Test of the starter  
**Ignition:** Gas ignition phase.  
**Preheat:** Phase of heating of the combustion chamber after detecting the gas ignition.  
**FuelRamp:** Phase of acceleration until speed of slow motion.  
**Running:** Engine working correctly, pilot have full control of engine power.  
**Stop:** Engine off.  
**Cooling:** Starter operating to cool the engine.  
**GlowBad:** Defective or disconnected glow plug.  
**StartBad:** Defective starter, insufficient RPM reached during start.  
**Low RPM:** Engine shutdown due that rotor speed is below the minimum.  
**HighTemp:** Excessive temperature  
**FlameOut:** Exhaust GAS Temperature below the minimum  
**TimeOut :** Start sequence over 30s

## 10. Troubleshooting:

### 10.1 Start:

Problem:	Cause:	Solution:
When raising the trim of the radio, the LED is not illuminated	FADEC in stop mode after a running.	Switch off an then on again the FADEC.
	Bad adjustment of the radio transmitter	Program the parameters of the radio and verify them
	Supply failure	Verify the voltage of the batteries. In case that it not work, verify connections, switch, etc.
After cycling the throttle "Glow bad" message appear	-Blown glow plug or disconnected -Pump battery disconnected.	Check glow plug and battery
After cycling the throttle nothing happens and later the "Start bad" message appear After cycling the throttle the rotor turns but later the "Start bad" message appear	-Starter motor bad/disconnected	Check starter
	Starter power too low	Check starter power settings.
	RPM sensor failure	Check RPM
	Starter power too low or ignition rpms set to low	Check the autostart parameters
The RPM are cycling but the gas doesn't ignite.	Gas can empty or gas solenoid valve disconnected or blocked	Check the gas coming to the engine
	Glow plug brightness too low	Check/adjust glow plug power. The glow should have at least 2 filament turns pulled out, and with high brightness. Check with a butane lighter the correct brightness.
	Gas tube incorrectly set inside the engine	Ask the engine manufacturer for correct location.
	Too much gas. Mix too rich to ignite	Reduce the gas flow, use only butane mix trough a 0,3mm restrictor
When the start gas is ignited the "start bad" message appear	The starter failed to have the minimum RPM to continue the sequence.	-Check the RPMINICI value on the autostart parameters -Raise the starter power.
When the start gas is ignited, the FADEC does not begin to pump fuel nor the LED blinks.	The temperature read by the FADEC is lower to the programmed start temperature due at that the start gas flow is insufficient to reach start the temperature.	Check the exhaust temperature with the hand terminal. -Increase the gas flow, reduce the power of the starter in thisphase or lower the programmed start temperature.
When the start gas is ignited the LED of the FADEC begins to blink but the pump does not work	Adjustment of the pump start point defective.	Repeat the adjustment of Pump start point and verify the operation of the pump. Adjust the parameter #20 of the submenu
Excessive fuel flow at the beginning of the starting. Start very hot.	Adjustment of the pump start point defective.	Repeat the adjustment of Pump start poin.Verify the operation of the pump. It must start smoothly and turn slowly. Do the test by disconnecting the fuel line from the engine and trigger a autostart squence. Check the fuel flow to check it in real conditions. Fine tune the "pump start point" if necessary to have the lowest flow and that the pump start each time.
Once the pump is started and the engine is running in fuel, it takes too much time in arriving to idle	The fuel Start Ramp value is too low.	Raise the "start ramp" value.
Once the pump is started an the engine is running in fuel, the exhaust temperature is excessive	The fuel Start Ramp value is too high or weak starter motor	Lower the "start ramp" value.
Once the pump is started an the engine is running in fuel, the exhaust temperature is excessive and the engine doesn't arrive at idle.	Too low top RPM of the starter motor and it cannot push the engine to self above to self sustain.	Change starter, check the clutch for friction, use a higher voltage battery.
When the engine arrives at idle the system changes to automatic mode, extinguishing the LED, but the speed is higher than the programmed . lowering slowly until arriving at idle	The fuel Start Ramp value is too high.	Lower the "start ramp" value.

### 10.2 Running:

Problem:	Cause:	Solution:
10.2.1 The engine does not reach the maximum power.	Maximum speed badly fit.	Verify the Maximum speed and readjust it.
	Battery of the pump empty or with too low cells, defective or insufficient pump, defective plumbing, including the fuel injectors inside the turbine obstructed.	Verify the indicator of power of the pump in the HDT. If it indicates 1000, check the pump, battery, tubes...
10.2.2 Instability of the power at medium and and low power.		
	Stability delay too low.	Increase the "Stability delay". With a value of 50 the engine must run without problems.

**10.3 Acceleration:**

<b>Problem:</b>	<b>Cause:</b>	<b>Solution:</b>
10.3.1 When changing quickly the throttle from idle to full power, the engine accelerates quickly until an intermediate point and later the power raises slowly until arriving at the maximum power.	An external change to the FADEC in the circuit of fuel supply has taken place from the last normal start/stop cycle, as it can be the change of pump, change of the number of elements of the battery, or change in the engine. The internally stored data do not agree with the real ones, reason why the FADEC must find the new values.	Wait until the engine accelerates to the maximum power. Then lower the power slowly with the throttle stick until idle and raise it slowly until the maximum power 2 or 3 times with the intention of which the FADEC can find the data of all the margin of operation. Each movement must last like 10s minimum. Once this is done, verify that with fast movements of stick the engine responds immediately. Stop the engine lowering the trim of the radio so that the FADEC keeps the new data in the permanent memory.
10.3.2 Too slow acceleration	The value of acceleration delay is excessive.	Lower the delay. The habitual value oscillates between 20 and 60 in a standard engine.
	The exhaust temperature is very high or the maximum programmed temperature is too low. The FADEC modifies the time of acceleration on the basis of the margin of temperature between the maximum and the current one. If this difference is small, the acceleration will be slower since a greater risk exists of exceeding the maximum temperature.	Verify the adjustment Maximum temperature, and check the exhaust temperature..
10.3.3 Acceleration does not uniform. When accelerating quickly the engine from idle to the maximum, this accelerates quickly to an intermediate point in which it becomes stabilized during a second, raising to maximum power next.	The value of acceleration delay is too low. The FADEC tries to accelerate the engine more quickly than it allows, causing that the temperature raises excessively, moment in which the FADEC reduces the fuel flow to maintain the temperature controlled.	Increase the value of the acceleration delay until the acceleration is fast and without steps.

**10.4 Deceleration:**

<b>Problem:</b>	<b>Cause:</b>	<b>Solution:</b>
10.4.1 Extinguished of the engine. When lowering quickly the throttle from maximum power to idle, the engine is stopped.	The value of the deceleration delay too low. In some engines the abrupt reduction of the fuel flow causes a flame out.	Increase the value of the "Deceleration delay" parameter.