General presentation of Commander6D

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Machine management

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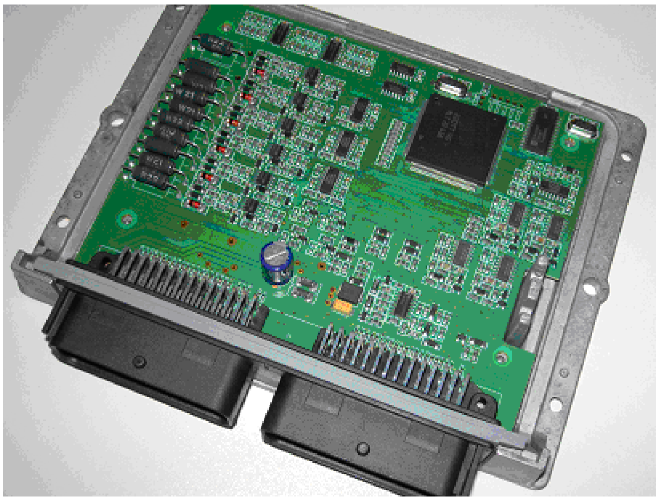

TECHNICAL CHARACTERISTICS
- SUMMARIZE-

The Commander Diesel is an engine management ECU and has a very high computing power, numerous inputs and configurable outputs, allowing a very flexible and effective use.
It can manage either piezoelectric or electromagnetic injectors, common rail or pump injectors.
The injector output commands of Commander6D are logical outputs (without power) which controls an external injector driver specific to every type of injector.

ELECTRICAL CHARACTERISTICS

Power supply from 7 volts to 18 volts DC.
Power supply and power grounds separated
Consumption minimum while operating at 13 volts: 460 milliamperes,
Consumption on stop: 0 milliampere,
5volts sensors power supply: 400 milliamperes maximum,
10volts external devices power supply: 200 milliamperes maximum.

TEMPERATURE CHARACTERISTICS

In operation, -40°C to 85°C.

SEALING CHARACTERISTICS

IP 67 (on request).

COMMUNICATIONS

Two CAN-BUS:
- Tuning and networking of ECUs (masters, slaves, and externalized sensors and commands) by main CAN-BUS WinjNet (™ Skynam).
- Connection of the auxiliary CAN-BUS on external CAN-BUS 2.0B (11 or 29 bits identifiers selection for every frame), speed of transmission 125 Kbits at 1 Mbits, for access to an OEM CAN-BUS, OBD or for third party data recording.

HACKER PROTECTION

Tunings protected by selectable locking.
Unlocking only possible by the owner of the ECU or in factory at Skynam.
Total deletion of the data if attempt of violation.

MANAGEMENT OF ENGINE CYLINDERS

The number of engine cylinders is configurable by the motorist, as well as the angle between cylinders for the irregular engines.
The number of cylinders can be 1, 2, 3, 4, 5, or 6
The angular distribution of cylinders can be
- regular: the angle between cylinders is regularly distributed on the engine cycle. For a 4 cylinders, it is 180°, for a 6 cylinders, it is 120°...
- specific by calibration: this configuration can be used only with an even number of cylinders. The specific angle can be calibrated in 1/100th of degree.

ANALOG CONVERTIONS INPUTS

- 1 internal input measures tension power supply.
- 4 resistive inputs (CTN-CTP or logics), with 1.21 KOhm pull-up resistor to 5 volts
- 9 analog inputs 0-5 volts, with 1 MOhm pull-down

- 2 selectable analog - resistive inputs, with 1 MOhm pull-down or 1.21 KOhm pull-up to 5 volts, following selection
- 1 logical input, with 4.7 KOhm pull-up to 12 volts
- 16 analog or resistive inputs by CAN-Bus connection

According to the selected type of application, they are used for:

- switch of race configuration (inhibit launch limiter),
- switch of gear shifting configurable logical or analog,
- battery tension,
- calibrable pedal position,
- calibrable electric motor position (useful in motorized throttle),
- calibrables variable geometry turbo positions (one possible for each turbo),
- intake pressures (one possible per bank of cylinders),
- Intake airflow meter,
- atmospheric or dynamic pressure,
- engine temperature,
- intake temperature,
- fuel temperature,
- oil temperature,
- fuel low pressure,
- fuel high pressure,
- oil pressure,
- differential exhaust pressure,
- input exhaust temperature (PT200),
- output catalyst or DPF temperature (PT200),
- wideband Lambda meter (corrected by exhaust pressure),
- thermocouple (with analog interface),
- programmable auxiliary inputs to create specific sensors (for example position of intake flaps, pressures, temperatures and different switches).

FREQUENCIAL INPUT

Frequencial inputs are self adaptive in level and shape of signal to limit the impact of the possible parasites (starter, injectors). To do it, a specific microprocessor is allocated to each input to handle and shape its analog signal.

- 1 measure of rpm on fly wheel, programmable inductive – Hall,
- 1 measure of camshaft phase, programmable inductive – Hall,
- 4 auxiliary measures, programmable inductive – Hall.
- 16 measures by CAN-Bus connection

When a sensor is in Hall effect mode, it is necessary to put in the loom a 1KOhm to 10KOhm pull-up resistor between the sensor signal and 12 volts after key or 5 volts, following the type of sensor Hall.

According to the selected type of application, they are used for:

- measure of rpm and phase of crankshaft on configurable type of flywheel,
- measure of angle of phase mark of camshaft on configurable type of marks,
- measure of turbo rpm on programmable number of pulse by round,
- measures of auxiliary rpm on programmable number of pulse by round,
- measures of wheels speeds on programmable number of pulse by round,

PARAMETRIZATION OF THE INPUTS

Every measure of the ECU (pressure, pedal, electric motor position, speed) can be allocated to one of the physical inputs of the ECU, or has a value received by the CAN from an external sensor, or from a calculated value, including from the auxiliary CAN-BUS.

So, it is possible

- to add measures when all the physical inputs are used,
- to change physical input for a fast repair if an used input is damaged and that there are free inputs (naturally with changing the pin of the ECU connector).
- to use special sensors, for example measure of NOx sensor supplying its values by CAN-BUS, measure of turbo speed outputting an analog tension function of the speed.
- to make calculations on several inputs before converting the result of these calculations in the chosen measure (example: several inputs potentiometers of pedal or electric motor position, several sensors of pressure)

See chapter advanced operation, configuration of inputs.

INPUTS DIGITAL FILTERING

Every measure of the ECU has a programmable digital filtering.

FAULTS STRATEGIES

For every measure of the ECU (pressure, pedal, speed), it is possible to define a strategy of fault detection, a strategy of value replacement in case of defect, or to use the standard strategies supplied by the ECU.

See chapter advanced operation, configuration of inputs.

DIAGNOSTIC

The ECU remembers the faults on the measures, the blackout or the short circuit, occasional or repeated, and allows the deletion of these defects under order of the motorist.

More, it remembers the system defects, miss of 30, loss of power supply, watch dog reset, …These systems defects ask for a particular attention and indicate an important problem of assembly or manipulation.

MONITORING

Programmable recording of values overshoots on the measures or the calculations selected by the motorist:

- in extreme value,
- in duration on the extreme value,
- in total duration,
- in number of overshoots.

The trigger of recording maybe made on an advanced strategy defined by the motorist.

Erasure by software (with possible protection).

Alarm light programmable (LED):

- immediate or with programmable delay,
- cumulative (on the total duration) with programmable switch on and off.

LOAD CALCULATIONS

- pressure / rpm,

INJECTION

6 logical channels command the injector driver corresponding to the type of injector equipping the engine.

- Piezoelectric,
- Electromagnetic.

1) For the piezoelectric commands, the tension of command of injectors is managed dynamically from 95 to 180 volts, by a function of the fuel high pressure.

The module gives a diagnostic of the working of its internal high tension and of the working of injectors.

2) For the electromagnetic commands, the command of injectors is managed on peak and hold. The peak tension is tunable between 20 volts and 65 volts, and the duration and the peak current are also adjustable. The hold current is adjustable from 1 to 18 amperes.
The module gives a diagnostic of the working of its internal high tension and of the working of injectors.
3) The injections are sequential phased on the beginning of injection, and the complete system (Commander + driver) **accepts the covering of injection of a cylinder by an other one**: there are thus no constraints on the phase nor the length of the injections, contrary to the systems which do not agree to make two injections at the same time and have to make a collision management between cylinders.
4) The fuel quantity to be injected is given in milligrams, resolution 1/10° milligram.
Milligrams are then transformed into cubic millimeters (resolution 1/10° cubic millimeter) by a function taking into account the fuel temperature, a correction which can be made for each cylinder (for tuning the disparities between injectors).
Then cubic millimeters are transformed into injection times in microseconds according to the type of injector used.
5) There are 5 possible injections in the engine working:

- The Pilot 2 injection
- The Pilot 1 injection
- The Main injection
- The complementary injection or advanced post injection (on option)
- the delayed post injection

They are distributed in 3 groups:

- The torque injection, which gives some fuel to the engine to supply the torque
- the delayed post injection which sends some fuel to the particles filter, for the cleanup.
- The complementary injection (on option), between the main injection and the post injection, serves as advanced post injection, used to warm exhaust gases.

The torque injection can itself be broken in three, in this order:

- The pilot 2 injection (very advanced)
- The pilot 1 injection (advanced)
- The main injection

6) The Commander controls in real time (during the engine working) that the intervals are sufficient between the different injections of the same cylinder.
The allowed interval of time depends on the fuel pressure and on the duration of the previous injection.
If the interval between 2 injections of the sequence:
Pilot 2 – Pilot 1 – Main – Complementary – Post
is too short, the injector has no time to close and the quantity of fuel is increased there.
The Commander repositions then the inaccurate phases of the injections in precedence order.
See ' Detail of the command of injection '.

AUXILIARY COMMANDS

14 programmable auxiliary commands
- ON-OFF,
- PWM from 10 Hz to 10 KHz,
- PWM software from 10 Hz to 1 KHz,
- angular (square signal the period of which is the engine cycle and the cyclical ratio of which is adjustable)
- engine synchronous (angular phased).

Types control:

- 1 weak power push-pull,
- 2 programmable push-pull or open drain commands,

- 10 open drain commands,
- 1 weak power open drain command.
- for the Peak and Hold auxiliary commands, it is needed to add a specific Skynam device (example: Peak and Hold programmable in duration and intensity of the peak, and intensity of the hold).

According to the selected type of application, the outputs commands are used for:

- turbo rpm or pressure management (double turbo or triple possible turbo),
- low pressure fuel pump,
- fuel pressure by injectors rail leak,
- fuel pressure by pump flow,
- pre-post heating control,
- electric motor positioning (with looping on a potentiometer), to use for example a throttle of intake or exhaust or some other devices with precise angular positioning.
- proportional electrovalve two wires (standard closed by spring) or three wires (opening and closure electrically controled).
- electric motor of rotation (adjustable speed, with possible looping on frequencial inputs),
- shift light,
- alarm defects,
- programmable type by the motorist.

FUEL HIGH PRESSURE

The Commander owns three possible types of management of the fuel pressure:

- by the flow only (electrovalve on supply side)
- by the leak of rail only (electrovalve of leak on the injectors rail only)
- combined by the flow and the rail leak (an electrovalve on each side)

Whatever is the mode of management of the fuel pressure, it is made by one (or two) PID looped on the measure of fuel pressure.

When the fuel pressure management is made only by the flow (supply side), procedures of specific managements are foreseen to decrease a too much high fuel pressure with regard to the target when injectors are stopped, notably during the deceleration cutoff for which a strategy of rail emptying can be made.

In the case or both commands of flow and rail leak are combined, a module of interaction controls the PID:

- at the starting up, when the fuel is cold, the flow remains maximum. The pump warms the fuel by compressing more fuel than needed, the pressure being managed only by the leak.
- then, when the fuel is in temperature, the fuel pressure is mainly managed by the flow, the rail leak serving only when the pressure cannot be decreased by the decrease of the flow.

TURBO

The Commander can manage:

- 1 turbo,
- 2 twin turbos in parallel (1 by bank of cylinders)
- 2 sequential turbos in parallel
- 2 serial sequential turbos
- 3 turbos, with two in parallel and the third serial with both first ones

Turbos in sequential mode are started only under selectable conditions.

The command is normally made by the command of a pneumatic leak electrovalve or a variable geometry.

The management maybe made according to the intake pressure or the rpm of turbos, with dynamic switching from one mode to the other one, and possible switching in case of not validity of measure.
For 'V' engines with separated intake by bank, it is possible to read 2 sensors of pressure, allocated each to a bank of cylinder, to manage each of the twin turbos with its own pressure.
Furthermore, it is possible to integrate a restrictor pressure into the management of the target of overboost, by using one of the auxiliary inputs to measure this restrictor pressure and by integrating this measure into the calculation of the target of overboost.

PRE-POST HEATING

A strategy of Pre heating and Post heating is present in the ECU, to control in ON-OFF (standard glow plugs) or in PWM (fast heating glow plugs) a device of command of power of glow plugs.
Because the intelligence is in the Commander, this device could be only a power relay.
If this device emits some diagnostic by a simple wire (OK-Error), the state can be used via an auxiliary input. If the diagnostic is emitted by the CAN, it can be got back by an XCan variable (see auxiliary CAN-bus). The result of the diagnostic can be integrated by the motorist into the procedure of reheating thanks to the advanced functions.

RPM LIMITER

On the injection, made by a reduction of the fuel quantity managed by a PID.
Launch (move off) limiter (unavailable in cleanup version),
Race limiter configurable.

DECELERATION CUTOFF

Made by injection cut off, with smoothing of the injected quantity into the descent and into the ascent (anti shocks) according to the rpm and to the speed pedal.
The minimum rpm of deceleration cutoff is programmable as an offset of the tic over rpm target.

SEQUENTIAL GEARBOX

Up to 10 gears the order of which is selectable (to be able to define an automotive box, a motorcycle, or special).
Gear shift switch logical (by grounding) or analog (by level of programmable tension) or calculated (example: speed pedals on foot release)
The rpm and the accelerator pedal position below which the ECU does not intervene on the engine management is adjustable separately for the upshift and the downshift.
The time of intervention is adjustable by map separately for the upshift or the downshift, for every gear and any other calculated or measured parameters (for example, modify the time of intervention of the gear according to the rpm or the engine torque).
The type of intervention is adjustable separately for the upshift or the downshift. It consists of a modification of injected quantity, controled by a map. The speed of returning to normal (slope) is also adjustable by map, to avoid shocks.

ENGINE MULMAPPING

Groups of modification allow modifying the engine tuning, for example to have several tunings according to a rotator.
Three groups of modification are available, allowing, with the original tuning, to obtain four different engine tuning.
A group of modification is constituted by a map of modification of maximum torque, by a map of modification of demand of torque by the driver, by a map of modification of richness target and a map of modification of smoke limitation.

Every group of modification can be activated by the one or other one of the variables known by the ECU (measures or generic results of calculation of the ECU, or values received by the auxiliary CAN-BUS, or results of calculations of pilot modules).
One of the applications frequently used in racing is to change engine tunings according to the positions of a rotator.

AVANCED FUNCTIONS

The Commander offers the motorist the possibility to develop its own strategies.
The development of these strategies does not require either the learning or the knowledge of a programming language.
Their programming uses a specific technique developed by Skynam called **SKYMCOD ™ mapped, intuitive and effective Programming**.
SKYMCOD corresponds to a way of thinking natural. This technique of functional programming is even better used by the motorists than by the computer specialists.
It can be used in all the functions of the ECU to complement or add calculations or replace those of origin.

1) Pilot modules:

Every module is a box of calculation with zero, one or two values in input and a value to output, and boxes can be linked or be nested ones with the others.
The values of inputs of modules can be either the measures or the generic results of calculation of the ECU, or the values received by the auxiliary CAN-BUS, or the results of calculations of pilot modules, with possibility of recursive calculation.
These modules of calculation are able to control the auxiliary commands and the complementary commands, of supplying procedures of detection of defects and degraded operation, and thus of intervening in all the domains of management of the ECU.

2) Parameterization of the inputs of measures:

Every measure of the ECU (pressure, pedal, speed) can be allocated to one of the physical inputs of the ECU, or has a value received by the CAN of an external sensor, or to a calculated value, including the auxiliary CAN-BUS.
So, it is possible
- to add measures when all the physical inputs are used,
- to change physical input for a fast repair if an used input is damaged and what there are free inputs (naturally there changing pin of the connector ECU).
- to use special sensors supplying values by CAN-BUS, or supplying tensions according to the measure.
- to make calculations on several inputs before converting the result of these calculations in the chosen measure.

3) Auxiliary PID:

A PID is an organ of control allowing to make closed looped regulation by a process.
The Auxiliary PID is not originally dedicated to the control of a particular process.
The processes which they are going to control are left with the choice of the motorist, contrary with some other which are dedicated to particular tasks as the management of the motorized throttle, the turbo pressure, the fuel pressure or the positioning of camshafts …
Every auxiliary PID is a module of calculation of regulation with an input (the variable on which is made the looping), and an output: the value of command of the PID.
All the variables of the ECU can be selected as value of looping to be regulated by one of the modules of auxiliary PID.
All the outputs of the ECU, the auxiliary commands, the complementary commands (see lower) can be controlled by the values of commands of the auxiliary PID.
By comparison, the PID fixed by management of fuel pressure has for looping value the fuel pressure and as command the electrovalve of fuel pressure.

This auxiliary PID can be used for example to manage flaps in the intake or between staged turbos, …

4) Auxiliary measures:

The inputs of measure not used by the selected type of application are left at the disposal of the motorist to add sensors or switches, to use them as active inputs of pilot modules and special procedures of calculation, or as simple information of display.

These auxiliary measures, as the other measures, can either use internal inputs of the ECU, or the values received by CAN-BUS Skynam sensors, or calculations already made by the ECU including values received from the auxiliary CAN-BUS.

5) Filtering of the measures:

Every measure of the ECU (pressure, pedal, speed, auxiliary measures) has a calculation of filtering by weighted average, the weight being given by a map an input of which depends on the difference between the measured value and the average, and of which the other input is selectable. An adaptive filtering is so realized, allowing shorter response times in case of real movement of the measure.

6) Strategies of defect of the measures:

For every measure of the ECU (pressure, pedal, speed), it is possible to define a strategy of fault detection, a strategy of value replacement in case of fault, or to use the standard strategies supplied by the ECU. For the measures of speed (turbos, wheels) a configurable strategy very elaborated by correlation analysis of speed and of acceleration is supplied.

7) Auxiliary commands:

The auxiliary outputs of the ECU not used by the selected type of application are left at the disposal of the strategies of the motorist and can be controlled by pilot modules.

8) Complementary commands:

They are hooks which allow to intercept and to modify at will all the targets of the ECU so that the motorist can intervene with its own strategies there:

- modification of maximum torque quantity
- modification of anti friction quantity
- modification of driver demand quantity
- modification of smoke limitation
- demand of protection engine torque
- stop richness correction
- modification of richness target
- modification of pilot 1 injection quantity
- modification of pilot 2 injection quantity
- modification of post injection 1 quantity
- modification of main injection phase
- modification of pilot 1 injection phase
- modification of pilot 2 injection phase
- modification of post injection 1 phase
- modification of tick over rpm target
- modification of rpm limiter
- modification of fuel pressure target
- modification of turbo pressure 1A and 1B target
- modification of turbo rpm 1A and 1B target
- modification of turbo pressure 2 target
- modification of turbo rpm 2 target
- stop pre-post heating
- ban DPF regenerations

9) CAN-BUS auxiliary values:

The values received from the auxiliary CAN-BUS can be used in the strategies of the motorist, as active inputs of pilot modules or as simple information of display.

The motorist can also send data on the auxiliary CAN-BUS to supply information to the connected devices, the dashboard, the gearbox, the data recordings, …
Furthermore, a temporal control of reception of frames allows to declare received frames in error.

ECU LOOM

J56		FUNCTION	COMMENTARY	CHARACTERISTICS
1	OUT	INJECTION E	Ground command open drain - 5th injected channel	450 milliamperes (750mA peak)
2	OUT	INJECTION F	Ground command open drain - 6th injected channel	450 milliamperes (750mA peak)
3	OUT	AUXILIARY COMMAND 5	Ground command open drain	4 amperes (10A peak)
4	OUT	AUXILIARY COMMAND 8	Ground command open drain	4 amperes (10A peak)
5	OUT	AUXILIARY COMMAND 4B	Ground command open drain	4 amperes (10A peak)
6	OUT	AUXILIARY COMMAND 4A	Ground command open drain	4 amperes (10A peak)
7	OUT	AUXILIARY COMMAND 6	Ground command open drain	4 amperes (10A peak)
8	OUT	AUXILIARY COMMAND 11	Ground command open drain	125 milliamperes (500mA peak)
9	OUT	AUXILIARY COMMAND 9	Ground command open drain	4 amperes (10A peak)
10	OUT	AUXILIARY COMMAND 1	Command push-pull Vbat	50 milliamperes
11	GND IN	ENGINE GROUND ECU SUPPLY	Ground supply for ECU	
12	GND OUT	SENSORS GROUND	Ground output for sensors supply	
13	OUT	5V SENSORS SUPPLY	5v output for sensors supply	Regulated 5 volts (total max 400 mA on the two 5 volts outputs)
14	SUPPLY	PERMANENT + 30 POWER SUPPLY	12 volts permanent power supply	6-18 volts
15	CAN	CAN1_H	CAN WinjNet	With integrated 120 Ohms resistor
16	CAN	CAN2_H	Auxiliary CAN (external)	Without integrated 120 Ohms resistor
17	OUT	10V REGULATED SUPPLY	10V output for external device supply	Regulated 10 volts (total max 200 mA)
18	IN	INPUT LOGIC 1	ON-OFF input by switching to ground	Internal pull-up 1.21 KOhms to 5V
19	IN	INPUT ANALOG 5	0-5 volts analogic input	Measurement range 0-5 volts, pull-down 1MOhm
20	IN	INPUT ANALOG 6	0-5 volts analogic input	Measurement range 0-5 volts, pull-down 1MOhm
21	IN	INPUT ANALOG 7	0-5 volts analogic input	Measurement range 0-5 volts, pull-down 1MOhm
22	IN	INPUT ANALOG 8	0-5 volts analogic input	Measurement range 0-5 volts, pull-down 1MOhm
23	IN	INPUT ANALOG 9	0-5 volts analogic input	Measurement range 0-5 volts, pull-down 1MOhm
24	IN	INPUT SPEED 1	Speed input 1	Inductive-Hall selection, gain automatic adaptation
25	IN	PHASE SENSOR	Phase sensor input on camshaft	Inductive-Hall selection, gain automatic adaptation
26	IN	INPUT SPEED 2	Speed input 2	Inductive-Hall selection, gain automatic adaptation
27	IN	INPUT SPEED 3	Speed input 3	Inductive-Hall selection, gain automatic adaptation
28	IN	INPUT SPEED 4	Speed input 4	Inductive-Hall selection, gain automatic adaptation
29	OUT	INJECTION A	Ground command open drain - 1st injected channel	450 milliamperes (750mA peak)
30	OUT	INJECTION B	Ground command open drain - 2nd injected channel	450 milliamperes (750mA peak)
31	OUT	INJECTION C	Ground command open drain - 3rd injected channel	450 milliamperes (750mA peak)
32	OUT	INJECTION D	Ground command open drain - 4th injected channel	450 milliamperes (750mA peak)
33	OUT	AUXILIARY COMMAND 3B	Disconnectable Vbat push-pull command	2.5 amperes (10A peak)
34	OUT	AUXILIARY COMMAND 3A	Disconnectable Vbat push-pull command	2.5 amperes (10A peak)
35	OUT	AUXILIARY COMMAND 7	Ground command open drain	4 amperes (10A peak)
36	OUT	AUXILIARY COMMAND 10	Ground command open drain	4 amperes (10A peak)
37	OUT	AUXILIARY COMMAND 2	Ground command open drain	4 amperes (10A peak)
38	OUT	LED DIAG-ALARM	LED command	10 milliamperes
39	GND IN	POWER GROUND ENGINE	Ground input for power commands	
40	GND IN	POWER GROUND ENGINE	Ground input for power commands	
41	OUT	5V SENSORS SUPPLY	5v output for sensors supply	Regulated 5 volts (total max 400 mA on the two 5 volts outputs)
42	SUPPLY	AFTER KEY POWER SUPPLY + 15	After key 12V power supply	6-18 volts
43	CAN	CAN1_L	CAN WinjNet	With integrated 120 Ohms resistor
44	CAN	CAN2_L	Auxiliary CAN (external)	Without integrated 120 Ohms resistor
45	IN	INPUT MIXT 2	analogic - resistive selectionnable input	Measurement range 0-5 volts
46	IN	INPUT ANALOG 1	0-5 volts analogic input	Measurement range 0-5 volts, pull-down 1MOhm
47	IN	INPUT ANALOG 2	0-5 volts analogic input	Measurement range 0-5 volts, pull-down 1MOhm
48	IN	INPUT ANALOG 3	0-5 volts analogic input	Measurement range 0-5 volts, pull-down 1MOhm
49	IN	INPUT ANALOG 4	0-5 volts analogic input	Measurement range 0-5 volts, pull-down 1MOhm
50	IN	INPUT RESISTIVE 1	0-5 volts resistive input	Pull-up 1210 Ohms to 5 volts
51	IN	INPUT RESISTIVE 2	0-5 volts resistive input	Pull-up 1210 Ohms to 5 volts
52	IN	INPUT RESISTIVE 3	0-5 volts resistive input	Pull-up 1210 Ohms to 5 volts
53	IN	INPUT RESISTIVE 4	0-5 volts resistive input	Pull-up 1210 Ohms to 5 volts
54	IN	INPUT MIXT 1	analogic - resistive selectionnable input	Measurement range 0-5 volts
55	GND OUT	SENSORS GROUND	Ground output for sensors supply	
56	IN	RPM +	RPM sensor input on crankshaft	Inductive-Hall selection, gain automatic adaptation

GENERAL TECHNICAL CHARACTERISTICS

AN ECU VERY POWERFUL AND VERY FLEXIBLE

The Commander is a machine owning very high computing power and having numerous inputs and configurable outputs, allowing from the very beginning a very flexible and effective use. Furthermore, thanks to very powerful advanced functions, the motorist can implement itself sophisticated functions not foreseen in the original software, or complement or modify the existing functions in the original software.

The Commander also owns in standard diagnostic functions of defects of the sensors and sophisticated functions of recording of overshoots completely configurable (monitoring of the engine and its devices).

COMMUNICATION, TUNING AND CHAINING

The Commander can communicate and be configured by means of the PC software Winjall (™ Skynam), and this communication is made by means of the CAN-BUS only.

1) Can-bus WinjNet (™ Skynam):

Several Commander ECUs can be chained by this network in a vehicle and exchange data to manage the same engine as the V10 or V12.
Sensor or command modules can be added on the network to complete the functions of an ECU or a group of ECU.
One or some of these Commanders can be declared masters, the others being slaves. Every master has to manage a unity in the vehicle, for example the engine, and the slaves become then extensions of the master.
All these ECUs will be together seen and controlled by the software Winjall, for an integrated tuning, the master owning the maps and the common tunings (as for example the map driver demand) and taking charge with redistributing these common data to the slaves: it is not need to load or to modify these common data in every ECU of the chain.
On the other hand, every slave owns the maps and the tunings of its own tasks, as for example the maps of correction of injection by injector, for the cylinders that it has to manage, but the integrated presentation by Winjall allows a simple and easy access to the various ECUs at the same time.

2) Auxiliary Can-bus:

The Commander owns a 2nd CAN-BUS with configurable speed by which it can send or receive chosen data, for example from OEM CAN-BUS, OBD or from external data recording.
The Commander uses this auxiliary CAN-BUS in the standard 2.0B (11 bits or 29 bits identifiers, selected for every frame).

POWER SUPPLY

The Commander is capable to work in a range of tension of power supply battery going from 7 volts to 18 volts, although the nominal power supply tension is 13,5 volts.
It allows to work perfectly on vehicles without alternator, and generally, the other devices of the vehicle stop working well before itself.
If the battery tension falls in the neighborhood of 5 volts during the activation of the starter, as by cold time and damaged battery, the problem on starter is remembered in diagnostic system for control.
If the battery tension falls in the neighborhood of 5 volts during the working, the loss of power supply is remembered in diagnostic system for control.

TEMPERATURE

The Commander it is capable to work in a range of temperature going of-40°C in +85°C. It must not however be too much near the sources of heat of the engine (exhaust, cylinders cooled by air). It is necessary to take into account the internal temperature of the electronics which borders 70°C at ambient temperature.

SEALING

The Commander has a waterproof ness of type IP67, that is it is waterproof in the dust, and in a complete dumping in the water during at least 30 minutes (on request).
However, this waterproof ness is really insured only if the loom was correctly made on the ECU side, that is pins are crimped with appropriate tool and provided with their rubber terminator and that is the not used channels are also provided with rubber terminators of suited blindness.

WATCH DOG

The Commander has an electronic watch-dog which allows it to make a complete reset (reset hardware) in case of not recoverable internal defect.
The complete ECU, and not only the microprocessor, restarts then completely, not generating notorious dysfunction more important than an impression of miss fire.
This type of event should occur only exceptionally rarely, and denotes generally of a serious problem of assembly of the ECU loom and\or a ground connection, or an overshoot of the characteristics of operation (example: internal temperature, internal presence of water).
The reset is then remembered in diagnostic system for control.
If several resets are made, the repetition is also noted in diagnostic system.

MEMORY CHARACTERISTIC

The permanent memory of Commander is a FLASH EPROM, allowing the update of the softwares (and data) by transmission since the PC.
The internal memorization of the data of tuning and recording is also made in this permanent memory: no inside battery is necessary.
To make this memorization, the Commander needs a permanent power supply that it uses only some fractions of a second to some seconds after the contact is switched off.
While it uses this permanent power supply, it makes its diagnostic LED flash.
It is imperative not to switch off the permanent power supply (it is a 'permanent' power supply) during this lapse of time.
It is the same strongly disadvised to disconnect the ECU of its loom directly without having switched off the contact at first and since the diagnostic LED goes out.
The problems of loss of permanent power supply were minimized, and in normal working, the miss of this power supply will simply prevent the ECU from remembering the last data to be recorded.
The miss of permanent power supply is then remembered in diagnostic system for control.

CHARACTERISTIC OF CALCULATION

The heart of Commander is a fast microcontroller, having a DSP calculation coprocessor (Digital Signal Processing).
Its numerous capacities of input-output give it an outstanding flexibility:

- correction of fuel volume injector by injector,

- programmable auxiliary outputs following various modes,
- …
- addition of programmable auxiliary sensors,
- combinations of inputs for the measures,
- Definition of strategies of defect of measures.

The software of Commander is written in assembler for a wide optimization of the speed of calculation.

Besides the generic functions of engine management, the computing power of Commander allowed to implant multiple additional functions of calculation, directly accessible to the motorist. This one can so implement, if it is need, its own strategies to adapt even better its ECU to the needs of the engine and its devices, the whole without damaging the main calculations which are made as often as it is necessary for an immediate management of the events and the state of the engine.

BASIC ENGINE CONFIGURATION

I) CALCULATIONS OF LOAD:

The Commander knows how to make various types of calculations of load:

- pressure / rpm,
- airflow / Rpm (additional intake pressure sensor).

II) NUMBER OF CYLINDERS AND ANGLE BETWEEN CYLINDERS:

The number of engine cylinders is configurable by the motorist, as well as the angle between cylinders for the irregular engines.

1) Regular angle:

The angle between cylinders is regularly distributed on the engine cycle. For a 4-cylinder, it is 180°, for a 6-cylinder, it is 120°...

2) Specific angle:

This configuration can be used only with an even number of cylinders.
The specific angle is the angle which separates the odd cylinders from the even cylinders: cylinders 1 and 2, 3 and 4, 5 and 6...
The angle between the odd cylinders (1 and 3, 3 and 5) is always regular: it is the engine cycle divided by half the number of cylinders (360° for a 4-cylinder engine, 240 for a 6-cylinder).
For example: a 6-cylinder with a specific angle of 72° will have:
72° between cylinders 1 and 2,
168° (240-72) between cylinders 2 and 3,
72° between cylinders 3 and 4,
168° between cylinders 4 and 5,
...

III) ENGINE MEASURE OF RPM AND PHASE:

To measure its rpm and calculate and set the events phased with the engine, the Commander needs two devices:

- a flywheel target on the crankshaft with its sensor,
- a flywheel target on the camshaft with its sensor,

FLYWHEEL

The flywheel sensor can be inductive or Hall effect.
The number of teeth is programmable, from 8 to 60 teeth.
Although the computing power of Commander is sufficient to support an engine rpm far beyond the mechanical possibilities of an engine, the flywheel should be chosen with a number of teeth all the more minimized as the foreseen maximum rpm must be raised, for quality questions of sensor's signal rpm. **A good balance precision of the low rpm - quality of the high rpm is reached around 500 000 teeth / minute.**
On the contrary, if the engine must be able to start from very low rpm, it is necessary to increase the number of teeth of the flywheel. The engine can start only when the biggest tooth (see typical of mark) becomes lower than 100 milliseconds.
The type of mark is programmable too:

- a supplementary tooth,

- a missing tooth,
- two consecutive missing teeth,
- regular teeth (in that case, the sensor camshaft is imperative, and it is necessary to ensure that the tolerances of camshaft are small enough so that the mark of cam always passes on the same tooth of the crankshaft).

MINIMUM RPM OF SYNCHRONIZATION CONTROL

A test of loss of synchronization is made in every engine round by the ECU, allowing it to control that the flywheel is correctly read.
If a tooth was missed or if an excess tooth is seen (a strong parasite), or if the rpm is too much disrupted, the injection is stopped and the search for the flywheel mark is restarted.
We can indicate the rpm below which the test of loss of synchronization of the flywheel will not be made.
This rpm is normally 0, and the test of synchronization is made as soon as the engine runs.
For certain engines with a very light flywheel or with few cylinders, it is better not to make this test before certain rpm is reached because the engine turns too irregularly at low rpm, preventing the ECU from letting start the engine.

CAMSHAFT MARK

The camshaft sensor can be inductive or Hall effect.
The type of camshaft mark can be on position or on state of the camshaft target:

- mark on position: all the teeth of the target camshaft have to be in the same half round of camshaft. It means that the other half round of camshaft must be empty.
- mark on state: on the flywheel mark of one of both rounds of the engine cycle, there has to have a camshaft tooth, and on the other engine round, it does not have to have it. This configuration is often used for common rail diesel engines. For this configuration, the camshaft sensor has to be in Hall effect.
- dynamic phase: When the engine does not own a phase sensor, the ECU can phase on the engine by using a method of dynamic phase synchronization:

TOP DEAD CENTER MARK

A calibration allows adapting the angular distance between the mechanical Top Dead Center and the Top Dead Center Mark on the flywheel seen by the sensor. It allows to give the real phase in degrees in the maps of engine phase (the phase injection).
Furthermore, if the flywheel must be changed or angularly repositioned, it would be enough to redo this calibration without having to modify the maps to find back the engine tunings.

A calibration also allows to set the measure of camshaft phase to top dead center 0°.

INJECTION COMMAND

I) PRESENTATION:

Commander6D has 6 injection channels.

ELECTRICAL COMMANDS

The electrical commands of the injection channels are weak power logical commands by the ground. They serve for commanding the injectors driver additional module.

ADDITIONAL MODULE OF INJECTORS COMMAND

Two types of modules exist for which one **the covering of injection between cylinders is allowed**: there is thus no constraint on the phase nor the length of the injections, contrary to the systems which do not agree to make two injections at the same time and have to make a collision management between cylinders.

a) Controlling the piezo electric injectors:

The injector tension of command is positioned between 95 volts and 180 volts by an adjustable map in the module, on calculated data received in real time from the Commander:
- a target function of the fuel high pressure = Max (fuel high pressure, fuel high pressure target),
- the injectors temperature estimated according to the engine temperature.

The module gives a diagnostic of the working of its internal high tension and of the working of injectors.
In case of overheating or available power exceeding, the module decreases the tension of command of the injectors to lower the consumed power down to the available power and indicates it in its diagnostic.
For the needs of very strong power, it is possible to connect two modules, each controlling half of the injectors.

b) Controlling the inductive injectors:

This module commands injectors in Peak and Hold mode.
- The tension of the peak is programmable between 20 volts in 65 volts and the time of this peak is also programmable.
- The level of the hold current is programmable between 1 ampere and 18 amperes.

The module gives a diagnostic of the working of its internal high tension and of the working of injectors.
In case of overheating or available power exceeding, the module decreases the tension of command of the injectors to lower the consumed power down to the available power and indicates it in its diagnostic.
For the needs of very strong power, it is possible to connect two modules, each controlling half of the injectors.

CALCULATION OF INJECTION

The fuel quantity to be injected is a mass, given in milligrams (resolution 1/10° mg).
Then this mass is transform in volume, given in cubic millimeters (resolution 1/10° mm3), by a function of the fuel temperature.
Finally, the volume is transformed in injection time, given in microseconds (resolution 1 µs), by a function of the fuel pressure and dependent on the type of used injector.

SEQUENCE OF INJECTION

The injection is sequential phased on the beginning of the injection.

There are three categories of possible injections in the engine working:

- The torque injection, which gives some fuel to the engine to supply it with the torque,
- the late post injection which sends some fuel to the particles filter, for the cleanup.
- The complementary injection, situated between the main injection and the post injection, serves as advanced post injection, used to warm exhaust gases.

The torque injection engine can be cut in three injections:

- The pilot injection 2,
- The pilot injection 1,
- The main injection.

The first one if it exists is the pilot injection 2, then comes the pilot injection 1 if it exists, then comes the main injection, if it exists.

We can thus have 5 different injections, in the order:

- The pilot injection 2,
- The pilot injection 1,
- The main injection,
- The post injection 2 or complementary injection (on option).
- The post injection 1.

CORRECTION OF INJECTORS

Every injector has a correction map, to balance the disparity between injectors. This map gives a coefficient of modification of the injected volume.

II) TORQUE INJECTION:

The torque injection (which gives the torque to the engine) can be cut in 3 parts:

- the pilot injection 2 (very advanced injection),
- the pilot injection 1 (advanced injection),
- the main injection,

In normal working, pilot injections serve for preparing the combustion of the main injection: they are thus made before the main injection. They allow to improve the combustion of the fuel, and thus decrease the noises and allow to obtain more engine torque. They also serve in the strategies of cleanup of the engine.

The main injection is the injection which is going to bring the main torque of the engine.

CALCULATION OF INJECTION QUANTITY

The fuel quantity given by the torque injection gives the torque to the engine.

A set of maps give the available torque of the engine, according to the maximum torque (maximum quantity of fuel which we can be injected in the engine) corrected by the engine temperature, the intake temperature and the atmospheric pressure.

Every moment, a more or less big portion of this available torque is injected in the engine, according to the activity of different elements of engine management, as notably:

- the engine start
- the driver demand (accelerator pedal position)
- the gear shifting, with modification of the injected quantity to decrease or increase the torque of the engine and a jolt smoothing procedure.
- the deceleration cutoff, with a jolt smoothing procedure,
- the tick over management, to maintain the engine rpm to the tick over target
- the rpm limiter, by decrease of the injected quantity to conform to the current rpm limiter target,
- the protection of the overshoot of turbos rpm

- the complementary protection, which allows the motorist to decrease the torque or to cut the engine following strategies that he will choose (for example on loss of oil pressure)
- the smoke limitation control, to avoid driving an oil-fired stove
- the complementary modification of injected quantity, so that the motorist can develop additional features, as the anti skating, the maximum speed limit, …

REPARTITION OF INJECTION QUANTITY

The quantity of torque injection must be then distributed between three injections composing the torque injection:
- the pilot injection 2,
- the pilot injection 1,
- the main injection,

A set of map allows to manage this distribution, according to the quantity of the torque injection, the engine rpm, the engine temperature, the intake temperature, the atmospheric pressure, and the additional calculations that the motorist can program itself.

PHASE INJECTION CALCULATION

The phase of the injections is also very important, and plays a role similar to that of the advance in the ignition of engines with piloted ignition.
A set of maps allows to position each of three injections composing the torque injection in the engine cycle, according to the quantity the torque injection and the engine rpm, with correction by the engine temperature, the intake temperature, the fuel temperature and the atmospheric pressure.
A dynamic calculation also allows to modify their phase during the accelerations, to have a stronger acceleration or reduce the noises and the emissions.
An additional correction allows the motorist to insert its own strategies of modification of the injection phases.

III) COMPLEMENTARY INJECTION (ON OPTION):

The complementary injection is a late injection, positioned between the main injection and the post injection.
The quantity which it injects is not counted in the torque injection.
It allows to make injections being of use to other functions than the main injection or the post injection.

It is to note that the use of this injection in the zone of phase of engine torque is very dangerous because it is not subjected to the limiter nor to the deceleration cutoff.

IV) LATE POST INJECTION:

The competition software has a simplified module of management of regenerations for the categories asking for a particles filter.

The post injection is a very late injection which allows to send some fuel to the particles filter to facilitate regenerations.
These regenerations can be spontaneous when the internal temperature of the filter is high enough, when the load and the engine rpm are sufficient.
If regenerations are not naturally sufficient, it is necessary to provoke them with the post injection.
Controls of temperature allow to avoid the deterioration of the particle filter and the catalyst.

The strategy of regeneration of the particles filter of Commander takes into account all these parameters, allowing to determine if it is necessary to generate post injections, which quantity is to be injected and the phase of these injections. Emergency procedures also allow to stop post injections.
As in all the calculations, the motorist can insert its own strategies of generation of post injections.

V) CONTROL OF MINIMUM TIME BETWEEN INJECTIONS OF THE SAME CYLINDER:

If the interval between 2 injections of the sequence:
Pilot 2 – Pilot 1 – Main – Complementary – Post
is too short, the injector has no time to close and the quantity of fuel is increased there.
To avoid this phenomenon, the Commander controls in real time (during the engine working) that the intervals are sufficient, and should the opposite occur, repositions the injections in priority order.

RICHNESS REGULATION

The Commander can be configured to measure the richness with a wideband Lambda sensor specifically calibrated for diesel engines, and to correct it.

PRECISION OF THE SENSOR LAMBDA

The precision of the indication given by the sensor Lambda is increased by the use of correction of measure according to the exhaust pressure.

PRINCIPLE OF RICHNESS CORRECTION

Contrary to gasoline engines (piloted ignition), the diesel richness regulation gives the maximal allowed richness: the richness regulation can only decrease the driver demand quantity if this one produces a too high quantity of fuel. The coefficient of correction of richness is thus a value at most equal to 1 applied to the driver demand.

GLOBAL ACTIVATION

A software switch allows to validate globally or not the correction of richness.

PROGRAMMABLE ACTIVATION

When the richness correction is globally allowed, we can also define the range of load, rpm and engine temperature in which the richness correction must be made.
A map of complementary cut of the richness correction, with selectable inputs, allows the motorist to implement its own strategies of richness correction unlooping.

TARGET OF RICHNESS

To drive this correction, we use a target map to indicate the maximum desired richness according to the load (intake pressure) and the rpm.
A second one map function of the rpm and the driver demand (given by the pedal) allows to modify the target of richness.
Three maps of multimapping tuning with selectable activations (see 'Groups of modification multimapping tuning'), on rpm / load, allow to modify the basic target.
Furthermore, an advanced calculation hook map with selectable inputs for addition of strategies of target modification allows the motorist to implement its own strategies of modification of target.

LIMITATION OF CORRECTION

We also have a programmable limit of correction, forbidding the Commander a too much lean correction.

REGENERATION OF PARTICLES FILTER

The Commander can be configured to make regenerations of the particle filter, if it is present on the exhaust line.
A simplified version of regenerations is necessary, because some categories of car-racing ask for the presence of the DPF (Diesel Particles Filter).

Regenerations are made by 3 different modules:

- module of regeneration demand, according to the clogging level of the DPF,
- module of regeneration permission, according to the working state of the engine,
- module of regenerations execution.

I) DEMAND OF REGENERATION:

The clogging level of the particles filter is calculated on the basis of a reference map of differential pressure of the filter, function of the engine rpm and the torque injection quantity.
By comparison between this pressure reference and the measured pressure, a rate of immediate clogging and a rate of average clogging are calculated.

It is necessary to activate the regeneration enough early not to block the particles filter.
Furthermore when the mass of soots increases, the heat emission during the regeneration increases, and can provoke the deterioration of the filter.
It is relevant to foresee the regeneration when the conditions are good: running with prolonged loads (highway or long straight road), or to delay it when they are bad.

NORMAL DEMAND OF REGENERATION

Regenerations are asked if the rate of average clogging reaches a standard trigger threshold of regeneration demand. This threshold is given by two sets of maps:
1) a basic map of clogging threshold, according to the rpm and to the torque injection quantity, gives the level of clogging to achieve to ask for a regeneration according to the working state of the engine.
2) a coefficient of modification of clogging threshold given by a 4D simplified map, according to the engine acceleration, the speed of the torque injection quantity, of the rpm and the torque injection quantity itself, gives a coefficient of correction of the coefficient of modification.
When the conditions of engine working are good: strong prolonged load (high rpm and important TIQ + slow evolution of the rpm and the TIQ), we shall give a low threshold of clogging, provoking regenerations easy to make.
When they are bad, we shall give a high threshold of clogging, asking for regenerations only if the filter is in danger.

DEMAND OF INSTANT REGENERATION

The emergency regenerations are asked if the rate of instant clogging reaches the threshold given by a map of emergency threshold of clogging according to the rpm and to the torque injection quantity. Generally, the emergency thresholds are positioned very high, a little below the limit of clogging of the DPF.
If the demand of emergency regeneration is positioned, it will not be any more released until the run of the regeneration or until the ECU switch-off.

II) TRIGGER OF REGENERATIONS:

So that a regeneration can be run, the conditions of working of the engine have to allow it: all the states of control must be satisfied (regeneration allowed by all the controls).

EMERGENCY BAN

During the entrance in tick over pedal position (deceleration cutoff or tick over), if the speed of rise of pedal exceeds a programmable threshold, regenerations are forbidden until the exit of tick over pedal position.
It is made to increase at most the engine brake in case of emergency demand by the driver.

MINIMUM LIMIT OF ENGINE WORKING

There are ranges of very low load in which no stable mode of regeneration in high temperatures is possible: this function defines the minimum torque which the engine has to supply according to the different rpm, this minimum torque also ensuring a minimum stream of exhaust.
The permission to regenerate according to the engine working is given by
- a curve limits of torque injection quantity with regard to the rpm <u>from</u> which the permission is given,
- a curve limits of torque injection quantity with regard to the rpm <u>below</u> which the permission is canceled.

These two curves define a hysteresis of passage between both states 'allowed' and 'forbidden' to avoid the oscillations of permission when the load crosses the limit of permission.

MINIMUM LIMIT OF INPUT EXHAUST TEMPERATURE

In correlation with the minimum load of the engine, we use a curve of minimum input exhaust t° to allow regenerations.
It ensures that the stream of exhaust given by the minimum load also exceeds a minimum quantity of heat:
- a stream of exhaust being enough without temperature does not allow to launch regenerations.
- in the other direction, a high temperature with a weak stream of exhaust will bring only a small one quantity of heat, not allowing either to launch regenerations.

It is to note that as soon as the active heating of exhaust gases is made, this function does not intervene any more because the obtained temperature exceeds the minimal limit which it gives.
The permission to regenerate according to the input exhaust t° is given by
- a curve limits of temperature with regard to the rpm <u>from</u> which the permission is given,
- a curve limits of temperature with regard to the rpm <u>below</u> which the permission is canceled.

These two curves define a hysteresis of passage between both states 'allowed' and 'forbidden' to avoid the oscillations of permission when the temperature crosses the limit of permission.

COMPLEMENTARY PERMISSION

We have a complementary map of regeneration ban, inputs of which are selectable: the motorist can add its own strategy of ban.
This complementary permission can serve to explicitly forbid regeneration following engine states, for example the deceleration cutoff, the engine start, the rpm limiter, the tick over, …
It can also serve to forbid regenerations if the richness is too high, to ensure the rate of oxygen being enough for correct combustion of soots.
Normally, the calibration of the interventions is made in a way that the levels of richness are correct, but this additional ban can serve as safety.

III) VIRTUALISATION OF REGENERATIONS:

If all the previous conditions are gathered, the regeneration is enabled and the engine interventions are made.
The run of the engine interventions can be set to pause to limit the temperature during the regeneration. This pause is called virtualisation.

1) To control the heat during the regeneration, we shall give a calibrable target of maximum temperature of catalyst output (normally 600°C). This target is given by a map function of the rpm and the torque injection quantity.
Indeed, the rise in temperature has a certain slowness depending on the stream of exhaust (depending itself on the rpm and on the engine load). To reach the temperature of combustion of soots, the quantity of necessary heat can be supplied either by warming more hardly, or by warming much longer. If we warm too hardly, we provoke an overshoot of acceptable temperature at DPF input, if we do not warm enough, time is too long to reach the desired temperature, to see we do not reach it at all: by modulating the strength of heater (by the interventions on the engine working – see lower) with the temperature level of passage in virtual mode, we obtain the regenerations execution desired working

2) When the temperature reaches the target (whether it is by intervention on the engine management or naturally because of the working state of the engine), the regeneration is set to virtual mode until it comes down again of a calibrable hysteresis. This hysteresis is given by a map function of the rpm and the load.

IV) RUN OF REGENERATIONS:

To run the regeneration, the engine management has the late post injection. This intervention is subjected to a supplementary control of exhaust temperature before being able to be launched.
These late post injections will raise the temperature inside and at catalyst output at the level of the minimal temperature of soot combustion (600°C without additive).
It is launched only during the active regenerations with additional control of t° before oxidation catalyst.
The fuel quantity which it supplies is a function of the rpm and the torque injection quantity.
Its phase (angle of the beginning of injection) is a function of the rpm and the torque injection quantity.

ENGINE MULTIMAPPING

This function is available only on the competition software.

Three groups of modification allow to modify the engine tuning, for example to have several tuning according to a rotator, allowing, with the original tuning, to obtain 4 different engine tuning (the original tuning plus 3 modifications).

A group of modification is constituted
- of a map of modification of maximum torque (maxi injected quantity),
- of a map of modification of driver demand (linearization of the torque demand with regard to the accelerator pedal position),
- of a map of modification of target of richness,
- of a map of modification of smoke limitation,

Every group of modification can be activated by the one or other one of the variables known by the ECU (measures or generic results of calculation of the ECU, or values received from the auxiliary CAN-BUS, or results of calculations of pilot modules).
Once defined by which ECU variable a group will be activated, one defines the value range of this variable which will activate the group.

In competition, one of the applications frequently used is to change engine tuning according to the positions of a rotator, by defining this measure of rotator position as variable of activation for all the groups, and by activating every group on one of the positions (value) of the rotator.

AUXILIARY COMMANDS

14 auxiliary outputs of Commander are generally power outputs of ground command in open drain (ground or nothing).
Two outputs can be programmatically configured in push-pull (ground or 12 volts power supply).

Some of the auxiliary outputs can be coupled so that a single command controls two electric outputs. In that case both outputs are set, that is if the one is active, the other one is passive. In the change of state of the double commands in push-pull, a very light phase shift is made. It allows for example to create H bridges.

I) FIXED COMMANDS:

DIAGNOSTIC LED

The Commander uses a special output among 14 to command its LED to specifically manage the state signals of the ECU and its diagnostic.

II) FIXED COMMANDS FOLLOWING TYPE OF APPLICATION:

LOW PRESSURE FUEL PUMP

The Commander can use one of the 14 outputs to command the low pressure fuel pump according with the standards FISA regulation: pump running during 5 seconds at the ECU switch on, then switch off of the pump if the engine does not run.
As soon as the engine runs, restarting of the pump.

FUEL PRESSURE AND FLOW

See below the details of the management of the fuel pressure.

TURBO

See below the details of the management of turbos.

PRE-POST HEATING

See below the details of the management of the pre-post heater.

ELECTRIC MOTOR OF POSITIONING

To use a device with precise angular positioning, with looping on a potentiometer. Is managed by a regulation of type PID on a H bridge PWM command (double push-pull) of which the control frequency can be chosen.
For this management we use a map of target to indicate the angular position of the electric motor. The inputs of this map of target are selectable and the target of position of the motor is thus a function of what wishes the motorist.

Measure of angular position:

The measure of position of the electric motor is normally made on a potentiometer, but can be made on two potentiometers thanks to the advanced functions of programming. The motorist can also define the way of correlating both track of the potentiometer and the strategies of defect.

Angular position calibration:

The ECU supplies a calibration of electric motor position. This calibration allows the ECU to record the minimum and the maximum of the values of potentiometer (or of calculation so double potentiometer) and will allocate them from then on the angular position 0 and the angular position 1000, with a linear interpolation between these two values for the intermediate angles.

ELECTRIC MOTOR OF ROTATION

Allows to manage the speed of an electric motor by a PWM with selectable frequency and cyclical ratio, with possible looping on one of the frequency inputs, which allows to control very finely the speed of the electric motor, according to parameters selectable by the motorist.
This function is not pre-programmed but must be built on the basis of the 'advanced Functions' (see examples in the programming documentation).

PROPORTIONAL ELECTROVANNE

Allows to manage the gradual opening of electrovalves, by a PWM with selectable frequency and cyclical ratio.
The Commander owns a particular mode of electrovalve control by making an effect of small hammer to force the precise positioning of electrovalves. If this working type is not wished, we shall rather configure the output in adjustable PWM.
The type of electrovalve can be two wires (standard electrovalve closed by spring) or three wires (electrovalve with opening and closure electrically controled).

III) PROGRAMMABLE COMMAND:

The auxiliary outputs of the ECU not used by the type of application are at the disposal of the motorist to implement its own strategies. See 'Advanced functions' lower to find a description.

IV) FUEL PRESSURE:

The Commander owns three possible types of management of the fuel pressure:

- by the flow only (fuel supply electrovalve)
- by the leak only (electrovalve of leak on the injectors rail only)
- combined by the flow and the rail leak (a electrovalve on each side)

One of these three configurations must be selected.

Whatever is the mode of management of the fuel pressure, it is made by one (or two) PID on the measure of fuel pressure which is always validated (an input is allocated to this measure, whether it is physical, calculated or by CAN-Bus sensor).

TARGET OF FUEL PRESSURE

A set of maps of target allows to define the desired fuel pressure.

1) Basic target:

A map of basic target indicates the wished base of fuel pressure, according to the rpm and to the torque injection quantity.

2) Additional correction:

A map of complementary command of target with selectable inputs allows the addition of strategies of fuel high pressure target by the motorist.

3) Dynamic enhancement:

When the pedal is pushed (strong demand of the driver) and when the load is strong (the engine intakes a lot of air), we deliver an important quantity of fuel. We can then strengthen the fuel pressure to limit smokes.

4) Target fall control:

A mapped control of target fall allows to limit the speed at which the target decreases, for example in the rise of foot.

Indeed, if the engine is loaded with and that the driver quickly raises the foot, the target is going to fall again immediately at a much lower level. The fuel pressure will follow the target.
If this rise of foot is immediately followed from a re acceleration, the fuel pressure has to go back up again.
This calculation allows to limit the fall of the target for a while, waiting to see if the re acceleration and the rise of target quickly follow.

5) Limits of target:

Two maps of safety allow to limit the excursion of the pressure target according to the engine rpm, one to define the minimum pressure and one to define the maximum pressure.

RAIL LEAK FUEL MANAGEMENT

The fuel pressure is managed by the rail if the electrovalve of fuel pressure (rail output side) is managed by an auxiliary output in PWM but if the fuel flow electrovalve (fuel supply side) is not managed.
The fuel quantity which the pump compresses is always maximal. The electrovalve empties the rail of the pressure excess: the fuel pressure is obtained by the balance between the filling of the injectors rail by the pump and its emptying by injectors and electrovalve.
The electric command can be inverted by the configuration of the output.
The frequency of the PWM can be chosen by the configuration of the output.

The management of fuel pressure is made by a PID looped on the fuel pressure.
The parameter setting of the PID is constituted by 3+1 maps.
By means of these four maps, a regulation RCO is calculated and applied to the PWM output of fuel high pressure command.
This RCO is equal to the RCO of base + derived RCO + integral RCO.
A limitation of the RCO allows to limit the electrovalve control to its useful range of operation.
It is possible to block the calculation of the integral of the PID to its current value: the motorist can choose its strategy for this blocking, for example to freeze the integral during the gear shifting, because the dynamics of the demand is very high and can provoke very important overshoots and undershoots of pressure.

SUPPLY FLOW FUEL MANAGEMENT

The fuel pressure is managed by the flow if the electrovalve of fuel flow (fuel supply side) is managed by an auxiliary output but if the electrovalve of fuel pressure (rail output side) is not managed.
The fuel quantity which the pump compresses depends on the RCO (cyclical ratio) which controls the electrovalve of fuel flow: we increase the pressure with the command of pump, but it is the injectors which empty the pressure: the pressure of fuel is obtained by the balance between the filling of the injectors rail by the pump and its emptying by injectors.

The management of fuel pressure is made by a PID looped on the fuel pressure.
The parameter setting of the PID is constituted by 3+1 maps.
By means of these four maps, a regulation RCO is calculated and applied to the PWM output of fuel flow command, the period of the PWM being also adjustable at the level of the parameter setting of the output.
This RCO is equal to the RCO of base + derived RCO + integral RCO.
A limitation of the RCO allows to limit the electrovalve control to its useful range of working.

The management of this PID possesses in more a peculiarity due to the limitations of working of the management by the flow which cannot decrease the fuel pressure when injectors are stopped.
If the command is too high when injectors are stopped, the fuel pressure is going to rise very high without that it is possible to make it decrease. Even if the pressure is correctly stabilized at the target level, if the target comes down, the pressure cannot decrease to follow this decrease.

In the phase of deceleration cutoff, a too high pressure is unwanted, especially if the injected quantities at the time of the move on are low, as at tick over, giving extremely short times of injection, for which the pollution and the stability of the engine working will be difficult to control.
To avoid this unwanted state, the Commander has a strategy of rail emptying to decrease a too high fuel pressure during the deceleration cut off.
Furthermore, the basic map of RCO of the PID taking into account the fuel consumption, the command of the pump will be adapted from the pre control (base of RCO) at injection cutoff: it gives a RCO close to a command of stopped pump.

COMBINED MANAGEMENT BY THE FLOW AND THE RAIL LEAK

The fuel pressure is collectively managed if the electrovalve of fuel pressure (rail output side) and the electrovalve of fuel flow (fuel supply side) are both managed by an auxiliary output.
Every output is controled by a PID, with a module of interaction management.
The PID of management of the flow does not manage the injectors stop and there is no procedure of rail emptying in deceleration cutoff. Indeed, it is the rail leak management that is in charge of making the pressure drop in that case.
Two phases of management are used:
1) At engine start, as long as the fuel temperature (rail input) is cold (below a programmable target):
The fuel pressure is managed by the rail leak.
After a first phase of filling, the flow remains maximum. The pump warms the fuel by compressing more fuel than necessities.
2) When the fuel temperature is sufficient (programmable target reached):
A module of interaction controls both PID:
The fuel pressure is mainly managed by the flow, the rail leak serving only when the pressure cannot be decreased by the decrease of the flow.

V) TURBO:

The Commander can manage:
- 1 turbo,
- 2 twin turbos in parallel (1 by bank of cylinders)
- 2 sequential turbos in parallel
- 2 serial sequential turbos
- 3 turbos, with two in parallel and the third serial with both first ones

Turbos in sequential mode are started only under selectable conditions.

The management of turbos maybe made according to the intake pressure or the rpm of turbos.
For V engines with separated intake by bank, it is possible to read two pressure sensors, each allocated to a bank of cylinder, and to manage each of the twin turbos with its own pressure.
Furthermore, as the maps of target are with selectable inputs, it is possible to integrate a restrictor pressure into the management of the target of overboost, by using one of the auxiliary inputs to measure this restrictor pressure and by integrating this measure into the calculation of the overboost target.

COMMAND OUTPUTS

The management of turbos has 3 output commands, one for every turbo.
The management of the commands of turbos (waste-gate or variable geometry) is made in PWM.
The electric command can be inverted by the configuration of the output.
The frequency of the PWM can be chosen by the configuration of the output.
- The ECU commands outputs of the turbos are ground commands, controlling normally pneumatic electrovalves. The frequency of the PWM can vary from 30 Hz up to 250 Hz following

the type of electrovalve. If it cannot be verified with the parts manufacturer, the frequency advised by the PWM is around 100 Hz.
- Some turbos have a variable geometry controlled by electric motor. The frequency of the PWM can vary from 50 Hz up to 1000 Hz. If it cannot be verified with the parts manufacturer, the advised frequency of the PWM is around 500 Hz.

If it is needed to control supplementary electrovalves to engage or bypass the turbos by flaps, or to also manage one wastegate back pressure, programmable auxiliary outputs can be used to make these additional controls.
According to the engine equipment, these outputs can then be managed according to the rpm of the sequential turbo or one or several turbos of the Pack 1, either according to the engine rpm, the intake pressure, or the fuel quantity, or any other parameter needed by the motorist.

TOOLS OF TURBO MANAGEMENT

Turbos are named 1A, 1B, and 2, as much for the output command as for the measure of turbo rpm.
Turbos 1A and 1B have to be twin turbos.
The turbo 2 benefits itself of a completely separated management.
The Commander has 2 packs of turbo management:
Whether it is for the pack 1 or the pack 2, the conditions of control are completely selectable.
Every Pack consists
- of a map with selectable inputs of type of management wished (in rpm or in pressure)
- of a map with selectable inputs of turbo rpm target
- of a map with selectable inputs of modification of turbo rpm target
- of a map with selectable inputs of intake pressure target
- of a map with selectable inputs of modification of intake pressure target
- of a parameter setting of PID of management of turbo rpm
- of a parameter setting of PID of management of turbo pressure
- of a map with selectable inputs of reset to zero of the integral of the PID

TURBO RPM MANAGEMENT

The choice of the management in turbo rpm or in pressure is made Pack by Pack, that is if 2 turbos 1A and 1B of the Pack 1 exist (commands of outputs validated), the 2 will be managed in pressure at the same time, or managed in rpm at the same time. The turbo 2 managed by the Pack 2 can be managed in rpm or in pressure independently of turbos 1A and 1B.
If during the management by rpm, one of the measures of turbo rpm of a Pack is declared in error:
a) If the management by pressure of the Pack is validated: (see paragraph 'Management in pressure')
The switching to the management by pressure is made. This switch is made in a common way inside every Pack of turbo management: for example, if the measure of turbo rpm 1A either if the measure of turbo rpm 1B falls out of order, the management of the Pack 1 completely switches to pressure management.
b) If the management by pressure of the Pack is not validated:
As long as the pack is in error, only the map of basic leak of the PID will be used, no correction being brought to it any more.

TURBO PRESSURE MANAGEMENT

For V engines with separated intake by bank of cylinders, we shall declare in the configuration of inputs the existence of bank 1 and bank 2 intake pressures, each being measured with its own sensor. We shall also declare the main pressure in automatic calculation, as resultant of the 2 banks, which will be used for the calculations of the injection management and the other one …

The 2 turbos of the Pack 1 will be managed so separately, each with its own pressure. The pressure of the bank 1 is automatically allocated to the turbo 1A and that of the bank 2 to the turbo 1B.
If only the main intake pressure is declared, both turbos 1A and 1B will be managed in the same way according to the unique pressure.
If during the management by pressure, one of the measures of turbo pressure of a Pack is declared in error:
a) If the management by rpm of the Pack is validated: (see paragraph 'Management in rpm')
The switching to the management by rpm is made. This switch is made in a common way inside every Pack of turbo management: for example, if the measure of turbo pressure 1A either if the measure of turbo pressure 1B falls out of order, the management of the Pack 1 completely switches to rpm management.
b) If the management by rpm of the Pack is not validated:
As long as the pack is in error, only the map of basic leak of the PID will be used, no correction being brought to it any more.

CHOICE OF MANAGEMENT TYPE TURBO RPM OR PRESSURE

If 2 types of management turbo pressure or turbo rpm are validated, the ECU allows changing the type of management in the other one.
The target and the difference with the target of both types of management are continuously calculated, even for the type of management that is not in use.

1) Map of selection:

A map allows to choose which one of both is used, to be able to use at best the 2 types of management.
Its inputs are selectable, and the strategy of use is thus left with the choice of the motorist.
This map accepts the hysteresis mode of operation to avoid oscillations between the 2 modes at the time of the switching from one to the other.
For example, we can choose to work in pressure up to a maximum turbo rpm, to switch to rpm management beyond this threshold to be sure to avoid overboosts, and to go back to pressure only if the rpm comes down below a certain a little lower threshold.
The map having two inputs, if two twin turbos are managed by the pack 1, the rpm of each can be examined, each by one of the inputs of the map.

2) Automatic change on error of measure:

If the error concerns the measure in use (pressure or turbo rpm), the ECU tries to switch type of management:
- If the other management is allowed (no error), the change of management is made.
- If the other management is not allowed (also in error), no management is more allowed, the management by pressure is chosen and only the map of basic leak of its PID is used (the proportional and the integral are not used during the errors).

If the error concerns the not used measure, the ECU will not switch to the type of management of this measure even if the map of working mode selection requests it.

PID OF CONTROL

Every Pack has 2 parameter settings of PID, one for the management in rpm and one for the management in pressure.

1) The Target:

It gives the absolute intake pressure wished for the PID of management pressure and the speed turbo wished for the PID of management turbo rpm. It is possible to select according to which parameters this target will be given. For a standard turbo management, it will be the engine rpm, and the torque injection quantity or the accelerator pedal position.
A map of complementary modification allows to make modifications of target according to parameters chosen by the motorist, as the atmospheric pressure, the intake temperature....

2) The basic leak:

It is a function of the engine rpm, and the target of turbo rpm for the management in rpm or the target of intake pressure for the management in pressure.

3) The leak immediate correction:

It is a function

a) Of the speed of the target (turbo rpm or intake pressure). Indeed, the more the target varies fast, the more it is necessary to anticipate the demand in pressure or in turbo rpm.

b) Of the distance between the target and the measure:

- for the management in rpm, the measure is the rpm of the turbo.
- for the management in pressure, several cases are possible:
    - for the Pack 2: the measure is always the main intake pressure.
    - for Pack 1: for the twin turbos, if it was declared a measure of pressure for every bank of cylinder, the measure is the pressure of the bank 1 for the turbo 1A and the pressure of the bank 2 for the turbo 1B. If the intakes of banks are not separated or if we manage only a single turbo, the measure of main pressure will be selected.

4) The long term leak correction:

It is a function of the same variables as the differential (see above).

In every cycle of calculation, (every milliseconds), a value is added to the value of correction calculated at previous calculation cycle, generating a new value of correction. We approach so gradually the perfect correction.

5) The reset to zero of the integral:

Is made by a map common to the rpm management and pressure management of the 2 parameter settings of PID of the pack. Its inputs are selectable: the motorist can choose its strategy for this reset to zero.

<u>a) For a standard turbo management:</u>

To avoid unwanted overboosts, we cut the integral correction which can generate a very important overshoot of target if, when the fuel quantity being too low, the turbo rpm or the pressure does not manage to rise at the level of the target: the calculation of PID then increases the integral at most to try to generate a higher leak to reach the impossible target, and when we accelerate brutally, the leak is wide open and the pressure rises very high.

It is thus necessary to force the integral to 0 in these circumstances, letting only the differential correct the basic leak.

<u>b) For the management of a sequential turbo:</u>

The integral can be maintained to 0 as long as the sequential turbo is not used.

VI) PRE-POST HEATING:

The procedure of reheating is made only if one of the auxiliary outputs is configured in command of control of reheating glow plugs power device.

The glow plugs can be commanded in ON-OFF or in proportional for the fast heating glow plugs. The Commander controls the electronic device of heating, which could be only a simple power relay. If this device emits a diagnostic on a simple wire (OK-Error), the state can be used via an auxiliary input. If the diagnostic is emitted by the CAN, it can be get by an XCan variable (see auxiliary CAN-bus). The result of the diagnostic can be integrated by the motorist into the procedure of pre-post heating thanks to the advanced functions and to the complementary map of cut of the reheating.

If the reheating is made in PWM to command fast reheating glow plugs, a modeling can be made to estimate the temperature of glow plugs to use the push tension only when it is necessary.

The reheating begins from the switch on if it is allowed. If the engine start fails and if a new attempt is made without switch off, the procedure of reheating is restarted since the beginning.

The procedure of reheating is subdivided into different phases, dependent on the working state of the engine:
- Active pre heating,
- Standby Pre heating,
- Engine starts with additional Pre heating,
- Engine starts without additional Pre heating,
- Engine turns, active Post heating, standby Post heating,
- Reheating end,

The alarm LED is used as signal of demand of wait to start by producing a fast blinking (10 Hz).

During all the procedure of reheating, the battery tension is tested. If it comes down below a threshold for a while, the procedure of reheating is aborted.
A map of complementary cut of the reheating is available for an additional definition of strategy of cut by the motorist.

PRE HEATING

The time of Pre heating is calculated according to the engine temperature and the battery tension.

POST HEATING

The time of Post heating is calculated according to the engine temperature and the battery tension.
The Post heating can be set in standby or stopped if the engine rpm is too high or if the engine load is too high.
The standby and the reactivation of the Post heating allows to make additional Post heatings for example during return to low load after deceleration cutoff of cold engine.
When the time of Post heating is lasted, the procedure of reheating is ended and the relay of reheating is switched off.

VARIOUS FUNCTIONS

I) RPM LIMITER:

ACTION OF THE LIMITER

The limiter is made by a reduction of the fuel quantity, managed by a PID.
A map of complementary command allows the motorist to modify the rpm of the limiter according to a strategy which he will define himself.

TYPES OF LIMITER

Two types of rpm limiters exist in the Commander.
The Commander allows to give different rpm for these two limiters, as well as the conditions to switch from one to another.

1) the move off (launch) limiter:

It allows by setting a rather low limiter to reduce the power of the engine to the move off of the vehicle, to avoid a too high skating of wheels,

2) the race limiter:

It is used for the full power of the engine. A map allows to decrease the limiter target according to the time spent in the limiter.

SHIFT LIGHT

It is the lamp which we switch on when the engine rpm is to reach the rpm limiter.
This lamp is commanded by an auxiliary output.
It is possible to make very precise control of this lamp, for example by modifying its switch on according to the gear position.

II) PEDAL POSITION:

DETERMINATION OF THE NUMBER OF POTENTIOMETRES

The standard working uses one pedal potentiometer, but it is possible to define 2 potentiometers by means of the advanced functions:
As all the measures, the information of input can be calculated instead of being measured. This calculation can result from an information of the auxiliary CAN-BUS, but also from another measure.
In this particular case, we shall define both inputs of potentiometer as auxiliary measure. These two auxiliary measures will be the inputs of a map of module which will make the comparison of both tensions (one can be rising and the other descendant, with a ratio of unitarian tension or divided. The value of output of the module will then be injected as input of the pedal measure, and the error of correlation of input potentiometers will be used to activate the error pedals and throw of the algorithms of degraded operation.

PEDALE CALIBRATION

The ECU supplies a calibration of accelerator pedal position. This calibration allows the ECU to record the minimum and the maximum of the values of potentiometers (or of calculation if double potentiometer) and will allocate them from then on the angular position 0 and the angular position 1000, with a linear interpolation between these two values for the intermediate angles.

III) TICK OVER AND CUTOFF POSITION:

The ECU supplies a function of calibration of tick over, which allows to define three parameters:

- The angular opening of the pedal until which the ECU has to consider that it is in tick over position. The ECU calculates automatically a small hysteresis on this tick over position to avoid the oscillations of calculation.
- The tick over rpm, which is a target. This target of tick over is used by a PID of regulation of tick over rpm.
- The offset of rpm above the tick over rpm for the cutoff zone. This adjustable offset is normally 300 rpm, that is for a tick over rpm of 1000 rpm, the limit of cutoff zone will be at 1300 rpm. The ECU adds a not adjustable hysteresis of 100 rpm to avoid the oscillations of calculation.

IV) DECELERATION CUTOFF:

The deceleration cutoff is made when the pedal position is in the tick over zone (pedal position < = tick over position) and when the rpm is in cutoff zone (engine rpm = > tick over target + Cutoff offset).

JOLT SMOOTHING

To avoid the jolts at input and output cutoff, by movement of load (movement of accelerator pedal) or by movement of rpm, the fuel quantity is smoothed by a slope. This slope is given by a map inputs of which are the speed of accelerator pedal and the difference between the engine rpm and the tick over rpm target.

The input ' Difference between the engine rpm and the tick over rpm target' allows to put back all the fuel if the engine rpm approaches too much the tick over rpm target.

SEQUENTIAL GEARBOXES

The Commander software manages directly the sequential gearboxes.

I) NUMBER OF GEARS:

The number of gears can be chosen (up to 10 gears).
We can choose the name of the gears according to the information potentiometer of gear positions. It allows to indicate if the box is organized in automotive box (Reverse, neutral, 1st) or box motorcycle (1st, neutral, 2nd) or special.
The name of gears is important because it is it who is used in the calculations of gearbox and the advanced calculations.

II) GEARSHIFT SWITCH:

The gear shift switch can be or
- logic: when it is put grounded, the ECU is informed about the gear shift, but only in the upshift direction.
- analog: of constraint gauge type, the switch gives a tension centered around 2.5 volts. If this tension passes below a minimum limit, or above a maximum limit, programmable by the motorist, the ECU is informed about the gear shifting and about the direction of the shift.
- calculated: as all the measures, the information of input can be calculated instead of being measured. This calculation can result from an information of the auxiliary CAN-BUS, but also from another measure. In this particular case, it is possible to define as switch the speed of the accelerator pedal, and to declare for example that we gear shift when we quickly raise the foot.

III) COMMON TUNING TO ALL THE GEARS:

We configure three common values to all the gears:
- Minimum engine rpm: it is the rpm below which the ECU does not intervene on the engine management. The tuning of the limit of rpm is different for the upshift and the downshift.
- Minimum pedal position: as for the rpm, the ECU does not agree to intervene on the engine management below a certain programmable accelerator pedal position. The tuning of the limit of pedal is different for the upshift and the downshift.
- Wait before new gear: after a gear shift, the ECU refuses a new gear shift during a programmable time. It avoids intervening involuntarily a second time if the pilot keeps the hand on the gear lever.

IV) SPECIFIC TUNING BY GEAR:

CALIBRATION OF THE GEAR POSITIONS

We indicate to the ECU the position of the various gears according to the tension of the potentiometer of measure of position of the gearbox: for every gear, we give to the ECU a range of tension (or of calculated value if we have defined the input gearbox positions on a calculation) surrounding the value supplied by this potentiometer.
The tensions of the potentiometer must be rising.

The ECU supplies a function of automatic calibration of gears. Once this function launched, it is enough to shift all the gears. The ECU calculates then the range of tensions of potentiometer corresponding to every gear.

INTERVENTIONS DURING THE GEAR SHIFT

The upshift and the downshift have different regulations.

Two maps allow for every gear to adjust different the time of intervention, one for upshifts and one for downshifts.
The second input of these map is selectable by the motorist, to be able to modify the time of intervention according to another parameter: for example, modify the time of intervention of the gear according to the rpm or the engine torque, …

The intervention is launched as soon as the ECU receives from the switch the gear shift signal, if the rpm and the pedal are above the calibrated limits and if the waiting time before new gear is exceeded, and lasts as long as the defined intervention time for this gear is not elapsed.
The upshift and the downshift have different tuning of intervention.
For the upshift as for the downshift, the type of intervention on gear shift is a modification of the injected quantity: the motorist will define in the map of modification of injection the fuel quantity to inject, according to the parameters which interest him.
He will also define the slope (the speed) with which we return to the normal injection at the end of intervention in the map of slope of injection, according to the parameters which interest him.
This allows to limit jolts during the gear shifting.

V) ROBOTIZED BOXES:

The wait before new gear also serves for programming the robotized boxes, that is the boxes for which yew needs to maintain the intervention hanging all the time when the switch is pushed (the time of programmable intervention does not then serve).
To inform the Commander that the box is of this type, the wait before new gear must be simply set to 0.
The ECU adds systematically a blanking time of 10 milliseconds to avoid bounces on the switch of the robotized boxes.

CONTROL OF OPERATION

I) BREAKDOWNS DIAGNOSTIC:

The commander makes a permanent analysis of the working of the system and the sensors, and remembers their defects, even past.

1) System diagnostic:

Diagnostic system is permanently displayed by the Winjall software below the name of the ECU. It gives the defects such as watch-dog resets, problems of risks or losses of data application on heavy loss of power supply (or not of 30), …

A function of Winjall allows to set back to zero diagnostic system.

2) Diagnose application:

Two functions coexist: a function of display of application diagnostic, and a function of reset to zero of this diagnostic.

Application diagnostic consists essentially in the recording of the defects of the sensors and\or the channels of measures of these sensors in the ECU.

The recorded defects can be

- black out: permanent,
- short circuit: permanent,
- occasional black out: black out appeared once then disappeared,
- occasional short circuit: short circuit appeared once then disappeared,
- hardware cut: when the input of the measure is not a physical input of the ECU, for example received from the CAN-BUS, and when this measure is not received.

Furthermore, the ECU indicates if the breakdown is in progress, and thus the function is invalidated.

II) OVERSHOOTS RECORDING:

This function allows to record and to show values overshoots by recording exceeded values, overshoots number, durations of the extreme overshoot, and total times of overshoots.

The ECU Commander has 6 identical channels of recording of overshoot.

For every canal:

VALUE TO WATCH

The value to be watched is chosen in the list of the dozens measures and results of calculations known by the ECU (for example the engine rpm, the oil temperature, the speed of rise in engine temperature).

In the values to be watched, you also find the variables of pilot modules (see advanced operation).

The second condition to launch the recording can be added to obtain more elaborated recordings: for example, record the falls of oil pressure when the engine rpm is higher than 1500 rpm.

One chosen the level limits that the value has to overtake to launch the recording by adjusting the map of recording control.

This map with hysteresis (see advanced operation) allows to define the start up and the stop of the recording according to the value of the variable to be watched and of the 2nd condition variable (if desired).

With this map, it is possible to make logical combinations of type ' and ', 'now', 'nor', ' nand ', …

RESULT OF RECORDING

A function of the Winjall software gives the results of the overshoot recording:

- the extreme value reached by the variable to be watched, and the direction of the monitoring (overshoot downward, or overshoot upward),
- the number of times when the variable exceeded the limit,
- the duration of the overshoot for the reached extreme value,
- the total duration of the value overshoots.

VISUAL ALARMS

It is possible to switch on alarms on the condition of overshoot.
The functions of visual alarm 'Light of immediate alarm' and 'Light of cumulative alarm' allow to switch on and to switch off the alarm light of the ECU, following different modes.
As there are 6 channels of recording of overshoot for a single alarm, the alarm will remain switched on as long as a canal of recording asks for it, even if the others do not ask for it.

1) Immediate alarm:

The immediate alarm lights when the value exceeds the allowed limit, that is when the recording is launched, and goes out as soon as the value returns in the allowed limits, that is when the recording stops.
We can add a waiting time before the alarm lights, to prevent for example that the alarm switch on if the defect is very short, or to not perturb the driver for a too temporary defect.

2) Cumulative alarm:

The cumulative alarm lights when the value exceeds the allowed limit and when the total time of overshoot overtakes the programmed 'time before alarm'.
It goes out when the defect disappeared since much longer that the asked 'time before alarm reset', if the number of defect did not exceed the programmed 'number of overshoots forbidding the extinction of the alarm'.
If the number of overshoot reaches this limit, the alarm will not go out any more before we made a reset to zero with the Winjall software.

ADVANCED OPERATION

The commander has three advanced very powerful, programmable types of commands, which can be combined to realize completely new functions.
Furthermore, the auxiliary channels of measure can directly use inputs not used by the type of application chosen (with or without turbo, sequential gearbox, fuel high pressure).
Finally, it is possible to send or to receive information by the auxiliary CAN and to use the information received in the advanced calculations.

The use of these advanced functions and the development of specific strategies does not require either the learning or the knowledge of a programming language.
Their programming uses a specific technique developed by Skynam called **SKYMCOD ™** mapped, intuitive and effective **Programming**.
SKYMCOD corresponds to a way of thinking natural.

A very didactic file 'ADVANCED OPERATION' explains and comments in detail on the use of these functions and gives it of numerous examples.

I) CONFIGURATION OF THE ECU:

The ECU can be configured to make pre programmed tasks, as management of one or several turbos, electric motor of positioning (example variable geometry turbos), fuel pressure, …
To use these additional functions, it is generally necessary to use two functions:

- the parameterisation of inputs
- the configuration of the outputs

For example, to use a motorized throttle, it is necessary to:
- declare that the throttle position measure exists by allocating it an input of the ECU (physical input, or by CAN or calculated) in the function of parameterisation of the inputs
- configure an auxiliary output to electric throttle management.

II) AUXILIARY MEASURES:

They are measures not used by the chosen type of application and set at the disposal of the motorist to add analog or resistive sensors or switches, or measures of speed, to use them as active parts of the advanced functions or as simple display information.
They can be used as inputs of pilot modules, auxiliary or complementary commands, or as inputs of doubling or tripling of measure (two potentiometers accelerator pedal or positioning electric motor, three measures of intake pressure).

For example, no input speed is used in the standard calculations, but the ECU has 4 measures of wheel speed, 3 measures of speed turbo, …
If we need to make a management of anti skating, it is simply enough to activate wheels speeds by allocating to them channels of inputs (physical input or CAN), and to make the necessary comparative calculations with pilot modules to manage an additional degradation of phase or injection quantity …

III) PARAMETERISATION OF INPUTS:

Every measure of the ECU (pressure, pedal, speed) can be allocated to one of the physical inputs of the ECU, or has a value received from an external Skynam sensor by the CAN WinjNet, or to a calculated value, including the frames of the auxiliary CAN-BUS.
So, it is possible
- to add measures when all the physical inputs are used,
- to change physical input for a fast repair if an used input is damaged and that there are free inputs (naturally with changing the pin of the ECU connector).
- to use special sensors, for example measure of NOx sensor supplying its values by CAN-BUS, measure of turbo speed outputing an analog tension function of the speed.
- to make calculations on several inputs before converting the result of these calculations in the chosen measure (example: several potentiometers pedal inputs or electric throttle, several pressure sensors).
To do it, Winjall supplies a function of configuration of the inputs from which we can choose as every measure:
- the canal of input by which it will be informed
- the type of release of error to be used (standard or calculated by an advanced function)
- the type of error replacement to be used (standard or calculated by an advanced function)

The advanced calculations are described below in pilot modules.

IV) DIGITAL FILTERING OF THE MEASURES:

Every measure of the ECU (pressure, pedal, speed, auxiliary measures) has a filtering calculation by weighted average, the weight being given by a map.
Weighted average = (the previous one average + current measure) / (coefficient of weight + 1).

STATIC MEASURES
For the static measures (pressures, pedal), one of the inputs of this map depends on the signed difference between the measured value and the average (value – average), allowing a first adaptation of the average to the movement of the measure.
Other input, selectable input by the motorist uses generally advanced calculations for a higher adaptability of the coefficients of weight.
The adaptive filtering so realized allows shorter response times in case of real movement of the measure.

MEASURES OF SPEEDS
For the measures of speed, one of the inputs of this map depends on the signed relative difference between the measured value and the average ((value - average) / average), allowing a first adaptation of the average to the movement of the measure.
Other input, selectable input by the motorist uses generally advanced calculations for a higher adaptability of the coefficients of weight.
The adaptive filtering so realized allows shorter response times in case of real movement of the measure.

MEASURE OF ENGINE RPM
The average rpm is calculated in a way adapted to the state of the actual engine rpm.
During the very low rpms, the measure is made tooth by tooth.
Then, it is made on a portion of engine cycle calculated according to the number of cylinders of the engine.

V) STRATEGIES OF MEASURE FAILURES:

For every measure of the ECU (pressure, pedal, speed), it is possible to define a strategy of detection of failure, a strategy of replacement value in case of failure, or to use the standard strategies supplied by the ECU.

STATIC MEASURES

The standard strategies of detection of failure consist in verifying that the value of input of the measure is in a range defined according to the type of input:

- analog sensor 0-5 volts: the value of input does not have to come down below 125 millivolts or rise above 4950 mv, that is the case of all the standard automotive sensors.
- resistive sensor (CTN-CTP): the value of input does not have to come down below 25 millivolts or rise above 4900 mv, that is the case of all the standard automotive sensors.
- calculated sensors: no standard check

The standard strategies of replacement consist in supplying a fixed value dependent on the measure itself:

- The engine temperature takes the value +80°C
- The intake temperature takes the value +20°C
- The richness takes the value 0 (null richness)
- The atmospheric pressure takes the value 1013 mbars
- The intake pressure takes the maximal value allowed by the map of conversion of pressure sensor, as if the sensor delivered 5000 millivolts, to enrich the engine at most.
- Pedal and position electric motor take the value angle 0
- …

MEASURES OF SPEED

For the measures of speed (turbos, wheels) a configurable strategy very elaborated by correlation analysis of speed and of acceleration is supplied.
These strategies are for example capable of tracking down a sensor breakage on one wheel speed from 2.5 km/h or a turbo from 5000 rpm.

SPECIFIC STRATEGIES

If for one or several inputs the motorist decides to program its own strategies of replacement of error or breakdown detection, it is necessary:

- for the replacement value to indicate which pilot module will supply the replacement value. He can so elaborate complex procedures, result of a complete chain of calculations, as for example to estimate an out of order intake pressure according to a turbo rpm and an engine rpm and …
- for the detection of error trigger he also has to define the variable which will serve to trigger the error, and the value range of this variable outside which the error is activated. The ECU also supplies error states for some variables, as for example for the values received from the auxiliary CAN-BUS, when a frame is not received in the selected timeouts. For example, for an input calculated on this CAN value, the variable to trigger the error can be the state of error reception.

Furthermore, every measure possesses a correlated variable of error state so that the motorist can activate also calculations when a measure passes in error. For example, to estimate the engine temperature from the past and from the load engine after the last valid temperature measure.

VI) MAP COMPLETELY PROGRAMMABLE:

The maps used in the advanced functions are completely programmable:

1) variables of input of the map:

We can choose the number of input variables of map and thus the number of axes of calculation: either two, or one, or none.

We can choose what will be these variables in the list of the dozens of measures and results of calculations known by the ECU (for example the engine rpm, the used gear position, the speed of rise in engine temperature, the error state of a measure).

2) type of map interpolation:

We can also choose the way the calculation of interpolation will be made for every axis of map (the interpolation of lines can be different from that of the columns):

- standard interpolation with stop at the endpoints of scales,
- interpolation with continuation (extrapolation out of the endpoints of scales),
- without interpolation with truncated input (stairs downward),
- without interpolation with raised input (stairs upward),
- without interpolation, in hysteresis, for the maps with calculation of state.

VII) PILOT MODULES:

They are programmable modules of calculation allowing to develop specific strategies.

These modules are capable of piloting the auxiliary commands, the complementary commands and the maps with selectable inputs, and thus of intervening in all the domains of management of the ECU.

There are 24 identical pilot modules which can be chained.

A pilot module is constituted

- of a completely programmable map (we can choose its variables of input and its types of interpolation),
- of a variable called 'Pilot variable' the value of which is the result of the last calculation of the pilot module.

In the ECU, the calculations on pilot modules are made every 10 milliseconds (100 Hz) sequentially, by beginning with the module 1, then the module 2, then, up to the last module.

During the 10 milliseconds which follow, the Pilot variable of every module contains the result of this calculation.

We can make recursive calculations, that is the variable of input of the map of the module can be its own Pilot variable in which is then stored the new result of the calculation in the module.

TYPES OF CALCULATION

There are 6+1 types of possible calculations in a module:

- not enabled module
- calculation of coordinated
- calculation of average
- calculation of differential
- calculation of integral
- temporal calculation
- calculation of signed division

1) Coordinate calculation:

The value of the pilot variable is a quantity or a signed position, a direct result of the calculation of the map of this module.

2) Calculation of average:

The value of the pilot variable is the average of another variable.
This other variable is the variable of input of the vertical scale of the map of the module.
The calculation of average is a weighted average, in which the result of the calculation of the map of the module is the coefficient allocated to the previous average:
New average = [(former average * coefficient) + new variable value] / (coefficient + 1)

3) Differential calculation:

The value of the pilot variable is the differential or the speed of another variable.
This other variable is the variable of input of the vertical scale of the map of the module.
The map indicates the temporal distance in seconds used for the calculation of speed.
The temporal distance can go from 10 milliseconds to 10 seconds.
The calculation of speed is moving, that is if we ask for a speed over one second, we shall have every 10 milliseconds the speed of the value over the last second.

4) Integral calculation:

In every calculation (every 10 milliseconds), the direct result of the calculation of the map of this module is added (signed addition) to the previous value of this module:
Pilot variable = former pilot variable value + map calculation result.

5) Temporal calculation:

The temporal calculation uses an internal counter (not visible) which is set to 0 at the beginning of the count.
Every 10 milliseconds, this counter is increased by 1.
The result of the calculation on the map is the value which the counter has reached, expressed in seconds, so that the count is finished.
The value of the pilot variable is the remaining time before the count is finished.
When the count exceeds or reaches the target fixed by the map, the count is ended, and the value of the pilot variable of the module is thus set to 0.

6) Calculation of signed division:

The value of the pilot variable is a quantity or a signed position, a direct result of the calculation of the division of the variable of vertical input by the variable of horizontal input of the map of the module (the calculation is made every 10 milliseconds in the ECU).
Indeed, if it is easy to implement the 3 other basic operations (addition, subtraction and multiplication) with a map calculation, it is much more complicated to make a division. Pilot modules thus have directly this supplementary function.
In this signed calculation of division, the map serves for giving the precision of the calculation of division, that is the power of 10 with which the result is going to be given.

INITIALIZATION OF THE CALCULATIONS

The way of initialize modules at the start up of the ECU is chosen by the motorist:
Three types of initializations are possible in the calculations of modules:

- automatic initialization, fixed by the ECU,
- initialization by chosen fixed value,
- initialization by the value of the module remembered at the last extinction of the ECU, to continue the calculations from a session of ECU working to the other one.

VIII) AUXILIARY PID:

The auxiliary PID are organs of control allowing to make looped closed regulation by a process freely selected by the motorist.
Every auxiliary PID is a module of calculation of regulation with an input (the variable on which is made the looping), and an output: the value of command of the PID.

An auxiliary PID allows 3 simultaneous actions on the error between the target (the desired position) and the measure (the obtained position) of the value of looping:

1) a action proportional with the target (or wished position):

It is a not signed value between 0 and 1 (0.000000 and 1.000000): it gives the base of the command of the PID.

2) a differential action following the error of position:

The error of position is the difference between obtained position and wished position.
The differential value is a signed value between -1 and +1: it gives the immediate modification of the base of the command.
As its value goes from -1 to + 1 and as the base goes from 0 to 1, it can completely invert the direction of the command.
At every position measure of looping, we compare the position and the target and we get (by the map of differential) a signed value.
This value is generally positive if the position is too low with regard to the target, (in that case, we want to give more force with the command) and negative should the opposite occur.
The Differential Value can be considered as successive hammerings which are going to force the commanded device to go to the wished target.
The more we are far from the target, the more the knocks must be strong.

3) an integral action also following the error of position:

It is a signed value between -1 and +1: it gives the modification accumulated by the base of the command:
At first the accumulation 'Integral value ' is 0.
At every position measure of looping, we compare the position and the target and we get a signed value 'Integral increment'.
This value is generally positive too if the position is too low with regard to the target, (in that case, we want to give more force with the command) and negative should the opposite occur.
The Integral increment calculated is added all the milliseconds to the accumulation 'Integral value'.
The Integral value can be considered as a continuous push which is going to force the commanded device to go to the wished target, or to avoid the overshoots of position in the opening or in the closure.
The more we are far from the target, the more the push will become strong quickly, but a too strong push will exceed the target before beginning to be reversed.
We can also consider this integral value as fine correction of the command. Indeed, the values of Integral increment in the map are generally very small, because they are added to the accumulation 'Integral value' all the milliseconds.

CHARACTERISTICS OF THE AUXILIARY PID

The proportional and the integral can be set to null in function of criteria selected by the motorist.
The integral can be frozen, limited to a range of selected values, or reset and maintained to zero in function of criteria selected by the motorist.

The final command of the PID is the sum of the result of the calculation of these three parts.
The value of command of the auxiliary PID is given in standardized value between 0.000000 and 1.000000
It is also necessary to give to the ECU a means to make the command of the PID, for example one of the auxiliary outputs of the ECU which will command an actuator of the engine, or a complementary command if we want to insert a regulation into one of the standard calculations of Commander (modification of injected quantity, modification target of turbo, …).
It is possible to regulate the totality of the commands of the ECU, for example the injected quantity to limit the engine acceleration in certain phases of working of the vehicle.
The PID would then be based on the engine acceleration and would control the injected quantity through the complementary command of modification of injected quantity.

ACTIVATION OF THE AUXILIARY PID

So that an auxiliary PID is activated, it is enough to indicate to the ECU on which value of looping the PID has to work. This value of looping is freely chosen by the motorist.

TARGET

It is given by a completely programmable map, and the values of input of its scales can be freely chosen by the motorist in all the list of the calculations known by the ECU and thus the target can be freely determined.

PROPORTIONAL

It is given by a map among which a scale is fixed, the scale of lines, which is the value of target (desired value).
The other scale, that of the columns, is selectable by the motorist, allowing to work more finely on the proportional value.
This scale also allows to choose conditions in which the proportional will be annulled. The use of pilot modules will allow to calculate complex conditions of cancellation of proportional.

DIFFERENTIAL

It is given by a map among which a scale is fixed, the scale of lines, which is the error of position, given the difference between target (desired value) and value of looping (measured value). That is that if the position is higher than the target, the error is positive, and inversely.
The other scale, that of the columns, is selectable by the motorist, allowing to work more finely on the differential value.
This scale also allows to choose conditions in which the differential will be annulled. The use of pilot modules will allow to calculate complex conditions of cancellation of differential.

INTEGRAL

The value of integral is signed (it can remove as well as add to the command of the process).
At first, or at the exit of reset (see map of integral reset lower), the integral value is set to 0.
All the milliseconds, the result of the map integral increment is added (signed) to the integral value.

1) integral increment:

The map Integral increment is based on the error between the given target and the obtained position.
It thus has a fixed scale, the scale of lines, which is the error of position (difference between target and value of looping).
The other scale, that of the columns is selectable by the motorist.
The scale of the selectable columns allows to choose conditions in which the integral increment will be annulled, freezing the integral value on its position. The use of pilot modules will allow to calculate complex conditions of frost of the integral.

2) integral reset:

The auxiliary PID module possesses a map scales of which are selectable to set back the integral to 0.
The motorist can thus completely choose the conditions of reset and hold to 0 of the integral.
In this map, two values are possible:

- 'let': the calculation of the integral is allowed
- 'reset': the calculation of the complete is forbidden and the integral is forced to 0.

As in most part of the state maps, we can use the mode of interpolation with hysteresis to avoid the oscillations of permission at the passage of thresholds.

Integral reset is often used to prevent the integral from working in certain programmable conditions.
For example, for the management of the turbo pressure (PID already existing in the ECU), the complete is held 0 if the throttle position is too low, or if the speed of the target of turbo pressure is too high.
We put reset the integral to 0 generally when it is not capable of making a significant calculation, or when the correction which it can make is too slow or unwanted.
The use of pilot modules will allow to calculate complex conditions of reset to zero of the integral.
3) automatic integral limitation:
In a internal way, the integral cannot exceed a value bringing the PID to a final value of command lower than 0.000000 or higher than 1.000000
For example, if base+différential of the PID gives a value 0.250000, the value of integral cannot exceed -0.250000 downward or +0.750000 upward.
It is necessary because if in this example the integral could come down to -1, what is anyway useless because the final result of the PID stops at 0, and that this result of the PID suddenly had to increase, the integral would loose a precious time to hand on from -1 to -0.25 before the increase can be realized.
4) programmable integral limitation:
The auxiliary PID module also possesses two adjustable parameters to limit the value of the integral. A parameter limits the integral downward and one limits it upward.
It can be useful in numerous cases to limit the action of a PID, because the integral is not controlled in itself by the maps, but rather its quickness of reaction: the map of management of the integral is not a value of integral but a value of increment of the integral.
It is as well possible to prevent the integral to add to the command (or remove) by setting one of the limits to 0.
For example, if we want to manage a decrease of injected quantity to calm an engine in certain circumstances, by giving a target of maximal acceleration, the integral should not increase the quantity if the engine acceleration is lower than the maximal acceleration given by the target.

IX) COMPLEMENTARY COMMANDS:

These commands allow to intercept and to modify at will all the targets of the ECU.
It allows to insert calculations not foreseen in the original working of the ECU:

- modification of maximum torque quantity
- modification of anti friction quantity
- modification of driver demand quantity
- modification of smoke limitation
- demand of protection engine torque
- stop richness correction
- modification of richness target
- modification of pilot 1 injection quantity
- modification of pilot 2 injection quantity
- modification of post injection 1 quantity
- modification of main injection phase
- modification of pilot 1 injection phase
- modification of pilot 2 injection phase
- modification of post injection 1 phase
- modification of tick over rpm target
- modification of rpm limiter
- modification of fuel pressure target
- modification of turbo pressure 1A and 1B target

- modification of turbo rpm 1A and 1B target
- modification of turbo pressure 2 target
- modification of turbo rpm 2 target
- stop pre-post heating
- ban DPF regenerations

The complementary commands are based on completely programmable maps. We can choose the variables of inputs of scales, including the variables of pilot modules, and the type of interpolation to be used.
It means that a long chain of calculations can modify the original working of the ECU.
If no input is selected for one of these maps, it is not used in the calculations (its value is forced to a neutral value).

X) AUXILIARY COMMANDS:

The Commander possesses 14 auxiliary outputs (others than injection).
They wear numbers, 1, 2, 3A, 3B, 4A, 4B, 5, 6, 7, 8, 9, 10 and 11 (plus a LED command not numbered).
These auxiliary commands, when they are not fixed as for the command of fuel high pressure, the positioning electric motor or the other options forced by the chosen type of application, possess a possibility of programming: they can be controled by completely programmable maps, including by calculations of pilot modules or auxiliary PID.

TWIN OUTPUTS

4 of these outputs can be coupled 2 by 2. We call them twin outputs: they are the outputs 3A and 3B, 4A and 4B.
When they are declared coupled, 2 outputs A and B are controled by the command A, but the state of the output B is the opposite of the output A.
- If the output A outputs of the ground, the output B is in opened drain (or 12 volts if push-pull).
- If the output A is in opened drain (or 12 volts if push-pull), the output B outputs the ground.

The coupled outputs 3 possess in more an option of electric control, by open drain or push-pull.
These outputs have to be the outputs used to manage an electric motor of positioning.

PROGRAMMABLE OPERATIONS

To the various types of outputs corresponds various possibilities of working.
Four types of programmable outputs are:

- command ON-OFF,
- command PWM (from 10 to 10000 Hz), and PWM software (from 10 to 1000 Hz)
- angular command,
- synchronous command.

1) Command ON-OFF:

The output works as a relay controled by a completely programmable map.
The output being ON-OFF, it is very recommended to use the mode hysteresis in the map of control of this output.

2) Command PWM:

This type is to be selected when we want that the output to be a PWM the cyclic report of which we can choose by a completely programmable map.
One chosen also the frequency of the PWM, 10 Hz to 10000 Hz, or 10 Hz to 1000 Hz for the PWM software and if we want that the first part of every cycle is passive or active.

3) Angular command:
An angular command is a square signal the period of which is the engine cycle and the cyclical ratio of which is flexible.
As the period of the engine cycle varies according to the rpm, the frequency of crenels also varies.
The cyclical ratio is controled by a completely programmable map.
We chosen also the number of crenels in the engine cycle, and if we want that the first part of every cycle is passive or active.
The engine cycle is divided into equal parts between crenels. That is if we chosen 4 crenellations, each shall make 720°/4 = 180°
The start of the angular command is not specially phased: all that we know, it is the number of crenels to be made during the engine cycle, and the cyclical report in the crenel

4) Synchronous command:
A synchronous command is an angular command (see above) the phase of the beginning of the crenel of which we can choose. The phase of the first crenel, or the angular position of beginning of the crenel, is chosen by the second completely programmable map. The other crenels of cycles (if they exist) follow then, regularly phased in the cycle.

OPTIONS OF THE OUTPUTS

Output	Base electric command	Option	pin connect.	Intensity	Maxi (1 millisecond)
1	push-pull 12v weak power	no	10	50mA	200mA
2	open drain (ground)	no	37	4A	10A
3A	open drain (ground)	push-pull	34	2.5A	10A
3B	open drain (ground)	push-pull	33	2.5A	10A
4A	open drain (ground)	no	6	4A	10A
4B	open drain (ground)	no	5	4A	10A
5	open drain (ground)	no	3	4A	10A
6	open drain (ground)	no	7	4A	10A
7	open drain (ground)	no	35	4A	10A
8	open drain (ground)	no	4	4A	10A
9	open drain (ground)	no	9	4A	10A
10	open drain (ground)	no	36	4A	10A
11	open drain (ground)	no	8	125mA	500mA
LED	push-pull 5v weak power	no	38	10mA	10mA

Nonstop acceptable total intensity 15 amperes

FUNCTIONS OF THE OUTPUTS

OUTPUTS		1	2	3A	3B	4A	4B	5	6	7	8	9	10	11
On-Off	fixed	X	X	X	X	X	X	X	X	X	X	X	X	X
	programmable	X	X	X	X	X	X	X	X	X	X	X	X	X
	positif twin programmable			X		X								
	négatif twin programmable				X		X							
	pre heating									X				
	FISA low pressure fuel pump													X
PWM	programmable		X	X		X		X			X	X	X	X
	software programmable						X		X	X				
	positif twin programmable			X		X								
	négatif twinprogrammable				X		X							
	turbo 1A		X											
	loop VGT turbo 1A		X											
	turbo 1B											X		
	loop VGT turbo 1B											X		
	turbo 2												X	
	loop VGT turbo 2												X	
	fuel pressure by rail leak							X						
	fuel pressure by pump flow								X					
	pre heating									X				
	loop positive VGT turbo 1A			X										
	loop negative VGT turbo 1A				X									
	loop positive VGT turbo 1B			X										
	loop negative VGT turbo 1B				X									
	loop positive VGT turbo 2			X										
	loop negative VGT turbo 2				X									
	positive positionning electric motor			X										
	negative positionning electric motor				X									
	positve proportionnal electrovalve			X		X								
	negative proportionnal electrovalve				X		X							
Angular	programmable	X				X								
	rev counter	X												
Synchronous	programmable						X			X				

The outputs 4A and 4B are general outputs, to which no specific function of engine management is attributed. They allow two separate or coupled PWM, or synchronous or angular commands.

Note: Skynam can supply

- 20 amperes electronic relays to control devices requiring for more power than can carry the outputs or if the acceptable total power is exceeded.
- relays of transformation of command by the ground to Push-pull command in 12 volts.
- relays of transformation of command by the ground to H Bridge command in 12 volts.
- relays with current control (switched current) with tunable current level.

XI) AUXILIARY CAN-BUS:

It is possible to ask the Commander to get or to send data on the auxiliary CAN-BUS.
The Commander uses this auxiliary CAN-BUS in the standard 2.0B (11 bits or 29 bits identifiers with the choice for every frame).
We select the speed of transmission of this CAN of 125 Kbits in 1 Mbit.
In the race software, a 5th type 'Injall', asks the ECU to generate automatically the frames of information necessary for the compatible dashboards with the previous ECUs Sybele, as for example dashboards AIM.

The communication by CAN is made by means of frames. They are the units of transmission, as a sentence in a text.
Frames transport the information to be exchanged between the various devices connected together.
This information is the data of the frame, as the words are the constituents of the sentences.
For every frame to be sent or to received, we supply its 11 bits or 29 bits identifier.
The frames data are constituted of 8 bytes which are grouped in 4 successive 16-bit values (LSB then MSB = little Endian) for the standard frames, or distributed at will for the specific frames.

DATA RECEPTION

1) Storage of the data:
To receive the data of the frames of the auxiliary CAN, the Commander has 16 specific variables called 'AuxCan variables '.
Each of these variables can be allocated to one or several bytes of data of the frames of reception and be then used in the advanced calculations (pilot modules, complementary commands and auxiliary commands).
2) Initialization of the data:
Every AuxCan variable can be initialized with a value chosen to fix its value at the start up of the ECU, before the reception of the first frame which corresponds to it.
3) Error of reception of the data:
An interval of maximum time between two receptions can be defined for every frame. If this interval of time is exceeded, the corresponding AuxCan variables are loaded with their value of error (identical to the value of initialization), and correlated error variables AuxCan are positioned in the state 'Error'.
This temporal control of error can also be deactivated frame by frame.

DATA TRANSMISSION

We can supply to the system of external data recording or to the original electronics of the vehicle the information which they need, as for example the engine torque and other for the automated gearboxes.
1) Frequency of transmission:
For every frame, we select the period of transmission between 10 milliseconds (100 Hz) and 10 seconds.
2) Choice of the data:
Each of 8 bytes of data (distributed in 4 16-bit variables for the standard frames) of the frame to be emitted can have a fixed value or be positioned to the value of a variable chosen in the list of the

dozens measures and results of calculations known by the ECU, including the AuxCan variables themselves.

XII) SOME EXAMPLES OF USE OF THE ADVANCED FUNCTIONS:

Among others, these advanced functions allow the motorist to implement:

- countings of time or events,
- sophisticated procedures of breakdowns monitoring and intervention, for example engine gradual cutoff on drop of oil pressure, …
- commands type of injection of additive or injection of water,
- controlling of speed regulated by electric motors
- regulations on the engine itself, type post injection or additional injection, or regulations on external devices, as the regulation of intake flaps, or others.
- modifications of original operating if necessary, for example rpm limiter or overboost pressure according to the position of gearbox,
- a limiter of speed, or another type of launch limiter according to the vehicle speed received from the auxiliary CAN or directly calculated by the Commander.
- …