General presentation of Challenger7

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Machine management

General presentation of Challenger7

TECHNICAL CHARACTERISTICS
- SUMMARIZE-

The Challenger7 is an engine management ECU and has a very high computing power, configurable inputs and outputs, allowing a very flexible and effective use.
It is specifically made for racing atmospheric and turbocharged engines 4, 6, 8 or 12-cylinder engines.

This ECU has been developed to directly replace the old Challenger4+ that can no longer be repaired (cannot be found anymore its electronic components) or maintained.
The replacement of the Challenger4+ by the Challenger7 is done without change in the loom of the ECU (or very little and simply), and, thanks to the power of the microprocessor and to the improvement of calculations, gives breathtaking engine acceleration compared to the ones you had with the Challenger4+.

ELECTRICAL CHARACTERISTICS
Power supply from 5,5 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: 50 milliamperes maximum,

TEMPERATURE CHARACTERISTICS
In operation, -40°C to 85°C.

COMMUNICATIONS
High speed serial interface (1 Mbits) on USB base for the engines tuning.
Auxiliary CAN-BUS 2.0B standard, speed of transmission 1 Mbits, for dashboard or third party data recording information.

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. The number of cylinders can be 4, 6, 8, 12.
The angular distribution of cylinders must be regular (for example 180° for a 4-cylinder).

ANALOG CONVERTIONS INPUTS
- internal input measure of power supply tension.
- rotator of race configuration (selection of launch limiter type or inhibits it),
- switch of gear shifting configurable logical or analog,
- gear position measurement potentiometer,
- calibrable throttle position,
- calibrable pedal position,
- intake pressure,
- atmospheric or dynamic pressure,
- engine temperature,
- intake temperature,
- wideband Lambda meter (or 0-1 volt differential Lambda sensor),

Note that, like on the Challenger4, the Accelerator pedal position and the Gear position measurements cannot be activated together because they share the same ECU input.
So, if the motorized throttle is activated (it uses the pedal position), there cannot be a gear position measurement and if you need to manage the gearbox, the ECU will manage it in a special mode.

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 flywheel, programmable inductive – Hall,
- 1 measure of phase on camshaft programmable inductive – Hall,

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.

INPUTS DIGITAL FILTERING

Every measure of the ECU has a programmable digital filtering.

FAULTS STRATEGIES

For every measure of the ECU (pressure, throttle, …), 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

- throttle / rpm,
- pressure / rpm (with or without turbo),

INJECTION

2 channels with saturated command (ON-OFF),

- for the Peak and Hold commands, or direct injection commands, it is necessary to add a Skynam specific device (example: Peak and Hold programmable in duration and intensity of the peak, and intensity of the hold).
Selectable types of injection:

- semi sequential (phase sensor not needed).

INJECTION RAILS

Injectors can be grouped in one or two rails.
Each injection rail possesses its own accelerating pump and its own injection phase.
Two types of double rail working are possible:

- rail 1 to 2: allows to move gradually from a rail to the other one. When we increase the rail 2, the rail 1 is decreased in the same way to compensate. Both rails can have different type of injectors, and thanks to the fuel flow coefficient between the two rails, the fuel quantity remains stable when moving from one to the other.
- rail 1 to 1+2: allows to add gradually the rail 2 to the rail 1. Configuration used to inject more fuel in the engine when we engage the rail 2. Both rails can have different types of injectors.

IGNITION

4 channels to command ignition power modules (the Challenger7 does not directly command the coils).
Types of selectable ignition

- distributed (simple or double distributor with possible advance shift between the two distributors),
- twin spark (phase sensor not needed),
- static (phase sensor needed).

FUEL PUMP

Managed in the standards FISA regulation:

- runs 5 seconds at ECU switch on and stops if the engine does not run,
- runs as soon as the engine starts,
- Stops as soon as the engine stops.

AUXILIARY COMMANDS

5 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)

Types of control:

- 2 programmable push-pull or open drain commands,
- 2 open drain commands,
- 1 push-pull (weak power) 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 pressure management,
- fly by wire,
- camshaft proportional shifting by PWM command,
- proportional electrovalve two wires (standard closed by spring) or three wires (opening and closure electrically piloted).
- shift light,
- alarm defects,
- rpm relay,

- temperature relay,
- 3-state rpm relay,
- rev-counter,
- programmable type by the motorist.

TURBO

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.
Supplementary management of back-pressure waste gates,
Post combustion (bang-bang).

CAMSHAFTS

The Challenger7 ECU can manage the proportional positioning of one camshafts.
The command of the camshaft is done by the management of a unique pneumatic leak electrovalve.

RPM LIMITER

On injection, ignition or both.
3 Configurable launch limiters, selectable by a rotary switch on the vehicle board,
Configurable race limiter.
Cutoff made on turning cylinder (always begin with a different cylinder).

DECELERATION CUTOFF

On injection, ignition or both, or no cutoff.

SEQUENTIAL GEARBOX

Up to 10 gears the organization of which is selectable (in automotive or motorcycle or special mode).
Gearshift switch can be logical (by grounding) or analog (by programmable tension level)
The time of intervention is adjustable by map, for each gear and according to the engine rpm.
The type of intervention on gearshift is programmable:

- ignition cutoff
- modification of the ignition with slope on go back to normal (by maps with selectable inputs)

These types of intervention can be combined.

TRACTION CONTROL

Traction control helps prevent spinning of the drive wheels, which occurs most often when the torque at the wheel is important and/or wheel grip is too low.
To avoid the losses of grip the ECU has been equipped with a traction control operating by engine acceleration exceeding survey.
A map allows to define the maximum acceleration allowed to the engine, depending on the engine speed (so that the maximum acceleration can follow the engine torque curve) and on the engaged gear position.
A PID manages the cylinders cut-off depending on the level of exceeding of the maximum acceleration allowed.

SELF-LEARNING: ADVANCED HELP TO ENGINE TUNING

- The injection time base map is pre filled with values allowing an easy engine starting up. Furthermore, a complete function of self learning was added to it to boost and facilitate the tuning of the engine, based on the richness target map and the reading of the Lambda sensor.
- The base ignition advance map has values allowing an easy engine starting up, but must be specifically adapted to the engine by the motorist.

- All other maps of the ECU are pre filled with values allowing a good engine working in the majority of the cases, notably the maps of starting up enrichment and rising in temperature, of altimetric adaptation, …
- The PID of fly by wire management, the PID of turbo management and the PID of camshafts positioning management are also pre filled and most of the time require no or little supplementary adaptation.

ADVANCED FUNCTIONS

The Challenger7 offers the motorist the possibility to refine the functioning of the ECU.

1) Parameterization of the inputs of measures:

Each ECU measurement (pressure, throttle, temperature,...) can be calibrated to fit the sensor which is connected:

- Throttle potentiometer calibration is used to indicate the to ECU mini and maxi throttle potentiometer positions and allows to work in angles (graduated from 0 to 1000), not tension.
- Inputs pressure and temperature have a linearization map that transforms the voltage measured in physical value (°C, millibars,...) The ECU can therefore use any sensor, it is sufficient to provide appropriate transformation maps.

2) Filtering of the measures:

Every measure of the ECU (pressure, throttle, temperature, …) 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.

3) Strategies of defect of the measures:

For every measure of the ECU (pressure, throttle, temperature, …), 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.

4) 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 command any device in ON-OFF or PWM.

ECU LOOM

J35		FONCTION	COMMENTAIRE
1	OUT	IGNITION D	Vbat push-pull command - 4th ignited channel
2	OUT	IGNITION B	Vbat push-pull command - 2nd ignited channel
3	OUT	INJECTION A	Open drain ground command - 1st injected channel
4	IN	ENGINE TEMPERATURE MEASUREMENT	0-5 volts resistive input
5	OUT	FUEL PRESSURE PUMP	Open drain ground command
6	IN	RPM +	rpm sensor input on crankshaft
7	IN	PHASE+	Phase sensor input on camshaft
8	IN	ATMO OR INTAKE PRESSURE MEASUREMENT	0-5 volts analog input
9	CAN	CAN2_L	auxiliary CAN (external)
10	CAN	CAN2_H	auxiliary CAN (external)
11	OUT	INJECTION B	Open drain ground command - 2nd injected channel
12	OUT	AUXILIARY COMMAND 1	Open drain ground command
13	COM	TX	Emission for ECU tuning (WinjNet)
14	IN	LAMBDA - MEASUREMENT	0-5 volts differential input -
15	ALIM	PERMANENT SUPLLY +30	Permanent 12 volts power supply
16	MASSE IN	ENGINE POWER GROUND	Ground input for power commands
17	OUT	AUXILIARY COMMAND 5	Vbat push-pull command
18	OUT	AUXILIARY COMMAND 3	Open drain ground command
19	OUT	IGNITION C	Vbat push-pull command - 3rd ignited channel
20	OUT	IGNITION A	Vbat push-pull command - 1st ignited channel
21	MASSE IN	ENGINE POWER GROUND	Ground input for power commands
22	IN	INTAKE TEMPERATURE MEASUREMENT	0-5 volts resistive input
23	OUT	5V SENSORS SUPPLY	5 volts output for sensors supply
24	MASSE IN	ENGINE SUPPLY GROUND	Supply ground of the ECU
25	IN	RACE CONFIG SWITCH	0-5 volts resistive input
26	IN	PEDAL OR GEARBOX POSITION MEASUREMENT	0-5 volts analog input
27	IN	POWER SHIFT SWITCH	analog - resistive selectionnable input
28	IN	THROTTLE POSITION MEASUREMENT	0-5 volts analog input
29	MASSE OUT	SENSORS GROUND	Supply ground for sensors
30	OUT	DIAGNOSTIC LED	Diagnostic LED positive command
31	COM	RX	Reception for ECU tuning (WinjNet)
32	IN	LAMBDA + MEASUREMENT	0-5 volts differential input +
33	ALIM	AFTER KEY SUPPLY +15	After key 12 volts power supply
34	OUT	AUXILIARY COMMAND 2	Open drain ground command
35	OUT	AUXILIARY COMMAND 4	Open drain ground command

MODULES OF STANDARD CALCULATIONS
- ELEMENTS OF CALCULATION-

According to the chosen type of application, Challenger7 ECU uses or not the various modules of calculation.

Standard maps:
For the majority of the calculations, Skynam supplies preset maps, which do not need to be retouched. These maps are noted 'standard map' in the list of the calculations below.
In some cases, Skynam supplies a sets of standard maps to choose by the motorist, as for example for the sensors conversions (tension/physical value) or the various PID of command of regulation (motorized throttle, tick over electrovalve, overboost pressure).

Specific maps:
The motorist does not have more than to make the calibration of the engine really specific (injection time, ignition advance, the cylinders corrections, turbo pressure target).

Calculation of load:
The engine can be equipped with an intake pressure sensor, in that case, the calculations of loads will be made from the intake pressure measurement.
If the engine is only equipped with a throttle potentiometer, the calculations of loads will be made from the measure of throttle position.

IGNITION ADVANCE

Basic advance: map, on rpm / load, in 1/100 crankshaft degree relative to the TDC.
Cylinders correction: 1 map by cylinder, on rpm / load, in 1/100 degree, applied to basic advance.
Dynamics tick over advance: standard map, on engine temperature / rpm, in 5 decimals coefficient of advance modification by the difference between the average engine rpm and the immediate engine rpm. Calculation used to stabilize the tick over.
Engine temperature correction: simplified 3D standard map, on engine temperature / rpm / load, in 1/100 degree.
Intake temperature correction: simplified 3D standard map, on intake temperature / rpm / load, in 1/100 degree.
Atmospheric pressure or dynamic pressure correction: simplified 3D standard map, on atmospheric pressure / rpm / load, in 1/100 degree.
Cutoff advances smoothing: standard map, on engine rpm / throttle speed, in coefficient 5 decimals to smooth the advance modification in input and output of deceleration cutoff to limit jolts.

IGNITION COIL LOAD

Angle of coil load: map, on rpm / battery tension, in 1/100 degree. This map can be automatically calculated by Winjall by supplying load times according to the various battery power supply.

INJECTION

Basic injection time: map, on rpm / load, in microseconds (possibility display in crankshaft degrees)
Engine temperature correction: simplified 3D standard map, on engine temperature / rpm / load, in 5 decimals coefficient.
Intake temperature correction: simplified 3D standard map, on intake temperature / rpm / load, in 5 decimals coefficient.
Atmospheric pressure or dynamic pressure correction: simplified 3D standard map, on atmospheric pressure / rpm / load, in 5 decimals coefficient.
Permission of deceleration cutoff (inhibited during bang-bang if turbo): parameter, value: injection, ignition or both, or no cutoff.

INJECTORS CORRECTION

Injectors correction time: map, on battery tension, in microseconds. Allows to integrate into the electric command of injectors the fuel loss due to the (relative) slowness of injectors reaction.

INJECTION RAILS

Progressive distribution between rails: map with programmable inputs (choice by the motorist), in coefficient on the basic I.T. in 5 decimals. Working dependent on the type of 2nd rail, 1 to 2 or 1 to 1+2.

ENGINE ROTATION START

Engine start rpm limit: standard map, on engine temperature, giving the rpm from which the engine is considered as running by itself (end of cranking).
Modification of injection time: simplified 3D standard map, on engine temperature / rpm / number of round since rotation start, in 5 decimals coefficient on basic I.T.

ENGINE START (STARTER)

Post start enrichment: standard map, on engine temperature, applied to the basic I.T. in 5 decimals coefficient. This coefficient is fixed at the end of cranking phase and linearly decreased according to elapsed time at the speed of 100 % in 30 seconds.

ACCELERATING PUMP

Rise: simplified 3D standard map, on load position / load speed / regime, in 5 decimals coefficient.

- In load calculation by throttle angle, the calculation of accelerating pump is made on the throttle movements

- In load calculation of intake pressure or airflow meter, two calculations of accelerating pump are available simultaneously.one on the load movements (intake pressure or airflow), and one on the throttle position movements. The pump used by the ECU is the biggest of both.

Decay: standard map, engine acceleration / rpm, in 5 decimals coefficient.
Correction level of accelerating pumps: parameter, 5 decimals coefficient of fast tuning of accelerating pump: the standard maps supplied by Skynam must almost never be modified, we use this coefficient to enrich or to lean accelerating pumps.
A coefficient by injection rail is available.
In load calculation of intake pressure or airflow, a coefficient for the accelerating pumps on pressure or airflow movement and a coefficient for the accelerating pumps of throttle movement, what gives four coefficients in two rail injection.

TICK OVER AND DECELERATION CUTOFF

Accelerator pedal tick over limit: parameter, in thousandth (give the pedal position under which the pedal is in tick over zone).
Tick over rpm target: parameter, rpm (give the basic value of tick over).
Offset deceleration cutoff: parameter, rpm (give the offset of rpm above the tick over rpm target for which we enter in deceleration cutoff zone).
Cutoff smoothing: map, on rpm / pedal speed, gives the slope of advance smoothing to enter and go out of deceleration cutoff from and to the load.
Tick over smoothing: map, on engine acceleration / difference engine rpm –tick over rpm target, gives the slope of advance smoothing to enter and go out of deceleration cutoff from and to the tick over.

RPM LIMITER

Limiters targets (three launch limiters and one race limiter): parameter, rpm.
Channels cutoff: parameter. Gives cutoff slope of channels of the selected limiter target (injection, ignition or both). Rolling cylinder cutoff (always begin with a different cylinder).

RICHNESS CORRECTION

Target: map of richness target, on rpm / load, expressed in richness.
Permission richness correction: parameter, ON-OFF.
Looping start wait: standard map, on rpm / load, expressed in milliseconds giving the maximum waiting time before use of the Lambda sensor.
Re-looping wait: standard map, on rpm / load, expressed in milliseconds giving the waiting time before re-looping when the conditions of looping are correct.
Speed of richness regulation: simplified 3D standard map, on rpm / load / relative distance richness-target richness.

MOTORIZED THROTTLE

Target: map of motorized throttle position target, on engine rpm / pedal.
Standard maps of PID of regulation of motorized throttle command.

TICK OVER PROPORTIONAL ELECTROVALVE

Target: map of proportional electrovalve position target, on rpm / throttle.
Electrovalve positioning: standard map, electrovalve target / battery tension, giving the RCO of command of the electrovalve.

TURBO PRESSURE

Target: map of overboost pressure target, on rpm / throttle position.
Standard maps of PID of regulation of turbo command by electrovalve of leak.
Throttle minimum position of Integral correction: parameter, value of throttle below which the Integral correction of PID is maintained in 0.
Maximum pressure target speed of Integral correction: parameter, value of overboost pressure target speed above which the Integral correction is maintained to 0.

BANG-BANG

Maximum time of bang-bang: parameter, bang-bang time after which it is cutoff. If this value is set to 0, there will be no bang-bang.
Bang-bang command state: map based on the rpm / load of the engine, with hysteresis of throttle position or pedal position (in motorized throttle) of output of bang-bang in the re-acceleration and rpm hysteresis of output of bang-bang in the rpm drop.

CAMSHAFT POSITIONING (FOR EACH CAMSHAFT)

Target: map of camshaft position target, on rpm / load.
Standard maps of PID of regulation of the camshaft position command.

FILTERINGS

Weighted average of measures: each input of measure has a filtering by weighted average (previous average + current measure) / (weight coefficient + 1).
For each measure, the coefficient of weight is given by a map to allow an adaptive filtering.
For the static measurements (pressures, throttle, …), one of the inputs of this map depends on the signed difference between the measured value and the average value (value-average), and the other input is selectable by the motorist.

GENERAL TECHNICAL CHARACTERISTICS

AN ECU VERY POWERFUL AND VERY FLEXIBLE

The heart of the Challenger7 is a fast microcontroller with a DSP calculation coprocessor (Digital Signal Processing), with very strong computing power.
The calculations are performed as often it is necessary for instant management of events and of the state of the engine.
The Challenger7 has inputs and outputs configurable, allowing a very flexible and efficient use.
It also owns 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

The Challenger7 can communicate and be configured by means of the PC software Winjall (™ Skynam), and this communication is made by means of a high speed serial interface USB based.
The Challenger7 owns an auxiliary CAN-BUS with 125 kBits to 1Mbits speed by which it can send data to a dashboard and/or external data recording.
It uses this auxiliary CAN-BUS in the standard 2.0B (11 bits or 29 bits identifiers, selected for every frame).

POWER SUPPLY

The Challenger7 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 Challenger7 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.

WATCH DOG

The Challenger7 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 Challenger7 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 Challenger7 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.

BASIC ENGINE CONFIGURATION

I) CALCULATIONS OF LOAD:

The Challenger7 knows how to make various types of calculations of load:
- throttle / rpm,
- pressure / rpm (with or without turbo),

II) NUMBER OF CYLINDERS AND ANGLE BETWEEN CYLINDERS:

The number of engine cylinders is configurable by the motorist.
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°...

III) ENGINE MEASURE OF RPM AND PHASE:

To measure its rpm and calculate and set the events phased with the engine, the Challenger7 needs two devices:
- a flywheel target on the crankshaft with its sensor,
- a flywheel target on a 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 Challenger7 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 camshaft sensor 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 is optional.
If it is not present, the sequential injection and the static ignition are not phased. The ignition will produce a spark each 360 crankshaft degree.
The camshaft sensor can be inductive or Hall effect.
It is used to find the 1st cylinder TDC
The type of camshaft target can be:

- 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.
- one missing tooth: on the regular teeth of the camshaft target, one tooth has been removed.
- one supplementary tooth: on the regular teeth of the camshaft target, one tooth has been removed every two teeth, except on one place, where we so have 3 consecutive half teeth.
- 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 gasoline direct injection or common rail diesel engines. For this configuration, the camshaft sensor has to be a Hall effect one.

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 the camshaft phase to top dead center 0°.

ENGINE COMMAND

I) INJECTION:

The precision of the calculation of injection of Challenger7 is 1µs, what is about 0,05% at tick over and 0,005% in full load.
Challenger7 has 2 injection channels.

ELECTRICAL COMMANDS

The electrical commands of these channels are ON-OFF.
For the Peak and Hold commands or the commands of direct injections, it is necessary to add a specific Skynam device (example: programmable Peak and Hold in duration and level of the peak, and level of the hold).

INJECTION RAILS

Injectors can be grouped in one rail, or two rails.
If they are grouped in two rails, a map allows to gradually choose the injected quantity for each rail according to the rpm en the load of the engine.
Each injection rail owns its own accelerating pump and its own injection phase: the 2nd rail being generally further from valves than the first one, the wetting of the intake must be more intense and the injection phase more early.
Two types of double rails working are possible:

1) Rail 1 to 2:

This configuration allows to move gradually from a rail to the other one: when we increase the rail 2, the rail 1 is decreased in the same way to compensate. Both rails can have different type of injectors, and thanks to the fuel flow coefficient between the two rails, the fuel quantity remains stable when moving from one to the other. Each rail has its maps of correction and delay of injectors opening.

2) Rail 1 to 1+2:

This configuration allows to add gradually the rail 2 to the rail 1: we use this configuration to give more of fuel to the engine when we engage the rail 2. Both rails can have injectors of different types and each rail has its maps of correction and delay of injectors opening.

TYPES OF INJECTION

The injection can be:

Semi sequential: (phase sensor not needed)

Engines with an even number of cylinders. Injectors are opened by groups: 2 (or more than 2) injectors are commanded by each injection output of the ECU.
This type of injection is not phased.

II) IGNITION:

The precision of the ignition calculation of Challenger7 is 1µs that is 1/10° at 16000 rpm.
Challenger7 has 4 ignition channels.

ELECTRICAL COMMANDS

The electrical commands of these channels are signals of command of external power modules, which can be or not integrated into ignition coils: The Challenger7 does not directly command the primary of ignition coils.

TYPES OF IGNITIONS

1) Static ignition: (necessary phase sensor)
It is the ignition with a coil by cylinder.
Modules are normally connected 1 by 1 to the outputs of the ECU by respecting the order of ignition of cylinders.
2) Static ignition not phased: (no phase sensor)
It is the ignition with a coil by cylinder.
Modules are normally connected 1 by 1 to the outputs of the ECU by respecting the order of ignition of cylinders, but the ECU could not determine the good engine round in the engine cycle, it executes a spark every 360°
3) Twin spark ignition:
For engines with an even number of cylinders, 360° opposed two by two.
Cylinders are lit 2 by 2: it is necessary to use a double coil by ignition module, and a module by ignition output of the ECU. We can also use coils with integrated module.
3) Distributed ignition:
Simple or double distributor with possible advance shift between the two distributors.

CORRECTION OF CYLINDERS

- For the static ignition (phased or not phased), each cylinder has a correction map rpm/load to compensate for an unbalanced combustion.
- For the lost spark ignition, no correction per ignition channel.

TIME OF IGNITION DELAY

A calibration allows to inform the ECU of the time of execution of the ignition command. Indeed, between the order given by the ECU to the coils through the modules, and the real peak of spark, there is a delay time characteristic of the power modules and the coils. This time is typically of about 15 microseconds, inconspicuous at low rpm, but which borders 1 advance degree at 11000 rpm.

III) RICHNESS CORRECTION:

The Challenger7 can be configured to measure the richness with its Lambda sensor, and correct it.
To drive this correction, we use a map of target to indicate the desired richness according to the load and to the rpm.
We also have two programmable limits of correction, forbidding the Challenger7 to enrich or to lean too much during this correction.
When the richness correction is allowed, we can also define the load, the rpm and the engine temperature below which the richness correction must not be made.
It is advised to use a wideband Lambda sensor (with electronic interface). It is also possible to use 0-1 volts 4 wires Lambda sensors by connecting them to the differential input of the ECU.

VARIOUS FUNCTIONS

I) RPM LIMITER:

ACTION OF THE LIMITER

The limiter can be chosen to act on the injection, the ignition, or both.
A slope parameter allows to gradually cutoff the cylinders as we approach the limiter instead of cutting off them all at the same time.
The ECU, every time it has to begin to cut cylinders off (rpm limiter, deceleration cutoff, sequential gearbox), begins with a different channel, to avoid warming always the same cylinders.

TYPES OF LIMITER

The Challenger7 ECU has four rpm limiters. It allows to give different rpm limits, as well as the conditions to switch from one limiter to another.
1) the three launch limiters allow three different launch strategies:
They allow by setting a rather low limit rpm to reduce the power of the engine at the takeoff of the vehicle, to avoid the wheels skating: the two rpm limits allow to have a better adaptation to the road grip. The limiter 1, 2 or 3 will be selected following the position of the race rotary switch at the vehicle board.
2) the race limiter:
It is used for the full power of the engine.

EXIT OF LAUNCH STRATEGY

At the end of each launch limiter, two strategies are allowed to move to the race limiter:
1) Immediate moving to race limiter:
2) Gradual moving to race limiter:
This gradual moving allows to not have the wheels spinning when the engine, revving up, will reach its maximum torque in conditions of low adherence.
To avoid this spinning, the RPM limiter is gradually raised from the launch limiter to the race limiter, at the maximum speed at which you allow the engine to rev up.
If the speed of engine revving exceeds this maximum revving speed of the limiter, the engines overtakes the limiter and goes into limiter.
But as the limiter is rising, the engine can accelerate at the speed of this rise.

SHIFT LIGHT

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

II) THROTTLE POSITION AND PEDAL POSITION:

The ECU supplies a calibration of throttle position and accelerator pedal position. This calibration allows the ECU to record the minimum and the maximum of the potentiometers values (or of calculation if double potentiometer) and will allocate them 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 throttle (or pedal in motorized throttle) until which the ECU has to consider that it is in tick over. The ECU calculates automatically a small hysteresis on this tick over position to avoid the oscillations of calculation.
- the basic tick over rpm value, which is originally only an information for the ECU, and not a real target.
- The offset of rpm above the tick over rpm for the deceleration cutoff zone. This adjustable offset is normally 800 rpm, that is for a tick over rpm 1000 rpm, the limit of cutoff zone will be 1800 rpm. The ECU adds a not adjustable hysteresis of 100 rpm to avoid the oscillations of calculation.

IV) DECELERATION CUTOFF:

The cutoff can be chosen to act on the injection, the ignition, or both, or no cut.
It is made when the throttle (or the pedal in mode electric throttle) is in the tick over zone and when the rpm is in the cutoff zone (normally throttle closed or pedal released and rpm above 1800 rpm).

V) TRACTION CONTROL:

The ECU permanently monitors the engine acceleration, and if this acceleration exceeds a maximum threshold, it gradually cuts off the cylinders:
This cylinders cutoff is done in the same way than the rpm limiter does, which means that it cuts off either injection, or ignition (advised), following the rpm limiter configuration.

PERMISSION OF CALCULATION

A configuration function allows to ask the ECU whether or not to control the traction: it allows to separately validate the traction control on the 4 positions of the race configuration rotator.
With this function, it is so possible to use the positions to specifically validate or not the traction control, and in addition to obtaining different launch limiters.
For example, you can deactivate the traction control in road configuration.

The traction control is forbidden if:

- the race configuration rotator is not in a position for which you have validated the traction control
- the engine is stopped or is starting
- the throttle position (or pedal) is in the area of deceleration cutoff or tick over
- the engine rpm is lower than the tick over rpm
- the launch procedure is activated (launch limiter)
- the engine rpm is higher than the rpm limiter (limiter cutoff being)
- while gear shifting
- the rpm sensor is in error

In these cases, the traction control is reset and does not cut off any cylinder.
In all the other cases, the traction control is activated.

OPERATION

A map allows to define the maximum acceleration allowed to the engine, depending on the engine speed (so that the maximum acceleration can follow the engine torque curve) and on the engaged gear position.
A PID manages the cylinders cut-off depending on the level of exceeding of the maximum acceleration allowed.
This PID calculates a cylinders cutoff ratio between 0 and 1:

- for 0, no cylinder is cutoff

- for 1, all the cylinders are cutoff
- between 0 and 1, a proportionate of the cylinders is cutoff.

If the number of cylinders to be cutoff is not an integer, the Challenger5 cuts completely the integer part of cylinders to cutoff, and cuts off the following cylinder on the decimal part every N engine cycles: this allows a very gradual and smooth cut.

SEQUENTIAL GEARBOXES

The Challenger7 manages directly the sequential gearboxes.

I) NUMBER OF GEARS:

The number of gears can be chosen (up to 10 gears).
We can also indicate if the gearbox is organized in automotive (Back, neutral, 1st) or motorcycle (1st, neutral, 2nd) or special by choosing the name of the gears in function of the information of the potentiometer of gearbox position.
The name of gear is important because it is it which 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.

III) COMMON TUNING TO ALL THE GEARS:

We configure four common values to all the gears:
- Minimum engine rpm before upshifting intervention: it is the rpm below which the ECU does not intervene on the engine management.
- Minimum pedal position before upshifting intervention: as for the rpm, the ECU does not agree to intervene on the engine management below a certain programmable throttle position.
- Minimum engine rpm before downshifting intervention: it is the rpm below which the ECU does not intervene on the engine management.
- Wait before new gear: after a gearshift, the ECU refuses a new gearshift during a programmable time. It avoids intervening involuntarily a second time if the pilot keeps the hand on the gear lever.

IV) SPECIFIC TUNINGS FOR EACH 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 each gear, we give the ECU a range of tension 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 UPSHIFT

A map allows for gear to adjust differently the time of intervention.

The second input of this map is the engine rpm, allowing to modify the time of intervention of gear position according to the engine rpm.

The intervention is launched as soon as the ECU receives from the switch the signal of gear upshift, if the rpm and the throttle are above the programmed limits and if the waiting time before a new gear is elapsed, and lasts as long as the gear has not shift or the time of intervention defined for this gear is not reached.
The type of intervention on gearshift is selectable. It can be
- ignition cutoff
- modification of the ignition with slope on go back to the normal (by maps with selectable inputs)

These types of intervention are combinable.

For example, we can choose to cut off <u>and</u> to modify the ignition:
The motorist will define in the parameter of modification of ignition the number of degrees of advance degradation.
He will also define the slope (the speed) with which we go back to normal at the end of intervention in the parameter of slope of ignition.
As we declared that we cut off the ignition at the gearshift, the ignition will be cutoff during all the defined time of intervention. At the end of gearshift, the ignition is degraded before being restarted: it thus restarts from a value lower than normal, and goes back up gradually to the normal value, at the speed defined by the slope parameter.
This allows to limit jolts during the gearshift.

INTERVENTIONS DURING THE DOWNSHIFT

A map allows for gear to adjust differently the time of intervention.
The second input of this map is the engine rpm, allowing to modify the time of intervention of gear position according to the engine rpm.

The intervention is launched as soon as the ECU receives from the switch the signal of gear downshift, if the rpm is above the programmed limit and if the waiting time before a new gear is elapsed, and lasts as long as the old gear is not dog-declutched or the time of intervention defined for this gear is not reached.
The type of intervention on gearshift is selectable. It can be
- ignition cutoff
- modification of the motorized throttle position (autoblip)

These types of intervention are combinable.

We can cut ignition off if for any reason the engine gives some torque at the downshifting: the gearshift is difficult or is not done at all.
The most common reasons are:
- Downshift demand during strong braking: the engine tries to drive the driving wheels faster than they turn and so produces an effort on the gears of gearbox
- the pilot requests a downshift while he has not enough dropped the accelerator: the engine drives the driving wheels and so produces an effort on the gears of gearbox

V) ROBOTIZED BOXES:

The wait before new gear also serves for programming the robotized boxes, that is the boxes for which it is needed to maintain the intervention all the time when the switch is pushed (the time of programmable intervention does not then serve).

To inform the Challenger7 that the gearbox is of this type, the wait before new gear must be simply set to 0.
The ECU adds systematically a 10 milliseconds time of blanking to avoid bounces on the switch of the robotized gearbox.

CONTROL OF OPERATION

I) BREAKDOWNS DIAGNOSTIC:

The Challenger7 makes a permanent analysis of the operation of the system and the sensors, and remembers their defects, even past.

SYSTEM DIAGNOSTIC

System diagnostic 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.

APPLICATION DIAGNOSTIC

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 Challenger7 has 4 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 engine temperature, …).
A second condition to launch the recording can be added to obtain more elaborated recordings: for example, record the engine temperature overshoots only when the engine is running.

One chosen the limits level that the value has to exceed to launch the recording by adjusting the map of piloting of recording.
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 4 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.

AUXILIARY COMMANDS

7 auxiliary outputs of Challenger7 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 pilots 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 Challenger7 uses a special output among 7 to command its LED to specifically manage the state signals of the ECU and its diagnostic.

FUEL PUMP

The Challenger7 uses one of 7 outputs to command the low pressure fuel pump following the FISA regulations: pump running 5 seconds at the start up of the ECU, then pump switch off if the engine does not run.
As soon as the engine rotates, restart of the pump.
As soon as the engine stops, stop of the pump.

II) FIXED COMMANDS FOLLOWING TYPE OF APPLICATION:

MOTORIZED THROTTLE

Is managed by a regulation of type PID on a H bridge PWM command (double push-pull) the command frequency of which we select.
For this management we use a map of target to indicate the throttle position according to the accelerator pedal position and the rpm, allowing to slow down or to accelerate the movement of the throttle with regard to that of the pedal.
It sometimes allows to win torque at low rpm by not allowing to open completely the throttle.
It also allows to bring the necessary air quantity for the good working of the bang-bang on turbo engines.

PROPORTIONAL TICK OVER ELECTROVALVE

For the intakes not having a motorized throttle, The Challenger7 knows how to pilot an intake proportional electrovalve by a direct PWM command the frequency of which we can choose.
For this management we use a target map to indicate the opening position of the electrovalve according to the throttle position and to the rpm. It also allows to bring the necessary air quantity for the good working of the bang-bang on turbo engines.
The type of electrovalve can be two wires (standard electrovalve with closure by spring) or three wires (electrovalve with opening and closure electrically commanded).

CAMSHAFTS PROPORTIONAL POSITIONING (VVT)

The Challenger7 ECU can manage the proportional positioning of one camshaft.
The command of the camshaft is done by the management of a unique pneumatic leak electrovalve.

The position management of the camshaft is done by a PID regulation on a PWM command the frequency of which we can choose. The electrical command can be inverted by the configuration of the output.
A map of target indicates the desire camshaft position according to the load and to the rpm.

TURBO PRESSURE
For overboost engines. See below the details of the management of turbos.

PROPORTIONAL ELECTROVALVE
Allows to manage the gradual opening of electrovalves, by a PWM command with selectable frequency and cyclical ratio.
The Challenger7 possesses a particular mode of piloting of electrovalve by making an effect of small hammering to force the precise positioning of electrovalves. If this mode of operation is not desired, we shall rather configure the output in simple tunable PWM.
The type of electrovalve can be two wires (standard electrovalve with closure by spring) or three wires (electrovalve with opening and closure electrically commanded).

III) PROGRAMMABLE COMMAND:

The Challenger7 possesses 5 programmable auxiliary outputs (others than injection and ignition).
They are numbered 1, 2, 3, 4 and 5.
These auxiliary commands, when they are not fixed as for the command of motorized throttle or fuel high pressure or the other options forced by the chosen type of application, possess a possibility of programming: they can be piloted by completely programmable maps.

TWIN OUTPUTS
2 of these outputs can be coupled. We call them twin outputs: they are the outputs 1 and 2.
When they are declared coupled, outputs 1 and 2 are controlled by the command 1, but the state of the output 2 is the opposite of the output 1.
- If the output 1 outputs of the ground, the output 2 is in opened drain (or 12 volts if push-pull).
- If the output 1 is in opened drain (or 12 volts if push-pull), the output 2 outputs the ground.
They possess in more an option of electric piloting, by open drain or push-pull. These outputs have to be the outputs used to manage a fly by wire.

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)
- angular command,

1) Command ON-OFF:
The output works as a relay piloted by a completely programmable map.
The output being ON-OFF, it is very recommended to use the mode hysteresis in the map of piloting 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, 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 piloted 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

OPTIONS OF THE OUTPUTS

Outputs	Basic electric command	Option	pin connect.	Intensity	Max (1 millisecond)
1	open drain (ground)	push-pull	12	4A	10A
2	open drain (ground)	push-pull	34	4A	10A
3	open drain (ground)	no	18	4A	10A
4	open drain (ground)	no	35	4A	10A
5	push-pull 12 volts low power	no	17	125 mA	500 mA

Nonstop acceptable total intensity 15 amperes

Note: Skynam can supply
- electronic relays 20 amperes to pilot devices asking for more power than support the outputs or if the acceptable total power is exceeded.
- relays of transformation of command by the ground in Push-pull command to 12 volts.
- relays of transformation of command by the ground in H Bridge command to 12 volts.

FUNCTIONS OF THE OUTPUTS

OUTPUTS		1	2	3	4	5
On-Off	fixed	X	X	X	X	X
	programmable	X	X	X	X	X
	overshoots alarm	X	X	X	X	X
	engine speed relays	X	X	X	X	X
	relays	X	X	X	X	X
	engine temperature relays	X	X	X	X	X
	pressure relays (turbo)	X	X	X	X	X
	twin programmable positive	X				
	twin programmable negative		X			
PWM	programmable	X	X	X	X	X
	twin programmable positive	X				
	twin programmable negative		X			
	turbo solenoid valve			X	X	
	camshaft positionning			X	X	
	motorized throttle positive	X				
	motorized throttle negative		X			
	intake solenoid valve positive	X				
	intake solenoid valve negative		X			
	proportionnal solenoid valve positive	X				
	proportionnal solenoid valve negative		X			
Angulaire	programmable					X
	rev counter					X

TURBO

The Challenger7 uses two means to efficiently manage a turbo engine:
- the dynamic management of the leak electrovalve of waste-gate (with possible management of back pressure) or variable geometry with elimination of the not desired overboosts,
- the post combustion or bang-bang.

The management of the turbo command (waste-gate or variable geometry) is made in PWM. The electrical command can be inverted by the configuration of the output. The frequency of the PWM can be chosen by the configuration of the output.

COMMAND OF THE OVERBOOST PRESSURE

To manage the overboost pressure, we use a map of basic target to indicate the desired pressure according to the load and to the rpm. This map supports the mode bang-bang, that is we can give a target of specific pressure in bang-bang.
The management of overboost pressure is a PID: the Proportional is the map of leak, the Differential is the map of immediate correction, the Integral is the long term correction.

DYNAMIC MANAGEMENT OF OVERBOOST

The dynamic management of the overboost made by the Challenger7 has the advantage to give very reactive engines by forcing the turbo to follow at best the target, notably during the demands of fast rise in pressure: as long as the overboost pressure does not reach the target pressure, the ECU gives a maximum command to force the turbo to rise in pressure as quickly as possible.

MANAGEMENT OF WASTE GATES WITH BACK-PRESSURE

For the high level waste gates needing in more a management of the back-pressure, the Commander ECU allows to use a programmable auxiliary command to manage this back-pressure.

ELIMINATION OF OVERBOOSTS

To avoid not desired overboosts, we cancel the Integral correction which can generate a very important overshoot of target if, when the throttle is little opened, the pressure does not manage to rise at the level of the target: the ECU increases then the Integral at most to try to generate a higher leak to reach the impossible target, and when we brutally accelerate, the leak is full opened and the pressure rises very high.
It is thus necessary to reset the Integral in these circumstances, letting the Differential correct alone the basic leak.
The reset to zero of the Integral of the PID of the turbo can be commanded by two different means at the choice of the motorist (each can be used alone, or in combination):
1) If the throttle position is below a limit value, no calculation of Integral, only the proportional and the Differential. It is justified by the fact that as long as we are not enough boosted, the turbo pressure does not rise whatever is the leak: not need of calculation of Integral.
2) If the speed of the target is above a limit value, no calculation of Integral, only the proportional and the Differential. It allows to let the Integral correct the leak and follow the target as long as this target does not move too fast. If the target quickly moves (generally by fast movement of the throttle), the Integral cannot follow and is not any more adapted. It is then better to reset it to 0.

POST COMBUSTION

Two parameters allow to manage the bang-bang:
- maximum time of bang-bang: the duration maxi of the bang-bang in milliseconds allows to cut it off after a while to avoid a too important heating of the turbo and the exhaust part of the engine. If this value is set in 0, there will be no bang-bang.

- map of bang-bang state command: allowing to define the strategies of input and of output of bang-bang. The strategy is based on the rpm / load of the engine, with throttle position or pedal position (in motorized throttle) hysteresis of output of bang-bang on re-acceleration and the rpm hysteresis of output of bang-bang on engine rpm decrease.

The tuning of the bang-bang itself is made by means of three maps:

- The ignition advance,
- the injection time,
- the motorized throttle target or the tick over electrovalve, or an auxiliary output commanding throttle opening by a pushing device.

A special mode of operation of these maps allows to define the values of air, fuel and advance in bang-bang mode separately from the normal mode of working.

ADVANCED OPERATION

I) PARAMETERISATION OF INPUTS:

Every measure of the ECU (pressure, throttle, speed) can be calibrated to adapt to the sensor to which it is connected.

THROTTLE AND PEDAL CALIBRATION

Throttle and pedal potentiometer calibration are used to indicate to the ECU mini and maxi potentiometer positions. This allows not have maps indexed on the tensions of the potentiometers, which may vary with the life of the potentiometer or change completely if you change or dismounts the potentiometer, but on angles (graduated from 0 to 1000).

STATIC MEASURES

The pressure and temperature inputs have a linearization map that transforms the voltage measured in physical value (°C, millibars,...). The ECU can therefore use any sensor, it is sufficient to provide appropriate transformation map. Skynam provided a large number of these maps of conversions, but if the motorist does not owns the one which corresponds to the sensor that it wishes to use, it can easily create his own. Skynam can also do for him.

II) DIGITAL FILTERING OF THE MEASURES:

Every measure of the ECU (pressure, throttle, temperatures, …) 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).
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.

III) STRATEGIES OF MEASUREMENT FAILURE:

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

The strategies of detection of standard breakdown 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.

The strategies of standard 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
- Throttle position takes the value angle 0
- …

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

- indicate for the replacement value which value we wish use
- indicate for the detection of error trigger the tension limits giving the allowed range

IV) MAP COMPLETELY PROGRAMMABLE:

The maps used in the advanced functions are completely programmable:

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 state of error of a measure).

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.

V) AUXILIARY COMMANDS:

The Challenger7 has 5 auxiliary outputs (other than injection and ignition) which have a possibility of programming: they can be driven by fully programmable maps, that is, the motorist may choose in a very advanced manner the functioning type of the output in the way to command devices not included in the original operating, like

- shift light in function gearbox of position,
- fan with proportional speed to engine temperature
- injection of water or additives
- …

VI) AUXILIARY CAN-BUS:

It is possible to ask the Challenger7 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.
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, 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 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 rpm and other data.

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.