

# Short presentation of Challenger8

Release: V1.00 – 04/02/2022

<http://www.skynam.com>



Machine management

The Challenger8 is an engine management ECU with a high computing power, configurable inputs and outputs, allowing a very flexible and effective use.



## GENERAL CHARACTERISTICS

Power supply range 5.5 to 18 volts DC

Consumption on stop: 0 milliamperes

5volts sensors power supply: up to 400 milliamperes

Size (mm) and weight (g) 120x165x40, 420

Automotive type connector FCI 90-way

ECU maps and tables: sizes adjustable by the user, with no size limit.

Flex fuel (Ethanol content) measurement and engine tuning.

## COMMUNICATIONS

High speed serial interface (1 Mbits) on USB base for the engines tuning.

One CAN-Bus standard 2.0B (11 or 29 bits identifiers selection for every frame), speed of transmission 125 Kbits to 1 Mbits, for sending data to an OEM CAN-BUS, a Dashboard or a third party data recording.

## HACKER PROTECTION

Tunings protected by selectable locking.

Unlocking only possible by the licensed owner of the ECU.

Total deletion of the data if attempt of violation.

## LOAD CALCULATIONS

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

## PRE-FILLED ENGINE TUNING

- The base ignition advance and injection time maps are provided with values allowing an easy engine starting up. They must be then specifically adapted to the engine by the motorist (self-learning for injection time).

- All other maps of the ECU are pre-filled with values allowing a good engine operation in the majority of the cases, notably the maps of starting up enrichment and rising in temperature, of altimetric adaptation, ...
- The PIDs of idle management, motorized throttle management, of turbo management, of camshafts positioning management are also pre-filled and most of the time require no or little supplementary adaptation.

### **ENGINE MULTIMAPPING**

Groups of modification allow modifying the engine tuning including while the engine is running, for example to have several tunings according to a rotator position (rotative multi-position switch).

Three groups of modification are available, allowing, with the original tuning, to obtain four different engine tunings.

A group of modification is constituted by maps of modification of ignition advance, of injection time, of richness target, and if the turbo exists of turbo pressure target.

### **MANAGEMENT OF ENGINE CYLINDERS**

The number of cylinders is configurable and can be 1, 2, 3, 4, 6, 8

- ignition correction per cylinder
- injection correction per cylinder

### **STATIC SENSORS INPUTS**

- 1 measure of the power supply tension.
- 3 resistive inputs (CTN-CTP or logics), with internal pull-up resistor bridge to 5 volts
- 4 analogic inputs 0-5 volts, with internal pull-down resistor (black-out detection)
- 4 selectable analogic or resistive inputs

### **Sensors:**

- battery tension,
- Switches and rotators:
  - switch of race configuration (inhibits launch limiter and ALS),
  - traction control sensitivity selection by 4-position rotator,
  - vehicle speed limiter selection by 4-position rotator,
  - engine protection prohibition switch,
  - clutch pedal switch (or by pressure measurement),
- Sequential gearbox:
  - gear shifting switch configurable logical (On-Off) or analogic (strain gauge measurement with tuning of the sensitivity),
  - gear position sensor,
- Positions:
  - calibratable pedal position,
  - calibratable throttle position,
  - calibratable turbo servo or VGT position,
- Pressures:
  - intake pressure,
  - atmospheric or dynamic pressure,
  - oil pressure,
  - fuel low pressure,
- Temperatures:
  - engine temperature (coolant or air refresh),
  - intake temperature,
  - oil temperature,
  - fuel temperature,
  - exhaust temperature,
- Richness:
  - wideband or narrowband Lambda sensor,

### Digital filtering:

Every measurement of the ECU has a programmable digital filtering (essential for example for removing pressures instabilities).

The digital filtering of each measurement is pre-tuned.

### Parameterization of the inputs:

Every measure of the ECU (pressure, pedal, throttle, speeds, ...) can be allocated to one input of the ECU.

### **SPEED AND FREQUENCY SENSORS INPUTS**

Speeds inputs are self-adaptive in signal level and shape: A specific microprocessor is allocated to each input to handle and shape its analogic signal.

- 1 measure of rpm on flywheel, programmable inductive – Hall,
- 1 measure of main camshaft phase, programmable inductive – Hall,
- 1 measures of auxiliary camshaft phase, Hall or magneto-resistive,
- 1 auxiliary measure, Hall or magneto-resistive shared with the auxiliary phase.

### Measurements:

- measure of rpm and phase of crankshaft on configurable type of flywheel,
- measure of angle of phase mark on main camshaft on configurable type of marks,
- measure of angle of phase mark on auxiliary camshaft on configurable type of marks,
- measure of vehicle speed and gearbox tailshaft speed, with programmable number of pulses per round,
- measure of frequency on auxiliary speed measure input of the fuel Ethanol content sensor

### Crankshaft flywheel singularities:

- Top Dead Center tunable from 0° to 720°, 1/10° resolution
- From 8 to 60 teeth
- Singularity: N-2, N-1, N, N+1, Multitooth (e.g. Audi, BMW, Porsche, Mercedes, Peugeot, Renault RS, Ford, Opel, Toyota, Yamaha, Mitsubishi, Kia, ...)

### Camshaft flywheel singularities:

- From 1 to 16 teeth
- Singularity: On teeth state, On teeth position, N-1, N, N+1 (same OEM list than for the crankshaft)

### **FAULTS STRATEGIES**

For every measurement (pressures, throttles, speeds, ...), the ECU provides in standard a failure detection strategy and an error replacement value.

The user can also define his own fault detection strategies, and his own replacement values in the event of a failure.

### **DIAGNOSTIC**

The ECU records the faults on the measures, the blackout or the short circuit, occasional or repeated, and allows the deletion of these failures when required by the user.

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

With alarm lights or Dashboard failure state display.

### **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.

Erasure by software (with possible protection).

Alarm light programmable:

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

### **ENGINE PROTECTION**

A switch allows to deactivate the engine protections.

Two general types of protection exist:

- engine stop protections, used in the event of a serious engine problem
- engine torque protections, in the event of a simple exceeding of limit, are reducing the engine torque (by decreasing the motorized throttle position, the turbo pressure)
- With alarm lights or Dashboard protection state display.
- In addition, an engine stop regulation can be requested so as not to stop abruptly the engine during an engine stop protection, for example to allow the turbo to cool down before the complete stop.

#### **1) Engine stop protection on:**

- low oil pressure (following engine speed and startup state)
- high oil  $t^{\circ}$
- high engine  $t^{\circ}$
- high intake  $t^{\circ}$
- high exhaust  $t^{\circ}$

#### **2) Engine torque protection on:**

- high exhaust  $t^{\circ}$
- high intake  $t^{\circ}$
- high oil  $t^{\circ}$
- high engine  $t^{\circ}$
- high intake pressure

### **INJECTION**

#### **4 channels with fixed type of command**

- saturated command (On-Off),
- for the Peak and Hold commands or direct injection commands, it is necessary to add a Skynam external injectors driver.

#### **Selectable types of injection:**

- sequential phased (needs phase sensor or dynamic synchro),
- sequential not phased (no phase sensor nor dynamic synchro needed),
- semi sequential (no phase sensor nor dynamic synchro needed).

The injection is phased on the end of the injector command (sequential injection standard). Phase from 0-720° in function of the engine speed and load, in 1/10°.

#### **Injectors dead time correction:**

Tunable in function of the on-board tension.

#### **Injection time calculation:**

- In function of the engine speed and load, microsecond resolution, multimapping, ALS
- Cylinder per cylinder correction,
- Enrichment procedure at engine start depending on the engine  $t^{\circ}$ , the elapsed engine rounds and the engine speed reached,
- Correction by engine  $t^{\circ}$ , intake  $t^{\circ}$ , exhaust  $t^{\circ}$ , atmospheric pressure, Ethanol content, rpm limiter, traction control, vehicle speed limiter ...
- Correction by rpm limiter (by launch procedure and by hard cut),
- Accelerations correction (accelerating pump),
- Correction of richness by looping on Lambda sensor according to the richness target map, with tunable correction range limits.

#### **Injection time self-learning:**

- A function of injection map complete self-learning is based on the richness target map function of the load and the engine speed and on the reading of the Lambda sensor.

## **INJECTION RAILS**

Injectors can be grouped in one or two rails. Both rails can have different types of injectors. Each injection rail possesses its own accelerating pump and its own injection phase.

Two types of double rail operation are possible:

- rail 1 to 2: allows to move gradually from a rail to the other one. When both rails have different types of injectors, the fuel quantity remains stable with the use of a fuel flow coefficient.
- 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.

## **IGNITION**

4 channels to command ignition power modules (the Challenger8 does not directly drive the coils) what prevents ECU heating.

### **Types of selectable ignition**

- static phased (needs phase sensor) one spark every 720°
- static not phased (no phase sensor needed) one spark every 360°
- twin spark (no phase sensor needed) one spark every 360°

### **Ignition advance calculation:**

- In function of the engine speed and load, 1/10° resolution, multimapping, ALS
- Cylinder per cylinder correction,
- Correction by engine t°, intake t°, exhaust t°, atmospheric pressure, Ethanol content, rpm limiter, traction control, vehicle speed limiter, gear shifting
- Correction by rpm limiter (by launch procedure and by hard cut),

### **Coil loading angle calculation:**

- Tunable in microseconds in function of the on-board tension (8v, 10v, 12v, 14v, 16v)
- Skynam provides the coil loading times of a large number of the most popular coils

## **FLEX FUEL**

Complete adjustment of the engine tuning according to the fuel Ethanol content measured with the Ethanol sensor, with sensor reading inhibition if the fuel flow passing through the sensor is insufficient for a correct reading of the Ethanol content.

- Correction of injected quantity according to Ethanol content, engine t°, engine load and engine speed.
- Ignition advance correction based on Ethanol content, engine t°, engine load and engine speed.
- Specific injected quantity at engine starting according to the Ethanol content and the engine t°.
- Specific ignition advance at engine starting according to the Ethanol content and the engine t°.
- Specific richness target according to the Ethanol content and the engine load.
- Specific turbo pressure target according to the Ethanol content and the throttle position.

## **AUXILIARY COMMANDS**

### **Up to 8 programmable auxiliary commands**

- 4 half-bridges, allowing 2 full-bridges. Each half-bridge can also be used as open drain command.
- 3 open drain commands,
- 1 LED output,

### **Types of control:**

- ON-OFF
- PWM from 10 Hz to 10 kHz
- engine angular (number of pulses per engine cycle selectable, with cyclical ratio adjustment).

### **The outputs commands are used for:**

- management of the turbo with or without servo control,
- motorized throttle,
- intake air bypass stepper motor (4, 5 or 6 wires),
- intake air bypass solenoid valve (2 or 3 wires),
- 2 camshafts proportional positioning (VVT)

- On-Off fans or speed controlled fans,
- electric water pump with variable speed,
- electric thermostat with proportional opening,
- shift light,
- alarms,
- type programmable by the motorist.

### **FISA 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.

### **MOTORIZED THROTTLES**

Throttle position target calculation:

- From accelerator pedal position and engine speed, with ALS positioning
- Correction on engine start
- Correction by engine  $t^\circ$
- Correction by traction control, vehicle speed limiter
- Blip at gear downshift
- Correction by idle management.

Commands by extended PIDs with static friction compensation and PWM frequency selection.

### **TURBOS**

Command of leak solenoid or servomotor (and VGT).

Turbos command calculation:

- Turbo pressure base target from throttle position and engine speed.
- Turbo pressure target multimapping.
- Turbo pressure and turbo speed targets correction by atmospheric (altimetric) pressure, engaged gearbox position (boost by gear), and Ethanol content.

Commands by extended PIDs with PWM frequency selection and overshoot limitation control.

### **POST COMBUSTION (ALS)**

Additional air supply is provided by motorized throttle or air intake solenoid valve or air intake stepper motor.

To avoid engine and turbo damages due to high exhaust gas temperature, the ALS is controlled by time and by exhaust temperature.

- Ignition advance is specific during ALS phases.
- Injection time is specific during ALS phases.
- Turbo pressure target is specific during ALS phases.
- Intake and exhaust camshaft position targets are specific during ALS phases.

### **CAMSHAFTS POSITION (VVT)**

Proportional positioning of 2 camshafts:

- intake and exhaust camshafts,

Camshaft position calculation:

- Intake camshaft position target from engine speed and load,  $1/10^\circ$  resolution, ALS positioning
- Exhaust camshaft position target from engine speed and load,  $1/10^\circ$  resolution, ALS positioning

The command of every camshaft is done by the management of one solenoid valve.

Commands by extended PIDs with PWM frequency selection.

### **ENGINE SPEED LIMITER**

The cylinders cutoff can be done on:

- **ignition only:** only the ignition is cutoff. This is the smoothest and most responsive cut and does not overheat the cylinders.
- **injection only:** only the injection is cut.
- **injection and ignition together:** injection and ignition are cut at the same time. It is not advised to use this mode
- **ignition then injection:** ignition is cut normally and injection will be cut 100 rpm above the limiter.
- **injection then ignition:** injection is cut normally and ignition will be cut 100 rpm above the limiter.
- Selectable Hard cut or Soft cut.
- Three configurable launch limiters, selectable by rotator.
- During the launch procedures, it is possible to reduce the ignition advance and to enrich the engine. This allows to have high turbo pressure even before the vehicle takes off for a cannonball start.
- The change from the launch limiter to the race limiter is done at a configurable slip speed, selectable by rotator.
- Soft cut: gradual cylinder per cylinder cutoff, and turning (always begins the cutoff sessions with a different cylinder to avoid always heating the same cylinder).
- Hard cut: all the cylinders are cutoff at the same time, with tunable hysteresis to uncut the cylinders.

### **DECELERATION CUTOFF**

On injection or ignition, or no cutoff.  
Cutoff base engine speed tunable.

### **IDLE MANAGEMENT**

The ECU manages the idle engine speed if an air actuator exists (motorized throttle, intake air bypass stepper motor or intake air bypass solenoid valve)

- A calibration allows to prohibit the management of idle speed.
- Calibrations allow to give the idle engine speed target and its modification as a function of the engine temperature.

Idle management done by extended PID.

### **SEQUENTIAL GEARBOX**

Up to 10 gears with a selectable organization (automotive or special mode).

Gearshift switch can be logical (by grounding) or analogic (by programmable tension levels).

The time of intervention is adjustable by two maps, one for upshifting and one for downshifting. In both cases, the time is tunable for each gear position and in function of the engine speed.

The type of intervention on gearshift is programmable:

#### **1) Upshift:**

- ignition cutoff up to the complete gear shift
- modification of the ignition advance with slope on return to normal

#### **2) Downshift:**

- ignition cutoff up to the dog declutching (for fast downshifting while braking hard)
- modification of motorized throttle position (autoblip), which allows to accelerate the engine to ease the downshift.

### **ROAD GEARBOX**

Up to 10 gears can be detected.

To read the engaged gear positions on a road gearbox, the ECU reads the gearbox tailshaft speed (in rpm) by means of a speed sensor, and it compares this speed with the engine speed.

Reading the gearbox tailshaft speed (rpm) can be done directly on the gearbox output (preferred method) but also by reading the speed of a driving wheel or of the vehicle speed if it gives the tailshaft gearbox speed.

### **TRACTION CONTROL**

The Traction Control is based on a comparison between the speed of the driving wheels and the speed of the non-driving wheels:

The ECU can therefore only perform Traction Control if the driving wheels speed and the non-driving wheels speed are either measured, or calculated from the engine speed and the engaged gear position for the driving wheels.

Several traction control sensitivities are tunable and the selection is done by a 4-position rotator. When Traction control is active, the ECU can intervene on the engine with

- a modification of ignition advance
- a modification of injection time
- an ignition cut-off level (gradual cut-off)
- a modification of the motorized throttle position (if it exists)
- a modification of turbo pressure (if it exists)

### **VEHICLE SPEED CONTROL**

The speed limitation is based on a comparison between the speed limitation target and the real vehicle speed.

The ECU can therefore only perform the speed limitation if the vehicle or wheel speed is either measured, or calculated from the engine speed and the engaged gear position.

Several vehicle speed limits are tunable and the selection is done by a 4-position rotator.

When Vehicle speed control is active, the ECU can intervene on the engine with

- a modification of injection time
- an ignition cut-off level (gradual cut-off)
- a modification of the motorized throttle position (if it exists)
- a modification of turbo pressure (if it exists)

### **AVANCED FUNCTIONS**

The Challenger8 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.**

- 1) Pilot modules (see specific documents of Challenger8 tuning)
- 2) Parameterization of the inputs of measures
- 3) Filtering of the measures
- 4) Programmable strategies of failure of the measures
- 5) Programmable auxiliary commands



# ECU LOOM

J42		FUNCTION	COMMENTARY	CHARACTERISTICS
1	GROUND IN	POWER ENGINE GROUND	Ground input for power commands	
2	OUT	INJECTION A	Ground command open drain - 1st injected channel	4 Amperes (10A peak)
3	OUT	INJECTION B	Ground command open drain - 2nd injected channel	4 Amperes (10A peak)
4	OUT	INJECTION C	Ground command open drain - 3rd injected channel	4 Amperes (10A peak)
5	OUT	INJECTION D	Ground command open drain - 4th injected channel	4 Amperes (10A peak)
6	COM	TX_FTDI	ECU tuning (WinjNet)	FTDI TTL level
7	OUT	LED DIAG-ALARM	LED command	10 milliamperes
8	IN	MIXED INPUT 1	analogic - resistive selectable input	Measurement range 0-5 volts
9	IN	MIXED INPUT 2	analogic - resistive selectable input	Measurement range 0-5 volts
10	IN	MIXED INPUT 3	analogic - resistive selectable input	Measurement range 0-5 volts
11	IN	SPEED INPUT OR AUX PHASE	Speed input or auxiliary camshaft phase input	Hall or magneto-resistive following external resistor
12	IN	MAIN PHASE	Main camshaft phase sensor input	Inductive-Hall selection, gain automatic adaptation
13	OUT	AUXILIARY COMMAND 1A	Disconnectable Vbat push-pull command	4 Amperes (10A peak)
14	SUPPLY IN	AFTER KEY POWER SUPPLY +15	After key 12V power supply	6-18 volts
15	GROUND IN	SUPPLY ENGINE GROUND	Ground supply for ECU	
16	OUT	AUXILIARY COMMAND 3	Ground command open drain	4 Amperes (10A peak)
17	OUT	AUXILIARY COMMAND 4	Ground command open drain	4 Amperes (10A peak)
18	OUT	AUXILIARY COMMAND 5	Ground command open drain	4 Amperes (10A peak)
19	COM	RX_FTDI	ECU tuning (WinjNet)	FTDI TTL level
20	OUT	5V SENSORS POWER SUPPLY	5volts output for sensors supply	Regulated 5 volts (total max 50 mA)
21	IN	MIXED INPUT 4	analogic - resistive selectable input	Measurement range 0-5 volts
22	IN	RESISTIVE INPUT 1	0-5 volts resistive input	Measurement range 0-5 volts
23	IN	RESISTIVE INPUT 2	0-5 volts resistive input	Measurement range 0-5 volts
24	IN	RESISTIVE INPUT 3	0-5 volts resistive input	Measurement range 0-5 volts
25	IN	RPM +	Crankshaft rpm sensor input	Inductive-Hall selection, gain automatic adaptation
26	OUT	AUXILIARY COMMAND 2A	Disconnectable Vbat push-pull command	4 Amperes (10A peak)
27	OUT	AUXILIARY COMMAND 1B	Disconnectable Vbat push-pull command	4 Amperes (10A peak)
28	SUPPLY IN	PERMANENT POWER SUPPLY +30	12 volts permanent power supply	6-18 volts
29	GROUND IN	POWER ENGINE GROUND	Ground input for power commands	
30	OUT	IGNITION A	12volts push-pull command - 1st ignition channel	50 milliamperes
31	OUT	IGNITION B	12volts push-pull command - 2nd ignition channel	50 milliamperes
32	OUT	IGNITION C	12volts push-pull command - 3rd ignition channel	50 milliamperes
33	OUT	IGNITION D	12volts push-pull command - 4th ignition channel	50 milliamperes
34	IN	ANALOG INPUT 1	0-5 volts analogic input	Measurement range 0-5 volts
35	IN	ANALOG INPUT 2	0-5 volts analogic input	Measurement range 0-5 volts
36	IN	ANALOG INPUT 3	0-5 volts analogic input	Measurement range 0-5 volts
37	IN	ANALOG INPUT 4	0-5 volts analogic input	Measurement range 0-5 volts
38	GROUND OUT	SENSORS GROUND	Ground output for sensors supply	
39	CAN	CAN2_H	Auxiliary CAN (external)	With integrated 120 Ohms resistor
40	CAN	CAN2_L	Auxiliary CAN (external)	With integrated 120 Ohms resistor
41	OUT	AUXILIARY COMMAND 2B	Disconnectable Vbat push-pull command	4 Amperes (10A peak)
42	OUT	AUXILIARY COMMAND 6	Ground command open drain	125 milliamperes