SRT / SRAE SOFTWARE DOCUMENTATION SUPER-USER

8. INJECTION

chapter 8

Release : 2.0

REVISIONS DOCUMENT

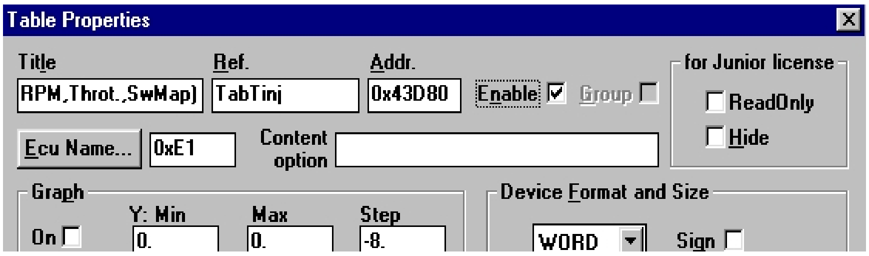
Release	*Author*	*Date*	*Modifications*
1.0	**M.Mersier**	**04/05/2004**	• **Creation (SRA)**
2.0	**M.Mersier**	**09/15/2006**	• **Update (SRT/SRAE)**

8.1 Base Fuel Injection Quantities

It is extremely important to understand that two possible maps presented hereafter cannot coexist. They are at the same address in the ECU, and only one set (the one adapted to your system) must be activated, the other one being deactivated.

In order to achieve this activation selection, you must enter the maps' properties and only enable the map you actually want to use.

Just a quick reminder on the way to change the "enable" tag in the map properties:



8.1.1 Quantity Injected as a Function of RPM / Inlet Air Pressure / Double map switch position (Non Turbo Engines)

The quantity of fuel injected per cylinder per engine cycle is expressed in microlitres as a function of RPM and inlet air pressure in mbar. The base map **EE.Ti.TabTinj1** .is expressed in microlitres (10^{e-6} Litre) / Bar [or nanolitres (10^{e-9} Litre) / mbar(10^{e-3} Bar)].

The double map switch position determines the Z-axis (if there isn't a double map switch, the active map is the first one; but in that case it's always safer to copy the same map in the two possible positions of the switch).

$$\boxed{\mathbf{QinjBase = (FD.Acq.Padm + FD.Ti.Offs\_alt) * CartoBase,f(RPM, Padm)}}$$

where:

- ***FD.Acq.Padm***, in mbar (inlet air pressure)
- ***FD.Ti.Offs_alt*** in mbar (Altitude Correction)

8.1.2 Base Fuel Quantity Injected as a Function of RPM / Throttle / Double map switch position (Non Turbo Engines)

The quantity of fuel injected per cylinder per engine cycle is expressed in microlitres as a function of RPM and throttle position. The base map is expressed in microlitres (10^{e-6} Litre) **EE.Ti.TabTinj** .

The double map switch position determines the Z-axis (if there isn't a double map switch, the active map is the first one; but in that case it's always safer to copy the same map in the two possible positions of the switch).

$$\mathbf{QinjBase = (1 - \frac{FD.Ti.Offs\_alt}{EE.Acq.PatmCarto}) * CartoBase, f(RPM, Throttle)}$$

where:

- ***FD.Ti.Offs_alt*** in mbar (Altitude Correction describe in the next paragraph)
- ***EE.Acq.PatmCarto*** in mbar (atmospheric pressure on the day of the engine mapping)

8.1.3 Base Fuel Quantity Injected for Turbo Engines

See § 9.6.4 "Open Loop Injection Quantity" in documentation Turbo-x.doc

8.1.4 Altitude Correction

The altitude correction is homogenous with the inlet air pressure as follows:

$$\mathbf{FD.Ti.Offs\_alt = (EE.Acq.PatmCarto - FD.Acq.Patm) * EE.Ti.tab\_KPatm, f(RPM)}$$

Where:

- ***FD.Acq.Patm***, in mbar (atmospheric pressure)
- ***EE.Acq.PatmCarto***, in mbar (atmospheric pressure on the day of the engine mapping).This function automatically makes a correction, adapting the injected quantity, based on the difference between to the current atmospheric pressure (on the day of use on the vehicle) and the reference atmospheric pressure at which the base map was made.

It is of course important, if possible, to try to do all the main mapping within a single day (atmospheric pressure being unlikely to change drastically during that time), so that the reference atmospheric pressure, filled-in at the beginning of the mapping, keeps its relevance.

EE.Ti.tab_KPatm, as a function of RPM. This function has an authority coefficient : standard value is 1.00, but it can be modified between 0 and 2 (if it turns out to be too strong or too soft) .

NOTE: This coefficient should be disabled (all set to 0.00) for dyno mapping, so that it is of no influence during the mapping.

8.1.5 Scale Factor

The scale factor (***EE.Ti.Kscale***) is used in the calculation of base injected fuel quantity as follows, and has a value between 0 and 2.

$$\boxed{\mathbf{QinjBase = QinjBase * EE.Ti.Kscale}}$$

8.1.6 Injection Quantity, Other Corrections

The other corrections are applied as follows:

$$\begin{aligned}\mathbf{Qinj = [}&\mathbf{QinjBase * FD.Ti.Kobj * FD.Ti.Ktess, f(FuelT) * FD.Ti.Kpadm, f(Padm)}\\ &\mathbf{* FD.Ti.Krpm, f(RPM) * FD.Ti.KTair, f(AirT) * FD.Ti.KPap, f(Throtttle)}\\ &\mathbf{* FD.Plus.Kinjfil * FD.Ti.Kdem, f(WaterT, NbTDCs) * FD.Ti.KPapReg, f(Throttle, RPM)}\\ &\mathbf{* FD.Ti.KCliqRicf(Cockpit\ Injection Trimmer)]}\\ &\mathbf{+ FD.Ti.EnrAccel - FD.Ti.AppDecel}\end{aligned}$$

If the result of the calculation is negative, ***Qinj = 0.***

- ***FD.Ti.Kobj*** is the Lambda correction as a function of engine speed and throttle position, read in the map **EE.Ti.tab_KObj** and has a value between 0 and 2.
- ***FD.Ti.Ktess*** is the correction as a function of fuel temperature, read in the map **EE.Ti.tab_KTess** and has a value between 0 and 2.
- ***FD.Ti.Kpadm*** is the correction as a function of inlet air pressure, read in the map **EE.Ti.tab_KPadm** and has a value between 0 and 2.
- ***FD.Ti.KRpm*** is the correction as a function of engine speed, read in the map **EE.Ti.tab_KRpm** and has a value between 0 and 2.
- ***FD.Ti.Ktair*** is the correction as a function of air temperature, read in the map **EE.Ti.tab_KTair** and has a value between 0 and 2.
- ***FD.Ti.Kpap*** is the correction as a function of throttle position, read in the map **EE.Ti.tab_KPap** and has a value between 0 and 2.

- ***FD.Plus.Kinjfil*** is the active correction during Upshift, and has a value between 0 and 2. It is calculated during the Upshift function. If it is not active, ***FD.Plus.Kinjfil*** equals 1.(for more details , see **Other_Strategies_x.doc**).

- ***FD.Ti.Kdem*** is the correction as a function of water temperature and number of TDCs since engine start, read in the map **EE.Ti.tab_KDem** and has a value between 0 and 8.

  When the maximum number of TDCs since engine start is reached (last column value), the correction function of water temperature is still active. From then on, this last column is the valid injection correction as a function of water temperature.

  - **EE.Ti.bornes_injdep** Table of breakpoints, expressed in number of TDCs sold since the starting up, for the table of correction after engine start.
  - **EE.Ti.Nbkp_injdep** Number of breakpoints for the previous table.

- ***FD.Ti.KPapReg*** is the correction as a function of throttle position and engine speed, read in the map **EE.Ti.tab_KPapReg** and has a value between 0 and 2.
  This correction is calculated only when the operating mode Inlet Air Pressure / Rpm is selected (**EE.CfgU.PadmRpm = 1** see Client_Configuration.doc**).** In operating mode Throttle / Rpm, ***KpapReg = 1* .**

- ***FD.Ti.KClicRic*** is the correction as a function of Cockpit Injection Trimmer position, read in the map **EE.Ti.Tab_KClicRic** Injection Correction f(Cockpit InjectionTrimmer position) and has a value between 0 and 2.

- **FD.Ti.EnrAccel** is the correction calculated by the acceleration transient function. It is expressed directly in microlitres and is the additive quantity of injected fuel. (for more details , see $8.3.2).

- **FD.Ti.AppDecel** is the correction calculated by the deceleration transient function. It is expressed directly in microlitres and is the subtractive quantity of injected fuel. (for more details , see $8.3.3

8.1.7 Rest of the terms in the injection time calculation

Qinj = Qinj * FD.Ti.PotTi * FD.LbP.GainLoop

- ***FD.Ti.PotTi*** is the correction during mapping with «VISION». It allows a correction between 0 and 64. At all other times it equals 1. (for more details , see Vision.doc).

- ***FD.LbP.GainLoop*** is the correction as a function of lambda sensor signal. It allows a correction between 0.5 and 1.5. If the lambda function is not authorised, **FD.LbP.GainLoop** equals 1. (for more details , see Lambda.doc).

8.1.8 Ratio Split Between the Two Injector Banks

The fuel quantity to be injected per cylinder is split between the two banks (if two banks exist). This ratio repartition is function of RPM and throttle position as described in the map **EE.Ti.tab_ratio**.

This is expressed as a percentage (100% = all the fuel on the high bank, 0% all the fuel on the low bank). If the final command time of one bank, after the application of the injector flow rate, gives a time less than Tmin1 or Tmin2, all the fuel quantity is injected on the other bank.
The changing of this ratio is filtered by two different coefficients, the first when the ratio is increasing (**EE.Ti.KfiltRatioUp**) (low bank to high bank) and the second when the ratio is decreasing (**EE.Ti.KfiltRatioDown**) (high bank to low bank).

8.1.8.1 "Vision" setting of the ratio potentiometer

A configuration map (**EE.Ti.ModePotRatio**) allows to choose the operating mode of the "Vision" ratio potentiometer: "substitutive mode" (the potentiometer value replaces the current value) or "additive mode" (the potentiometer value is added to the current value). The "VISION" configuration (.cfg) must be modified accordingly! (see Vision.doc)

8.1.9 Distribution of the injection between FRONT / REAR cylinders (V-engines)

For "V" engines, it can be necessary to apply a correction to one group of cylinders (front / rear), to compensate for air intake differences or exhaust temperature imbalance.
This correction is interpolated in the map **EE.Ti.tab_Krepart** as a function of throttle position and engine speed. This is expressed as a correction between 0% and 200% and is applied only to the cylinders (1 to 8) specified in the map **EE.Ti.RepartCylindre[cyl]** (0 = no correction; 1 = correction applied):

NOTE: this gain is applied on each selected cylinder as a whole (even when there are two banks of injectors, it's the global quantity of fuel that is corrected).

8.1.10 Individual Cylinder Correction

There are 8 similar maps of correction (**EE.Ti.CorInjCyl1** to **EE.Ti.CorInjCyl8**) for the injected fuel quantity as a function of RPM; one for each of the 8 cylinders. These corrections represent a gain between 0 and 2 and are applied as follows:

$$\boxed{\mathrm{Qinj}_n = \mathrm{Qinj} * \mathrm{EE.Ti.CorInjCyl}_n, f(\mathrm{RPM})}$$

8.2 Starting Injection

In order to manage to start properly the engine, there is a special working mode of the injection during fire-up.
During starting, the injection is not sequentially phased. The injections are made on all cylinders simultaneously and on each tooth of the crank trigger wheel. This mode of injection stops when the engine speed is considered sufficient or when the accumulated fuel injected reaches a threshold. The transition to sequential injection only starts at the moment when the engine speed exceeds the threshold.
In the case where the accumulated fuel reaches the limit but the engine speed has not reached its threshold, there is no more injection.
The accumulator is reset to zero on re-initialisation of the ECU (and therefore, after an unsuccessful fire-up, it is better to reset the ECU and start again, which re-enables the starting procedure).
The ratio maps (for 2 banks of injectors, if fitted) also apply in this mode.

- **EE.Ti.TinjDent** Quantity of fuel per tooth and per cylinder in micro-litres.
- **EE.Ti.CumulTinjDent** Cumulated fuel injection quantity limit in micro-litres f(water temperature)
- **EE.Ti.SRegStopInjDent** RPM threshold to exit the starting procedure & enter the start of phased sequential injection.

8.3 Throttle Transient Mode (Acceleration, Deceleration, Deceleration Cut)

8.3.1 Throttle Derivative

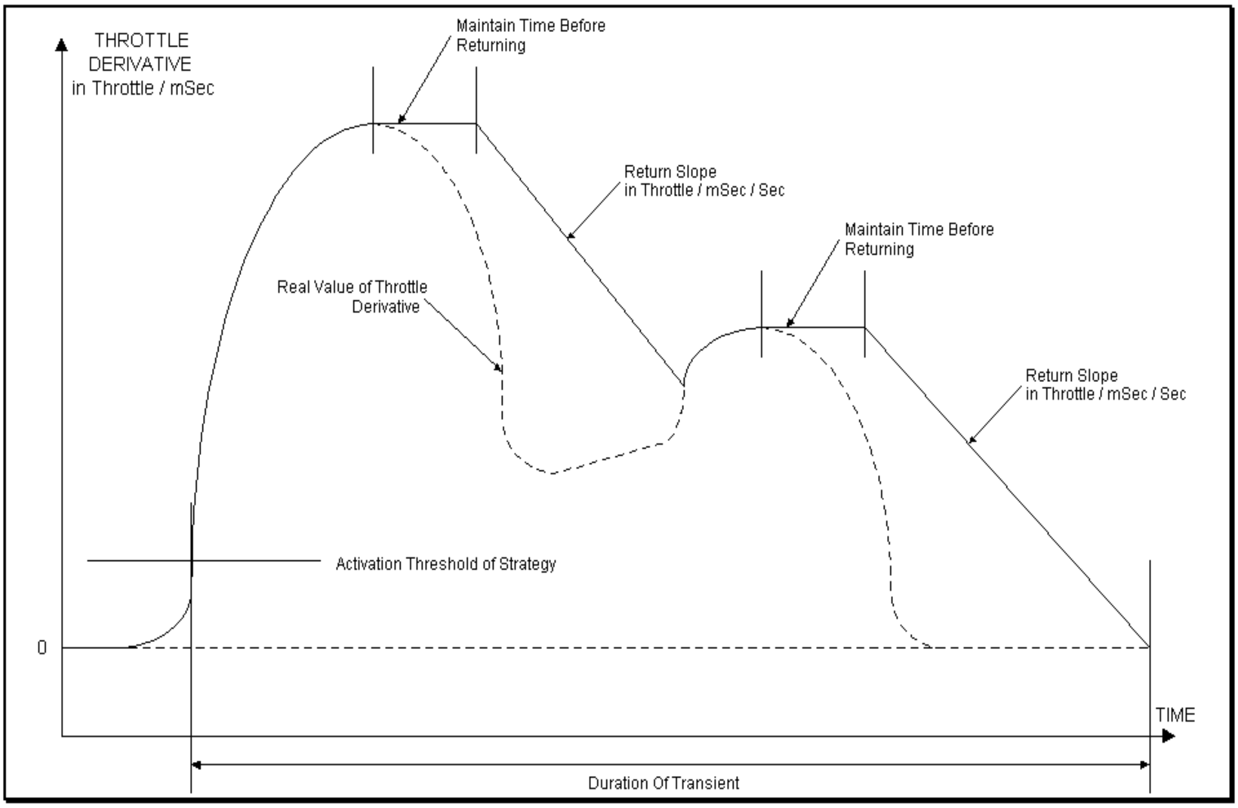
The calculation of enrichment and enleanment (when the throttle transient is active) is made from the throttle derivative. This is calculated on a programmable time interval to give a positive or negative result in Throttle (° or %) / millisecond.

EE.Acq.DfarfTime is the derivative calculation interval time.

The sign of the result of this derivative calculation determines acceleration (positive derivative) or deceleration (negative derivative). After this stage, the derivative is always considered as positive, for comparison with its thresholds. The value of the derivative is maintained for a certain period of time after it reaches a maximum and is then filtered back to zero.

EE.Acq.DerTime Hold time after the derivative reaches its peak value.

Step to return derivative to zero. (Parameters are different for acceleration **EE.Acq.Kderp** and deceleration **EE.Acq.Kdern**).



8.3.2 Acceleration Transient

The acceleration transient is not calculated unless the derivative exceeds the activation threshold.This uses the calculated derivative directly (limited to the maximum threshold.) to determine the additional fuel quantity to inject:

$$EnrAccelBase = \frac{dPap}{dT} * EE.Ti.KtrGen$$

where:

- ***dPap/dt***, filtered throttle derivative in ° (%) Throttle / millisecond.
- ***EE.Ti.KtrGen***, General conversion coefficient in microlitres / ° (%) Throttle / millisecond.
- ***EnrAccelBase***, base acceleration transient fuel quantity in microlitres.

➢ ***EE.Ti.KtrGen***, Conversion coefficient of throttle derivative into fuel quantity.

➢ **EE.Acq.DFarfPSI** Threshold of minimum derivative for activation of the acceleration transient.

➢ **EE.Acq.DFarfPSS** Maximum applied throttle derivative for acceleration transient.

This calculated base quantity is corrected according to the following formula and logic:

IF Turbo Mode is Active

Then

$$EnrAccel = EnrAccelBase * KTeau * KRpm * Kpap * KP2$$

Else

$$EnrAccel = EnrrAccelBase * KTeau * KRpm * Kpap$$

where:

- ***EnrAccel***, fuel quantity used in the injection time calculation in microlitres.
- ***EnrAccelBase***, base acceleration transient fuel quantity in microlitres.
- ***KTeau***, gain correction between 0 and 4; f(water temperature).
- ***KRpm***, gain correction between 0 and 4; f(RPM).
- ***KPap***, gain correction between 0 and 4; f(throttle).
- ***KP2***, gain correction between 0 and 4; f(turbo pressure).

➢ ***EE.Ti.tab_TrTeau***, Correction coefficient as a function of water temperature.

➢ ***EE.Ti.tab_TrReg***, Correction coefficient as a function of engine speed.

➢ ***EE.Ti.tab_TrPap***, Correction coefficient as a function of throttle position.

➢ ***EE.Ti.tab_TrP2***, Correction coefficient as a function of turbo pressure.

8.3.3 Deceleration Transient

The deceleration transient is not calculated unless the derivative exceeds the activation threshold. This uses the calculated derivative directly (limited to a maximum threshold) to determine the fuel quantity to withdraw prior to injection:

$$\boxed{AppDecelBase = \frac{dPap}{dT} * EE.Ti.KApGen}$$

where:

- ***dPap/dt***, filtered throttle derivative in ° (%) Throttle / milliseconds
- ***AppDecelBase***, base deceleration transient fuel quantity in microlitres.
-

- ***EE.Ti.KapGen***, Conversion coefficient of throttle derivative into fuel quantity.

- **EE.Acq.DFarfNSI** Threshold of minimum derivative for activation of the deceleration transient.

- **EE.Acq.DFarfNSS** Maximum applied throttle derivative for deceleration transient.

This base quantity is corrected by a coefficient f(RPM):

$$\boxed{AppDecel = AppDecelBase * EE.Ti.tab\_ApReg}$$

where:

- ***AppDecel***, fuel quantity used in the injection time calculation in microlitres.
- ***AppDecelBase***, base deceleration transient fuel quantity in microlitres.

- ***EE.Ti.tab_ApReg***, Correction coefficient as a function of engine speed.

8.3.4 Deceleration Fuel Cut

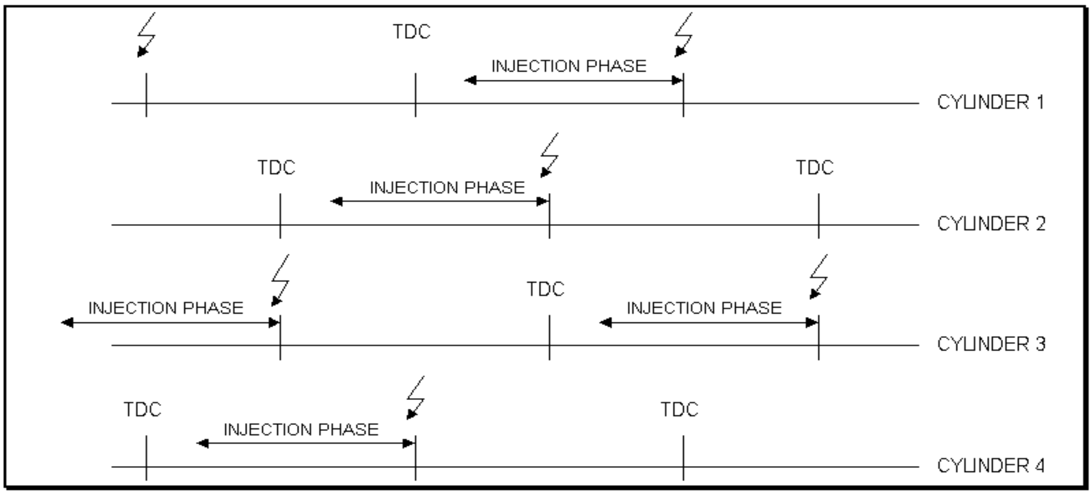
If this function is selected in the map **EE.Ti.ChxCoupureDecel** The deceleration fuel cut enables the total cut of fuel on all cylinders when the engine speed is above the threshold **EE.Ti.Sreg_coupure** and the throttle position is below the threshold **EE.Ti.Spap_coupure**:

In this case we have:

$$\boxed{Qinj = 0}$$

8.4 Phase of injection

The injection phase is defined in crankshaft degrees relative to the firing TDC.
It can be set from 0° to 720° and expressed relatively to the start or the end of the injection time.
In the case of an "end of injection" referenced phase, the opening position of the injector cannot exceed 720° (so, in that case, the maximum applied phase is 720° - the injection time equivalence in ° !).



There are two maps of injection phase as a function of RPM and throttle angle:

- **EE.Ti.tab_phase1**: is the first one for the primary bank of injectors (top bank)
- **EE.Ti.tab_phase2**: is the second for the secondary bank of injectors (bottom bank).

A third parameter limits the possible variation in phase (filter function), from one TDC to the next, and is expressed in crankshaft degrees.

8.4.1 Injection Phase Filter

The phase variation between 2 Tdc, is limited by the max value **EE.Ti.delta_phase**

8.4.2 Phase Positioning

The injection phase may be referenced from the start of injection or the end of injection. This selection is made in the map **EE.Ti.PhaseFinInj** The value of 0 defines the start of injection; the value of 1 defines the end of injection.

8.4.3 "Vision" setting of the Phase potentiometers

The configuration map **EE.Ti.ModePotPhase** allows to choose the operating mode of the “Vision” phase potentiometers: "substitutive mode" (the potentiometer value replaces the current value) or “additive mode" (the potentiometer value is added to the current value). The "VISION" configuration (.cfg) must be modified accordingly ! (see Vision.doc)