A'PEXi PowerFC (deleted 20 Apr 2008 at 01:52)

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The introduction to this article provides **insufficient context** for those unfamiliar with the subject.
Please help improve the article (http://deletionpedia.dbatley.com/w/index.php?title=A%27PEXi_PowerFC_(deleted_20_Apr_2008_at_01:52)&action=edit) with a good introductory style.

The **A'PEXi PowerFC** is a standalone automotive engine management system (EMS) or engine control unit (ECU). It replaces the existing engine control system and provides an interface to modify engine operating characteristics. The unit is a direct plug in replacement and is preprogrammed for the Japanese Domestic Market (JDM) vehicle. It requires no additional tuning if run on an equivalent fuel (100 octane). Existing peripheral devices such as air conditioning will continue to function. Existing ODB diagnostics are not maintained if present in the original equipment.

Datalogit (http://www.fc-datalogit.co.nz/index.html) provide a third party software package that interfaces with the A'PEXi PowerFC.

Contents

Operating Limits

The PowerFC provides idle control, RPM control, boost control and associated warnings to ensure engine operating limits are maintained.

RPM and Idle Control

PowerFC RPM[1] and Idle control are separate engine management tasks that ensure the engine does not stall when the throttle is released or exceed the engines operating limit when the throttle is depressed.

RPM Limit	This is a fuel or ignition cut RPM threshold [2]
Throttle Closure Fuel Cut (FC 1)	This is the RPM threshold above which fuel is cut when the engine throttle is closed in the absence of electrical load
Throttle Closure Fuel Cut with Electrical Load (FC 2)	This is the RPM threshold above which fuel is cut when the engine throttle is closed [3] in the presence of electrical load[4]
Idle RPM (Idle1)	This is the idle control target RPM without electrical load. Idle control is active when the throttle is closed and is achieved by adjusting the idle control valve in the throttle body.[5]
Idle RPM with Electrical Load (Idle2)	This is the idle control target RPM with electrical load

The fuel cut RPM settings (FC1 and FC2) must be set above the associated idle settings (Idle1 and Idle2).

Idle hunting can occur in the abscence of any mechanical fault with the idle control valve when a change is made to the injection and ignition map values at idle or the fuel cut and idle thresholds. The PowerFC will attempt to recalibrate (or "relearn") idle control after a change to these settings.[6]

Boost Control

Boost control is required on forced induction engines and is the maintanence of engine intake manifold pressure. The target manifold pressure is (generally) measured with reference to the turbo (or supercharger) inlet pressure rather than atmospheric pressure due to the slight vacuum created by the turbo during operation.

Boost	This is the inlet manifold pressure above which boost control is active[7][8]
Duty	This is the waste gate duty cycle (%). [9][10]
Correction	This is the current correction the PowerFC boost controller is applying to the base duty. [11]

Function Select

The PowerFC allows the following engine management functionality to be activated and deactivated as required.

Boost Kit	Activates the optional A'PEXi PowerFC boost controller[12]
Air-Flow Warning	Activates the MAF[13] voltage warning
Injector Warning	Activates the injector duty[14] warning
Knock Warning	Activates the knock sensor warning
O2 F/B Control	Activates O2 closed loop control

Air-Flow Warning

Threshold	This is the MAF voltage threshold above which the air flow warning is active
Setting	This is the duration (msec) that the check engine light is activated when the MAF voltage threshold is exceeded

Injector Warning

Threshold	This is the injector duty threshold (%) above which the injector warning is active
Setting	This is the duration (msec) that the check engine light is active when the injector duty threshold is exceeded

Knock warning

The knock sensor compares the frequency of actual engine vibrations with engine RPM. The presence of knock[15] (or detonation) is indicated by engine vibration that occurs at a frequency that differs with engine RPM.

The PowerFC references knock against an arbitrary scale from 0 to 100 and the associated threshold is generally set between these values.

Threshold	This is the knock sensor threshold above which the knock sensor warning is active
Setting	This is the duration (msec) that the check engine light is activated when the knock sensor threshold is exceeded

O2 feedback threshold

The O2 feedback threshold and associated control function uses the narrow band lambda sensor output to modify the current air to fuel ratio (AFR[16]) to achieve the target defined in the INJ Map. It is common practice to deactivate O2 feedback control when modifying or checking the INJ Map.

INJ Correction	Defines an injector pulse width correction below which O2 feedback control is active

The relationship between injector pulse width and target AFR is given in the INJ Map section.

LOAD

The PowerFC equates engine load with inlet manifold pressure on both MAP (Manifold Absolute Pressure) and MAF (Mass Air Flow) based units. The MAF based PowerFC calculates inlet manifold pressure from the associated air flow.

Once engine load has been calculated the associated injector pulse width required for correct fueling can be obtained. MAF based units calculate this pulse width and MAP based units consult a look up table. The LOAD associated injector pulse width provides a stochiometric air fuel ratio.

Map Reference

The Map Reference table defines the LOAD and RPM divisions used by the INJ and ING Maps.

LOAD	Defines 20 RPM reference points (N1 to N20)
RPM	Defines 20 load reference points (P1 to P20)

Air Flow Correction (AFC)

Defines eight MAF sensor voltages and associated Air Flow percentage corrections.

Air Flow Curve (AF)

Defines 32 MAF sensor voltages and the associated volume of air that enters the engine. This curve models the engines volumetric efficiency (VE[17]) with the throttle wide open (WOT[18]).

LOAD calculation

LOAD = min (2^15, (AFC * AF) / RPM) * (2^14))

Notice that the maximum LOAD is 32768 (= 2^15) and that this is also the maximum practical LOAD MAP Reference[19][20].

Injection Map

The PowerFC Injection Map is a 20 by 20 grid that defines a target AFR[16], Lambda[21] and Injector (Pulse Width) Correction[22] for each LOAD and RPM pair, (P, N).

The relationship between AFR, Lambda and Correction is shown in the following table. The Stoichiometric Air Fuel Ratio for each fuel has been highlighted. Notice that, independent of fuel type, Correction = 1 / Lambda.

The Injection Map target AFR = 14.7 * Correction for automotive petrol[23].

Air Fuel Ratio					Lambda	Correction
Petrol	Diesel	Propane	Ethanol	Methane		
14.0	18.8	14.9	8.6	6.1	0.95	1.05
14.7	14.5	15.7	9.0	6.5	1.00	1.00
15.4	15.2	16.5	9.5	6.8	1.05	0.95

Injector Pulse Width (PW)

PW = (SFR x TFR x WTC x ATC x IFC) + ((TPC x TPO) + BLO + ILO + ECO) (msec)

- SFR → Stoichiometric AFR pulse width[24](msec)
- TFR → Target (Air) Fuel Ratio given by the INJ Map pulse width correction
- WTC → Water Temperature Correction
- ATC → Air Temp Correction
- TPO → Throttle Position Offset or Accelerator Enrichment
- TPC → Throttle Position Correction or Enrichment Correction
- IFC → Injector Flow (%) Correction
- ILO → Injector Lag Offset
- BLO → Battery Voltage Offset

Injector Pulse Width controls the length of time (msec) each fuel injector is open and is proportional to the fuel delivered at the current fuel pressure[25].

Injection Correction

Water Temperature Correction (WTC)

LOAD	Two LOAD thresholds above which the associated water temperature correction applies

Corrections	Six PW corrections to apply for associated water temperature (and LOAD threshold)

Accelerate Injector (TPO)

RPM	Five RPM thresholds at which to apply the associated injector offset and decay
Amount	PW offset for the current RPM (given a positive change in TPS[26] output)
Decay	PW offset decay to apply to the current TPO

INJ vs. ACCEL TPS1 (TPC)

Input	Three TPS deltas that reference small, medium and large changes in throttle position (0 – 256)
Setting	Acceleration enrichment setting (0 – 256)

The relevant TPC correction is obtained by dividing the associated setting by 256.

Cranking (ECO)

Six water temperature dependent injection offsets (msec) added to the injector pulse width during engine cranking/starting.

INJ vs. Air Temp and Boost (max) (ATC)

The PowerFC provides three air temperature based injection corrections and two maximum loads.

Temp	Air temperature(C) at which to apply the associated correction
Setting	PW correction for the current temperature
Boost	LOAD maximum for the current temperature

INJ vs. Water Temp and Boost (max) (WTC)

The PowerFC provides two water temperature based injection corrections and maximum loads.

Temp	Water temperature(C) at which to apply the associated correction
Setting	PW correction for the current water temperature
Boost	LOAD maximum for the current temperature

Injection Settings

Injector flow is a function of injector size, fuel pressure and manifold (air) pressure.

FLOW = (actual fuel pressure / fuel pressure)$^{1/2}$ * injector size

Injector Correction (IFC) (ILO)

The PowerFC provides a pulse width correction (%) and lag time offset for each injector. These settings are used to adjust for non-standard injectors and/or fuel pressure variation[27]. Injector correction can be set within the range of 24.9% to 120% corresponding to injectors 4 times stock or 2/3 times stock respectively.

Correction (IFC)	standard flow / actual flow (cc)
Offset (ILO)	actual lag - standard lag (msec)

INJ lag vs. Battery Voltage (ILO)

- Six battery voltage dependent lag time offsets

Ignition Map

The PowerFC provides a 20 by 20 map or grid that contains the Ignition Angle, Before Top Dead Centre (BTDC) for each LOAD and RPM pair. Ignition Angle has the greatest influence on cylinder pressure, power, torque and detonation (or knock).

Ignition Correction

IGN vs. Water Temp (above operating temperature)

- Two water temperature dependant IGN timing offsets

The offset retards the timing or reduces the ignition angle BTDC.

IGN vs. Water Temp (below operating temperature)

- Four water temperature dependent IGN timing offsets (retard)

IGN DWELL vs. Battery Voltage

- Six, battery voltage dependant, IGN dwell[28] corrections

IGN DWELL vs. RPM

- Six, RPM dependent ignition, dwell times[29] (msec)

Ignition dwell does not affect ignition angle, it is used to adjust the length of time charge is applied to the coil pack before it is discharged to the spark plug.

IGN vs. Air Temp

- Three air temperature dependant IGN timing offsets (retard)

Footnotes

1. ↑ RPM = Revolutions Per Minute

2. ↑ The (standard) PowerFC uses a fuel cut and the PowerFC Pro uses an ignition cut at the RPM limit. Due to the nature of the fuel cut RPM limit the PowerFC can exhibit lean mixtures under full boost at maximum RPM. A boost controller with RPM compensation, such as the APEXI AVC-R, provides reduced manifold pressures at maximum RPM and hence less risk of leaning out.
3. ↑ Throttle closure is detected when the throttle position sensor (TPS) output is zero
4. ↑ Electrical load is (generally) triggered by turning on the air conditioning and/or associated fan
5. ↑ The ECU (electronic control unit) maintains idle by adjusting (opening/closing) the idle valve in the throttle body (fuelling and ignition is adjusted as normal)
6. ↑ Smooth and gentle variation in the injection and ignition map values around idle will aid stable idle control.
7. ↑ To avoid any boost threshold fuel cut the selected boost must exceed any external controller target
8. ↑ The PowerFC measures manifold pressure in kilograms per square centimetre (kg/cm2)
9. ↑ The waste gate duty cycle defines the percentage of time the turbo waste gate is closed. The turbocharger waste gate will remain closed (allowing engine intake manifold pressure to rise) until the waste gate duty solenoid is activated. While the waste gate duty solenoid is active boost pressure is bleed away from the waste gate actuator (allowing intake manifold pressure to fall). The base waste gate duty must be set high enough to achieve the desired boost pressure and low enough to provide engine protection against over boosting.
10. ↑ Base duty is modified by the A'PEXi PowerFC self learning boost controller
11. ↑ The PowerFC Boost controller correction is an arbitrary value between 255 and 0. This value cannot be modified directly and resets to the value of 255 when either the Boost or Duty is modified.
12. ↑ The WRX requires selection of the boost controller kit even if one is not installed
13. ↑ MAF = Mass Air Flow
14. ↑ Injector Duty = Actual Pulse Width (msec) / Maximum Available Pulse Width <msec> at the current RPM. As RPM increases the availble injection window decreases
15. ↑ High knock counts seen during deceleration are not caused by pre-ignition since no fuel is injected until the fuel cut RPM threshold is reached
16. ↑ [16.0] [16.1] AFR = Air Fuel Ratio
17. ↑ Volumetric Efficiency is the ratio of air entering the engine and engine capacity at a specified RPM
18. ↑ WOT = Wide Open Throttle
19. ↑ The constant 2^14 = 16384 was obtained by Datalogit after decompiling the A'PEXi PowerFC firmware
20. ↑ The maximum practical LOAD can be observed by setting a MAP reference greater than 2^15
21. ↑ Lambda = Actual Air Fuel Ratio / Stoichiometric Air Fuel Ratio
22. ↑ Pulse width correction (from the INJ Map) required to achieve target AFR for the current LOAD and RPM
23. ↑ An AFR of 12.5 has been shown empirically to provide best power
24. ↑ SFR is the pulse width in milliseconds required to achieve a stoichiometric AFR and is calculated from the MAF voltage at the current RPM (or recorded in the Base Map if defined)
25. ↑ Fuel pressure is controlled by the existing or after market Fuel Pressure Regulator. It monitors manifold pressure and adjusts the return fuel flow rate (back to the fuel tank)
26. ↑ TPS = Throttle Position Sensor
27. ↑ For example the Impreza WRX has two fuel rails (in series) feeding cylinders 4 and 2 followed by 1 and 3. The pressure drop for cylinders 1 and 3 causes them to run lean/hot (specifically cylinder 3). The injector settings provided by the PowerFC can compensate for this mechanical characteristic
28. ↑ DWELL = time to build ignition charge (in the associated coil)
29. ↑ Dwell times can be measured and set by monitoring the time taken to achieve peak amperage at each ignition coil

External links

- Turbo Magazine Feature (http://www.turbomagazine.com/features/0106tur_apexi_drag_racing_acura_integra/index.html) → " (covering the quarter mile in) 9.006 (seconds) at 156.43 mph"
- Autospeed Review (http://autospeed.com/cms/A_0301/article.html?popularArticle)
- A'PEXi PowerFC FAQ (http://paulr33.skylinesaustralia.com/docs/powerfc-faq/powerfc-faq.htm)
- Datalogit Software (http://www.fc-datalogit.co.nz/index.html)

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