MoTeC

MULTI THROTTLE TUNING METHOD

Introduction

This Technical Note details a simplified method to tune a boosted or naturally aspirated engine that contains an individual throttle for each cylinder using M1 GP Packages firmware.

➞ This method requires M1 Tune version 1.4.0.254 or later

Legend

- Parameter, Channel or Table within the package.
- `Parameter value`

Background

MoTeC's engine efficiency model calculation requires the measurement or estimate of a consistent inlet port pressure. In a common throttle engine the inlet port pressure can be consistently measured in the plenum using the inlet manifold pressure sensor.

On a multi throttle engine there is only a small volume of air between the throttle butterfly and intake valve. This causes the inlet port pressure to vary significantly with throttle butterfly angle, pre-throttle pressure and pulses created by the intake valve movement. Direct measurement of this inlet port pressure, using the inlet manifold pressure sensor, does not provide consistent values. Without a consistent measurement the inlet manifold pressure must be estimated using the Inlet Manifold Pressure Estimate table. To tune both this table along with the Engine Efficiency table becomes quite complex on a multi throttle engine due to the large number of variables.

Extensive research and testing has allowed MoTeC to develop a simplified tuning method to overcome these complexities. The method described here does not require tuning of the Engine Efficiency table. Only the Inlet Manifold Pressure Estimate table requires tuning.

In order to compensate for the effect of the pre-throttle pressure (Boost Pressure or Airbox Pressure), two tables have been added; Engine Efficiency Boost Pressure Compensation and Engine Efficiency Airbox Pressure Compensation.

Setup

- Turn off all Engine Efficiency table axes and set the remaining site to `100%`. This table will not be adjusted.
- Set Engine Load Normalised Mode to `Normal`. For more information about Engine Load Normalised and it's effects on the engine tune refer to the *Engine Load Normalised* section.
- Set Engine Efficiency Mode to `Manifold Air Density`.
- Set Inlet Manifold Pressure Mode to `Estimate`.
- Set Inlet Manifold Pressure Sensor Resource to `Not in Use`.
- For a boosted engine:
  - Setup and calibrate Boost Pressure Sensor.
  - Set Inlet Manifold Pressure Estimate Mode to `Boost Pressure Relative`.
  - Set Fuel Injector Primary Location and Fuel Injector Secondary Location to `Before Throttle Boost Referenced`. Use this setting even if the injectors are positioned after the throttles.

- For a naturally aspirated engine:
  - Setup and calibrate Airbox Pressure Sensor.
  - Set Inlet Manifold Pressure Estimate Mode to `Airbox Pressure Relative`.
  - Set Fuel Injector Primary Location and Fuel Injector Secondary Location to `Before Throttle Airbox Referenced`. Use this setting even if the injectors are positioned after the throttles.
- Set Fuel Timing Primary and Fuel Timing Secondary with an End of Injection earlier than ~380deg BTDC (before the inlet valve opens) for light to medium load.

  For higher load, the injection time can be set as needed. This will assist with the accuracy of injector differential pressure value.
- Initially set the entire Engine Efficiency Boost Compensation table and Engine Efficiency Airbox Compensation tables to `0%` trim

Tuning Boosted Engine

With this method the Inlet Manifold Pressure Estimate Main table is the primary fuel tuning table.

1. If the engine has not been tuned, set a low Boost Aim pressure to perform a safe initial tune, otherwise go to step 3.
2. Tune the Inlet Manifold Pressure Estimate Main table until the Exhaust Lambda matches the Fuel Mixture Aim for each site. This is only an initial tune and doesn't need to be detailed.

   Note: values greater than 100% are possible.
3. Once the engine is tuned at the low boost pressure (see step 1), set the Boost Aim Pressure to the maximum intended boost pressure. This is so the tuning is as accurate as possible for the highest (most critical) load.
4. Set the Engine Efficiency Boost Compensation to `0%` trim at the boost pressure set in step 4.
5. Tune the Inlet Manifold Pressure Estimate Main table until the Exhaust Lambda matches the Fuel Mixture Aim for each site.

   Note: values greater than 100% are possible.
6. Lower the Boost Aim pressure.
7. At 100% throttle, alter the Engine Efficiency Boost Compensation table to correct the fuelling.

   Typically, 100% throttle is the most important point to be perfectly correct.

   Leave the Engine Efficiency Boost Compensation at the boost pressure from in step 6 at 0% trim.
8. Repeat steps 6 and 7 for all boost pressures between the desired highest and lowest boost pressures.

→ Additional checks for tuning adjustments:

- In conditions with low boost and high throttle the boost might not match the tuned boost pressure. For example, when the throttle is opened quickly and the turbo speed is low. Be sure to check the tuning in these conditions and if needed, adjust the Engine Efficiency Boost Compensation table.
- Many systems other than fuelling use the Inlet Manifold Pressure value. With this method the value is no longer directly derived from a sensor, however the calculated value has similar behaviour and scale to inlet manifold pressure sensed on a common plenum engine.

  In many subsystems using the Inlet Manifold Pressure value, the calculated value may need adjusting slightly. In some systems the accuracy may be sufficient and no adjustment is necessary.

  These systems should only be adjusted after tuning the fuelling since this tuning method affects the result of the Inlet Manifold Pressure value.

  The resulting Inlet Manifold Pressure value may be higher than Boost Pressure in some conditions.
- If the Camshaft, Camshaft Position, Intake, Exhaust or any other parameter that affect the volumetric efficiency of the engine are changed, repeat all steps.

Tuning Naturally Aspirated Engine

With this method the Inlet Manifold Pressure Estimate Main table is the primary fuel tuning table. The table result value becomes the percentage of the cylinders displacement volume for air at the current Airbox Pressure and Temperature, inducted into the cylinder for the given engine speed and throttle position.

1. At a constant Airbox Pressure, tune the Inlet Manifold Pressure Estimate Main table until the Exhaust Lambda matches the Fuel Mixture Aim for each site.

   Note: values greater than 100% are possible.

2. If using a dynamometer with a controlled air intake, adjust the Ambient Pressure to change the Airbox Pressure and use the Engine Efficiency Boost Compensation table to correct the fuelling.
   Leaving the Engine Efficiency Airbox Compensation at the Airbox Pressure from in step 2 at `0%` trim.

➞ Additional checks for tuning adjustments:

- Many systems other than fuelling use the Inlet Manifold Pressure value. With this method the value is no longer directly derived from a sensor, however the calculated value has similar behaviour and scale to inlet manifold pressure sensed on a common plenum engine.

  In many subsystems using the Inlet Manifold Pressure value, the calculated value may need adjusting slightly. In some systems the accuracy may be sufficient and no adjustment is necessary.

  These systems should only be adjusted after tuning the fuelling since this tuning method affects the result of the Inlet Manifold Pressure value.

- If the Camshaft, Camshaft Position, Intake, Exhaust or any other parameter that affect the volumetric efficiency of the engine are changed, repeat all steps.

Relationship between Engine Load Normalised and Inlet Manifold Pressure

Ignition timing is tuned via a table that represents the load on the engine. Commonly, an ignition table with inlet manifold pressure and engine speed axis is used for this. Although inlet manifold pressure does not truly represent the load on the engine, it is directly related and it is a familiar method for tuning ignition timing.

With a multi throttle body setup engine there is no accurate inlet manifold pressure available, and a different method of determining engine load must be used.

In M1, the existing channel Engine Load Normalised is a more accurate way of representing the true load on the engine which takes into account the density of the air and the efficiency of the engine. For common throttle engines, Engine Load Normalised values in % are related to Inlet Manifold Pressure values in kilo Pascals (kPa).

For example, with 20 °C inlet air temperature and 100 kPa ambient pressure at a load point of 4000 rpm, 100 kPa inlet manifold pressure, the engine efficiency is likely around 100%. In this case, the Engine Load Normalised would also be 100% and therefore the ignition timing entered would be the same as in a MAP based Ignition Timing table.

If the inlet manifold pressure was lifted to 200 kPa at 5000 rpm, the Engine Efficiency table, once tuned, would likely drop to approximately 95%. This 5% drop, would equate to a 5% lower Engine Load Normalised value of 190%. In this case, the Ignition Timing value at 200 kPa and 5000 rpm can be entered into the Ignition Timing Main table at 190% and 5000 rpm with this tuning method.

➞ Incorrect Engine Efficiency table values due to incorrect injector calibrations (for example) will affect the Engine Load Normalised calculation quite dramatically. The cause of the incorrect values must be rectified or a full remap of the Ignition Timing Main table will be necessary.

To assist tuners to transition from MAP based tuning to the multi throttle tuning method described in this document, the following table provides some examples of inlet manifold pressure values compared to engine load normalised values.

Engine Speed	Inlet Air Temperature	Engine Efficiency	Inlet Manifold Pressure	Approximate Engine Load Normalised
4000 rpm	20 °C	100%	100 kPa	100%
5000 rpm	20 °C	105%	100 kPa	105%
5000 rpm	20 °C	100%	200 kPa (1 bar Boost)	200%
6000 rpm	20 °C	95%	200 kPa (1 bar Boost)	190%
6000 rpm	20 °C	90%	250 kPa (1.5 bar Boost)	225%
7000 rpm	20 °C	85%	300 kPa (2 bar Boost)	225%
8000 rpm	20 °C	80%	300 kPa (2 bar Boost)	240%
8000 rpm	50 °C	80%	300 kPa	220%

Compatibility

This method can be used with the following M1 firmware from MoTeC's GP package suite:

Variant	Version Name	Number
GPA (M130) (Public)	February 2016 or higher	1.10.0075 or higher
GPA (M150) (Public)	February 2016 or higher	1.10.0075 or higher
GPA (M170) (Public)	February 2016 or higher	1.10.0075 or higher
GPA (M190) (Public)	February 2016 or higher	1.10.0075 or higher
GPA-DI (M141) (Public)	February 2016 or higher	1.10.0075 or higher
GPA-DI (M142) (Public)	February 2016 or higher	1.10.0075 or higher
GPA-DI (M182) (Public)	February 2016 or higher	1.10.0075 or higher
GPR (M130) (Public)	February 2016 or higher	1.10.0075 or higher
GPR (M150) (Public)	February 2016 or higher	1.10.0075 or higher
GPR (M170) (Public)	February 2016 or higher	1.10.0075 or higher
GPR (M190) (Public)	February 2016 or higher	1.10.0075 or higher
GPR-DI (M141) (Public)	February 2016 or higher	1.10.0075 or higher
GPR-DI (M142) (Public)	February 2016 or higher	1.10.0075 or higher
GPR-DI (M182) (Public)	February 2016 or higher	1.10.0075 or higher
GPR-DI Proportional Pump (M141) (Public)	February 2016 or higher	1.10.0075 or higher
GPR-DI Proportional Pump (M142) (Public)	February 2016 or higher	1.10.0075 or higher
GPRP (M130) (Public)	February 2016 or higher	1.10.0075 or higher
GPRP (M150) (Public)	February 2016 or higher	1.10.0075 or higher
GPRP (M170) (Public)	February 2016 or higher	1.10.0075 or higher
GPRP (M190) (Public)	February 2016 or higher	1.10.0075 or higher
GPRP-DI (M141) (Public)	February 2016 or higher	1.10.0075 or higher
GPRP-DI (M142) (Public)	February 2016 or higher	1.10.0075 or higher
GPRP-DI (M182) (Public)	February 2016 or higher	1.10.0075 or higher