TUNING

Training Course Material 2014
Valid for Diag4Bike V14 only
On-line Multimedia User Manual is under preparation
TUNING STRATEGY

- Tuning system is based on DIAG4BIKE diagnostics
- Tuning software DIAG4TUNE is Built-in diagnostics
- Applicable for EFI Delphi

- **The tuning process does not require:**
  - the installation of additional component(s)
  - any motorcycle harness modification

- The first step in Tuning is saving of the original Calibration
DIAG4TUNE

Generally
TUNING METHODS

• EASY TUNING - *manual adjustment*
  • Low Cost
  • Fast process
  • Limited result

• ADVANCED TUNING - *map flash from database*
  • Fast process
  • Acceptable tuning result
  • Important improvement of engine function

• PROFESSIONAL TUNING - *engine fuel map optimization*
  • More time consuming
  • Best level of tuning
  • Optimal efficiency in all operating modes
  • Maximal Power and Torque efficiency
  • Best long term reliability of engine
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EASY TUNING

Manual adjustment only

DIAG4TUNE – EASY MODE

Available Functions

• Fuel Trim Table Adjustment +/- 20%
• Spark Advance Table Adjustment +/- 20%
• Acceleration Enrichment (AE) adjustment +/- 20%
• Lambda Closed Loop switch ON/OFF
• Throttle By Wire (TBW) speed up switch ON/OFF

Necessary Tuning Components

DIAG4BIKE Serial Diagnostics (V12/13)  EASY (BLUE) TUNING DONGLE
EASY TUNING

Manual adjustment only

DIAG4TUNE – EASY MODE
# EASY TUNING

**Manual adjustment 1 - Fuel Trim Table**

![Diag4Tune Easy mode](image)

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Value edit:

**New values** - 10.00%

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EASY TUNING

Manual adjustment 2 – Spark Advance Table
EASY TUNING

Manual adjustment 3 – Other Settings
EASY TUNING

Manual adjustment 3 (new) – Throttle by Wire (TBW)

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Accelerated TBW
TUNING METHODS

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• PROFESSIONAL TUNING - *engine fuel map optimization*
  • More time consuming
  • Best level of tuning
  • Optimal efficiency in all operating modes
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  • Best long term reliability of engine
ADVANCED TUNING

Map flash from database

DIAG4TUNE – ADVANCED MODE

Available Setting Functions

- AFR map adjustment for each cylinder
- VE maps display with adjustment possibility for each cylinder
- Spark Advance maps adjustment for each cylinder
- Acceleration Enrichment (AE) characteristic adjustment
- Throttle By Wire (TBW) characteristic adjustment
- Engine displacement
- RPM limit
- Calibration ID Modification

Available KEY Functions

- Access to DIAG4TUNE database
  - Calibration (Maps) Level 0 - stock intake and exhaust configuration
  - Calibration (Maps) Level 1 - open intake or exhaust
  - Calibration (Maps) Level 2 - open intake and exhaust

- Flash new Calibration Level X to the bike EFI
  - Calibration (Maps) can be modified by operator
ADVANCED TUNING

Map flash from database

DIAG4TUNE – ADVANCED MODE

Necessary Tuning Components

DIAG4BIKE Serial Diagnostics (V12/13)

TUNING DONGLE
ADVANCED TUNING

Map flash from database

DIAG4 TUNE – ADVANCED MODE

Easy mode
Pairing & Backup
Advanced mode
Maps download
VE Measurement
ECM Flash

USB dongle status: not connected
TUNING METHODS

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PROFESSIONAL TUNING

Engine Fuel Maps Optimization

DIAG4TUNE – ADVANCED MODE + VE MEASUREMENT

Available Setting Functions

- AFR map adjustment for each cylinder
- VE maps display with adjustment possibility for each cylinder
- Spark Advance maps adjustment for each cylinder
- Acceleration Enrichment (AE) characteristic adjustment
- Throttle By Wire (TBW) characteristic adjustment
- Engine displacement
- Idle speed temperature table
- Etc.
PROFESSIONAL TUNING

Engine Fuel Maps Optimization

Available KEY Functions

1/ Access to DIAG4TUNE database
   • Calibration (Maps) Level 0 - stock intake and exhaust configuration
   • Calibration (Maps) Level 1 - open intake or exhaust
   • Calibration (Maps) Level 2 - open intake and exhaust

2/ Flash new Calibration Level X to the bike EFI (estimation of real VE Maps)

3/ Real VE maps measurement – AUTOTUNE PROCESS
   • Bench Test
   • Road Test

3/ AFR Map adjustment

4/ Flash new Calibration (Maps) to the bike EFI
PROFESSIONAL TUNING

Engine Fuel Maps Optimization

 Necessary Tuning Components

DIAG4BIKE Serial Diagnostics (V12/13)

TUNING DONGLE

AFR TUNING MONITOR
PROFESSIONAL TUNING

Engine Fuel Maps Optimization

Useful tuning Components

SMART POWER BENCH

INSTALLATION SET LAMBDA

THROTTLE CONTROL LIMITER
TUNING METHODS

• EASY TUNING - *manual adjustment*
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Tuning which engine?

A. Original Engine Version (includes exhaust & intake) - Level 0

B. Engine equipped by open exhaust or intake – Level 1

C. Engine equipped by open exhaust & intake – Level 2

D. Significantly modified Engine
   - open exhaust & intake
   - modified engine displacement
   - modified compression ratio
   - modified valve timing and control
   - installed supercharging
   - etc.
Tuning of Engine A

A. Original Engine Version (includes exhaust & intake) – Level 0

- Does make sense any tuning?
- Engine setting is optimized for exhaust-gas emissions
- Fuel Map Optimization can bring limited increase of PW, T (c. 5%)
Tuning of **Engine B+C**

**B.** Engine equipped by open exhaust or intake – **Level 1**

**C.** Engine equipped by open exhaust & intake – **Level 2**

- Engines which are not comply with expectations
- Promises of intake & exhaust producers represent significant PW, T increase
- Reality is not so strong
- And more – several negative effect appears
  - Power holes in low throttle positions
  - Unstable regimes during low speed cruising (50 km/h)

- What can bring Fuel Map Optimization?
  - Interesting increase of PW,T in range usually 10-20%
  - Improvement of engine dynamic feature 15% is significant
  - Elimination of unstable regimes and power „holes“
Tuning of **Engine D**

**D. Significantly modified Engine**

- open exhaust & intake
- modified engine displacement
- modified compression ratio
- modified valve timing and control
- installed supercharging
- etc.

- Map optimization is here more complicated process and experienced operator is needed

- Tuning tool has to provide wide setting possibilities
  - Injector flow
  - Engine displacement
  - Etc.

- Fuel Map Optimization can bring significant increase of PW, T (tens of %)

- **DIAG4TUNE** *actual version don't provides Injector Flow only*
HARLEY – DAVIDSON

EFI DELPHI CALIBRATIONS
MAPS & PARAMETERS

TECHNICAL EXPLANATION
H-D SOFTWARE STRUCTURE

EFI SOFTWARE

APPLICATION (example 176)

CALIBRATION (example 32765-07A)

• FUEL MAPs
  • VE Map front cylinder
  • VE Map rear cylinder
  • AFR target Map

• SPARK TIMING MAPs (Ignition)
  • Spark Advance Map front cylinder
  • Spark Advance Map rear cylinder

• OTHER PARAMETERS
  • RPM limiter
  • Idle and Warm-up characteristic
  • Dynamic and Temperature enrichments (enleanment)
  • Throttle by wire dynamic control settings
  • Engine displacement
  • Injector flow
  • Etc.
EFI MAPs & Parameters Review

EFI SOFTWARE

APPLICATION (example 176)

CALIBRATION (example 32765-07A)

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EFI MAPs & Parameters Review

EFI SOFTWARE

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EFI MAPs & Parameters Review

EFI SOFTWARE

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  • Throttle by wire dynamic control settings
  • Engine displacement
  • Injector flow
  • Etc.
Value **VE** and **VE Map** organization

- **VE** = Volumetric Efficiency
- **VE Map indicates engine capability to bleed air**
- **VE** = \((\text{volume of really sucked air}) / (\text{engine displacement})\) %

- **VE Map** = **VE relation** (TPS, RPM) older and current models H-D
  = **VE relation** (MAP, RPM) new models H-D

**TPS** – Throttle Position Sensor  
**MAP** – Manifold Absolute Pressure  
**RPM** – Rotation per Minute
FUEL MAPs

- VE Map front cylinder

![Graph of VE Map front cylinder](image-url)
FUEL MAPs

- VE Map rear cylinder
### Example VE Map Front Cylinder XL 1200

#### Advanced mode

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Example VE Graph Front Cylinder XL 1200
EFI MAPs & Parameters Review

EFI SOFTWARE

APPLICATION (example 176)

CALIBRATION (example 32765-07A)

• FUEL MAPs
  • VE Map front cylinder
  • VE Map rear cylinder
  • AFR target Map

• SPARK TIMING MAPs (Ignition)
  • Spark Advance Map front cylinder
  • Spark Advance Map rear cylinder

• OTHER PARAMETERS
  • RPM limiter
  • Idle and Warm-up characteristic
  • Dynamic and Temperature enrichments (enleanment)
  • Throttle by wire dynamic control settings
  • Engine displacement
  • Injector flow
  • Etc.
AFR Value and AFR Map

- **AFR** = Air Fuel Ratio

- **AFR Map** is Map of AFR target values

- **AFR** = (aspirated air mass) / (mass of injected fuel)
  
  $\frac{\text{kg}}{\text{kg}}$

- **Stoichiometric ratio:** $\text{AFR} = 14.6$ (Lambda = 1)
  
  The optimum ratio for combustion – shows minimum emissions

  
  $14.6 \text{ kg Air} (21\% \text{ O}_2 + 79\% \text{ N}_2) + 1 \text{ kg Fuel} (\text{C}_x\text{H}_x) \Rightarrow \text{H}_2\text{O} + \text{CO}_2 + \text{N}_2$

- **AFR > 14.6** means **lean mixture**

- **AFR < 14.6** means **rich mixture**

**Other terms of mixing ratio**

- **LAMBDA** = coefficient of excess air

- **LAMBDA** = $\text{AFR} / 14.6$
FUEL MAPs

- AFR Map (AFR Target Map)
AFR mapa – Original values

 EFI operates in a closed loop
Calculation of Fuel Injection in **EFI**

or how to operate the Fuel Maps

**Open loop**

[Diagram showing Fuel Maps and calculation process]

1. Calculate the time of injection to the **Front Cylinder** using the AFR Map.

2. Calculate the time of injection to the **Rear Cylinder** using the VE Map for each cylinder.

---

**VE Map Front Cylinder**

**VE Map rear cylinder**

**AFR Map**

**Front Cylinder Injector**

**Rear Cylinder Injector**
Calculation of Fuel Injection in EFI or how to operate the Fuel Maps

Closed loop

Calculate the time of injection to the Front Cylinder

Calculate the time of injection to the Rear Cylinder

Front Cylinder Injector

Lambda probe Front Cylinder

Lambda probe Rear Cylinder

Rear Cylinder Injector
AFR Map ADJUSTMENT

• ENGINE TORQUE optimization

• ENGINE CONSUMPTION optimization

• NEGATIVE ENGINE BEHAVIOUR compensation
  • Random or frequent misfires at 30-40 MPH
  • Almost Regularly Evolution (SPORTSTER)
  • Limited Twin Cam

• TEMPERATURE PROTECTION
AFR Map – TORQUE OPTIMIZATION

Max. Twin Cam Engine Torque - AFR response characteristics

Max. Torque (Nm) 2500 - 3000 min\(^{-1}\)

- Rich
- Lean

Optimal range

TP - Throttle Position

Stochiometric
60% TP
100% TP
Average

AFR
### AFR Map – OPTIMIZATION & SETTING

Offer Built-in AFR Maps

![Advanced mode](https://www.diag4bike.eu)

#### AFR Map [IPs]

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## Dynamic AFR Map

### Air Fuel Ratio (AFR) Map - Optimization & Setting

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MAP [kPa]

**Note:** The table shows the air fuel ratio settings for different RPM values. The map allows for optimization and setting adjustments for engine performance.
### AFR Map – OPTIMIZATION & SETTING

#### Dynamic AFR Map with Compensation

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HARLEY – DAVIDSON
FUEL MAP OPTIMIZATION
(TUNING PROCESS)
DESCRIPTION
FUEL MAPs OPTIMIZATION

General Process

1. Step

Setting VE Maps of both cylinders in relation to the type of engine and accessories (exhaust and intake)

2. Step

Setting the AFR Map according to

• the wishes of the monocycle owner
• motorcycle behavior in different modes (negative)

3. Step

Step 1. & 2. is building important part of CALIBRATION that is stored in the EFI motorcycle
ADVANCED TUNING
Map flash from database

1. Step - Setting VE Maps

   Select the appropriate maps in the menu at the entrance to ADVANCED MODE

   • It is statistically calculated maps that represent a quick and simple solution
   • The key is to choose the appropriate VE Maps that match the configuration of the exhaust and intake.
   • The result of optimization with these VE Maps is rapid but will be only partial!

2. Step - Setting the AFR Map

3. Step – Save Calibration to EFI motorcycle
1. Step - Setting VE Maps

Perform measurement VE Maps when entering the menu **VE MEASUREMENT**

- The measurement is performed at the **Power Station (Bench Test)** or during the **Road Test**.

- The result is a maximum utilization of the engine and its accessories potential

- **To measure must install the AFR Tuning Monitor on a motorcycle**

- Map measurement is performed in several steps managed by **AUTOTUNE SYSTEM**. After each measurement VE map checks the difference and save the results to a motorcycle.

- If the differences are less than 5% of the measurement process will terminate

2. Step - Setting the AFR Map

3. Step – Save Calibration to EFI motorcycle
VE MEASUREMENT

• BENCH TEST
  • Full and Safe MEASUREMENT
  • Roller Bench which is able to provide sufficient load
    • Any DYNO BENCH
    • SMART POWER BENCH

• ROAD TEST
  • Limited possibilities
    • Weather conditions
    • Traffic restrictions
    • Limited result

• AFR TUNING MONITOR
  must be installed
SMART POWER BENCH

- Simulates engine load equivalent to road test
  - Heavy Roller
  - Built-in fan driven by roller
- Facilitates measurement of VE maps for tuning
- Provides measurement of power and torque
- Utilises built-in fan for engine & rear tyre cooling
- Providing rear tyre temperature measurement
- Cost effective high quality solution produced 100% in Europe (CZ Product)
AFR Tuning Monitor Installation

**DIAG4BIKE & AFR TUNING MONITOR connection**

1. USB cable
2. Communication interface DIAG4BIKE
   - AT531 5075 Bluetooth / USB
   - AT531 5074 USB
3. AT531 4032 - Diagnostic adapter (4 pin)
4. AFR Tuning monitor
   - AT106 4019 - Connection cable
   - AT 106 4016 - AFR tuning monitor
   - Oxygen sensors (wideband) 2x
AFR Tuning Monitor Installation

Key is to install a wide band lambda probes

• Installation in the exhaust
• Installation outside exhaust

Lambda installation set

• Use in the event of lack of space for wideband Lambda probe
• Motorcycle is equipped with a Narrowband Lambda probes with thread M12
• Motorcycle is not equipped with a Narrowband Lambda probes.
VE Measurement – BENCH TEST
Preparing for motorcycle tuning

1. Check the functionality of the motorcycle using the diagnostic function **Global test and control to the EFI using the measured parameters**. Failure of any motorcycle control unit may interfere with communication on diagnostic line that is used for tuning operations.

2. Verify proper operation of **spark plugs** control voltage must be at idle speed **below 15kV**. **Preventive replacement of plugs is the best solution**. At the same time we will check High-voltage cables and ignition module.

3. **Air filter** - to be replaced or washed

4. Ensure a **reliable supply** motorcycle electrical system - check the battery. In case of low battery to replace the battery or **provide continuous external recharging**

5. Make sure has **not installed any other tuning device** and if so, **it must be disconnected from the control unit EFI and especially since the diagnostic lines**

6. Make sure that the **tuning of the model and year is supported by the Diag4Tune** *(check actual information on the web)*

7. **Into the USB connector** on the computer slide the **Tuning Dongle**

8. Use **High Quality Fuel** only for VE measurement.
Harley-Davidson Models for tuning by Diag4bike

**EASY TUNING**

Easy Tuning, manual settings of AFR maps +/- 20%

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**ADVANCED TUNING**

Advanced Tuning, VE and AFR maps setting from Diag4bike database (Level 1, Level 2 and AFR dynamic)

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Note: SE and Sportster XR models not included

**PROFESSIONAL TUNING**

Professional Tuning, VE and AFR maps optimisation for a specific motorcycle

Note: SE and Sportster XR models not included

**Legend**

- **A** = Available
- **A** = Available except 2012 FLSTSE3, 2013 FXSBSE
- **P** = Under preparation

**Actual Priority Evolution Plan**

- **P1** = 12/2014
- **P2** = 1/2015
- **P3** = 2/2015
- **P4** = 3/2015

**How to check year of production from VIN:**

Check please the 10th character in VIN:

- 1 to 9 = 2001 to 2009
- A to F = 2010 to 2015