PLM

Professional Lambda Meter

User's Manual

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Meter Operation

Introduction

The *MoTeC* Professional Lambda Meter measures Lambda (or Air Fuel Ratio) over a wide range of mixtures with fast response time.

The display may be set to Show Lambda, Air Fuel Ratio (for Petrol, Alcohol, Gas, Diesel or 'blend' fuel) or equivalence ratio.

The PLM provides an Isolated Analogue Output Voltage proportional to Lambda that may be connected to an Analogue Meter or other measurement instrument such as a Data Logger or dynamometer.

The PLM also supports a CAN data link to devices such as the Motec Dash Logger for transmission of sensor and diagnostic data.

Sensor Placement

The sensor should be fitted to the exhaust system and the sensor tip protrude into the exhaust gas flow. When fitted it should be tilted at an angle of between 10 and 90 degrees to the horizontal, ie: with the tip of the sensor pointing down. This is to ensure that no condensed water builds up between the sensor case and the sensor ceramic.

It is recommended that where possible the sensor be placed at least 1m from the exhaust ports to avoid excessive heat and at least 1m from the open end of the exhaust system to avoid incorrect readings due to outside oxygen. This is however not mandatory, and where necessary for shorter exhaust systems the sensor should be placed closer to the engine.

Connections

The PLM has two D-9 pin connectors. The loom supplied with the PLM is fitted to the male connector. This is for connection to the sensor and to a power supply.

The 2 pin DTM connector is connected to a 12V DC power supply. The Power supply must provide current for both the Meter and the Sensor Heater Element. This can be up to 5 Amps at start up. The vehicle battery is usually the most convenient source of power.

The PLM can be connected to a PC for configuration by using the second, female D-9 connector. This connector also has pins for the CAN data bus, digital inputs and analogue voltage output.

See Appendix B for a description of the PLM pinout.

Lambda

Lambda gives a measure of Air Fuel Ratio that is independent of the type of fuel being used.

Lambda 1.0 corresponds to the stoichiometric ratio i.e. when there is no excess fuel and no excess air.

Lambda > 1.0 => Excess Air (Lean)

Lambda < 1.0 => Excess Fuel (Rich)

Lambda may be directly converted to Air Fuel Ratio for a specific fuel using a multiplication factor. The PLM will display Air Fuel Ratio by loading the appropriate configuration into one of the output tables. This is described below in the section *PLM Setup Software | Output Table setup*.

A table to convert Lambda to Air Fuel Ratio for various fuels is given in Appendix A.

Engine Tuning

The desired Air Fuel Ratio (or Lambda) is dependant on the tuning objective i.e. Power, Economy or Emissions. Normally at Full Load the Engine is tuned for maximum power and at light loads the engine is tuned for emissions or economy.

The following table gives a guide to the required Lambda values for different tuning objectives.

Objective	Lambda
Power	0.84 to 0.90
Economy	1.05
Emissions	1.00

Note   The exact requirements for a specific engine and fuel must be found by experimentation.
Note   On Turbo Engines extra fuel may be desirable to reduce exhaust temperatures and help avoid knock.

Operating Tips

If the Engine misfires for any reason including an over-rich mixture the Meter may falsely read Lean. This is due to excess air being present in the exhaust gasses which is caused by incomplete combustion when the engine misfires.

Engines with high overlap camshafts running at low speed may pump air through the engine resulting in a false lean reading, therefore the meter may need to read leaner than would otherwise be expected.

Analogue Output

The Analogue Output provides a voltage proportional to Lambda. The default configuration is set for 0 – 5 V to correspond to 0.5 to 1.5 Lambda. This scaling can be changed by using the PLM Setup software. Details are given in the section *Configuration* | **Analogue** *Output* below. For correct operation Aout- MUST be connected to the ground reference on the monitoring system.

Initial Configuration

The PLM is initially programmed with a configuration that will allow it to operate as a stand alone device. It will automatically detect the sensor type and display the lambda reading.

This configuration will also transmit data to an ADL when the CAN bus pins are connected to the ADL as described in Appendix B. The analogue output is initially configured with a 0 – 5 V output corresponding to 0.5 to 1.5 Lambda.

Making changes to the configuration

The PLM need only be connected to a PC if the user wishes to change the display type, the analogue output calibration or modify the configuration in some other way.

Warm-up Codes

Upon being powered up, the PLM will display the current version of software for about one second. It will then display a series of codes describing the warm-up progress. A description of these codes is given in Appendix D.

PLM Setup Software

Introduction

Computer Requirements:

The Personal Computer (PC) must be an IBM PC compatible running Windows95, 98, ME, NT4 or Windows2000 operating system.

Recommended Minimum specifications

Pentium 90, 16 MB RAM

Serial Port

The PLM connects to the PC with a standard serial communication cable. This is also known as a 'straight-though' cable.

Installing PLM Setup

Place the floppy disk in the 'A' drive.
Click on the Windows 'Start' button and select Run.
Type a:\setup.exe
Follow the setup program instructions
To start the program after installation, click on the Windows 'Start' button, and select 'Programs --> Motec --> PLM Setup --> PLM Setup 1.0'

Mouse and Keyboard

The PLM setup software may be operated using the keyboard or a mouse. It is often easier and faster to use the keyboard on many Notebook (laptop) PC's.

Main Menu

The main menu is used to access all of the functions of the PLM setup software. Click the mouse on one of the menu items, or press the Alt key together with the underlined letter. Eg: press Alt + S for the Setup menu. When the PLM Setup software is started, a configuration file needs to loaded before changes can be made. This can be from a file on disk, or from the PLM itself.

Configurations

The PLM configuration determines exactly how it operates. The initial configuration will display Lambda when the PLM is powered and connected to a sensor.
Changes can be made to the configuration to alter various aspects of the PLM. This includes: the display parameter (eg: to A/F ratio), modifying the scaling of the analogue output, sensor type, backlight intensity, etc. Standard configuration templates for most common preferences are included.

Configuration Files

The configuration files are stored on the PC hard disk and can be modified before being sent to the PLM. A new configuration can be created by selecting *File | New* from the main menu. After a configuration has been created or modified it should be saved with a meaningful name by selecting *File | Save* from the main menu.

Opening an Existing File

Before an existing configuration can be modified or sent to the PLM it must first be opened. To open a configuration file select *File | Open* from the main menu and select the desired file.
Note that the most recently used files appear at the bottom of the File menu, which is often the easiest way to open a recently used file.

Connecting to the PLM

A PC can be connected to the PLM with a serial cable running directly from a PC serial port to the female D-9 connector on the PLM. The serial port used can be selected from the *Options | Communications Port* item from the main menu.

Sending and Retrieving Configurations

The currently open configuration file can be sent to the PLM by selecting *Online | Send Configuration* from the main menu.

When a configuration file is sent to the PLM any changes are automatically saved to the file.

The configuration can be retrieved from the PLM by selecting *Online | Get Configuration* from the main menu.

It is advisable to *Get* the initial configuration from the PLM and save this before making modifications.

Changing the Configuration

Once an existing configuration file has been opened, or a new one created the various parts of the configuration may be modified by choosing the appropriate items from the main menu. The configuration setup items are accessed from the main menu item *Setup | Sensor, Display, Analogue Outputs*

Sensor

Sensor Type

The user can manually select the sensor used as Bosch LSU or NTK Uego. Selecting 'Auto' allows the PLM to determine the type of sensor being used.

Calibration Method

There are several options available for choosing the calibration method of the sensor being used. The default option for this is '*Use measured calibration value*'. This allows the PLM to determine the sensor calibration and can be used in most cases. If the calibration value of the sensor is known then it can be entered by selecting the second choice – '*Enter calibration value*'. This value is engraved on LSU sensors supplied by MoTeC. The other two methods are for advanced users and will not generally need to be used.

Heater Control

This allows the heater voltage to be set when using an NTK sensor. Again this is an option for advanced users and should be left at 10.5 volts (default value) by most users.

Display

This screen allows the user to set the parameters for the lambda meter display screen. The display update rate and filtering values are independent of the real values used for CAN and analogue voltage outputs.

Output to display

The user can choose the output to display from one of the two output tables.

Decimal Places

Selectable from 0 to 3. Normal use would be to 2 decimal places for lambda.

Update Rate

Displayed value will update from 1 to 10 times a second.

Filter Time

The data can be filtered so that it is more stable and easier to read. This is independent of the update rate.

Backlight Intensity

User definable from 0 to 100%.

Output Table Setup

The Output Tables are used by the PLM to calculate the displayed value. The PLM stores two tables that can be configured with different calibrations for displaying lambda, air fuel ratio or equivalence ratio.

In addition to a lambda calibration, there are a number of pre-defined calibrations for air fuel ratio for different fuels. To display one of these, the calibration must be loaded from the PC by clicking on the 'Load' button and choosing the appropriate calibration from the list displayed.

Advanced users can generate their own calibration tables using the Ipn[1] value measured by the meter. These can be saved for re-use.

Analogue Output

The PLM is capable of generating an analogue voltage based on the measured lambda value. This can be connected to another device, such as an ECU, data logger or dynamometer, allowing it to read the measured lambda value.

The type of value to be generated can be selected from the drop down list. This then appears in the 'Input' column of the Calibration Table.

Calibration Table

The calibration table allows users to set the voltage output that corresponds to the table input value. The table takes the input value and translates it to an analogue voltage by way of the calibration table. The output voltage can be in the range of 0 to 5 volts.

At least two pairs of values must be entered in the table, so that a straight line may be derived between the two points. The voltage is linearly interpolated between points in the table.

Once created, tables can be saved and then used in other configurations.

Other Setup Features

Digital Inputs

The PLM has two digital inputs, with two possible functions. Input 1 can be used to read engine RPM, and this value is then transmitted on the CAN data stream. The other function is to use an input to switch the unit on/off. The operate condition to enable the PLM can be based on either input.

This way the PLM can be set to operate only when measuring RPM, or when a switch is set.

CAN Messages

The PLM is pre-configured to send CAN data to a MoTeC ADL. See Appendix B for details of wiring the PLM to an ADL. The data to be transmitted can be the value from either output table 1 or 2.

Users should only change the Address or Compound ID, when connecting to a CAN device other than the ADL.

Dash Manager Setup

Under *Inputs | Communications* click on one of the blank CAN inputs. Then select template *PLM #1 (CAN ID 460)*. The channels available are then listed under *Received Channels*.

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[1] Normalised sensor pump cell current

Specifications

Meter

Power Supply

Input Voltage Range	7 to 16Volts
Input current	60mA Typical backlight off
	110mA Typical backlight on
	Plus sensor heater current
Protection	Reverse polarity protected
Load Dump Clamp	Max 40V at 100 Amp 100msec

Sensors

Sensors	1
Compatible Types	Bosch LSU / NTK UEGO
Calibration Methods	Automatic using sensor's built in calibration resistor
	Manual Table Entry
	Known Oxygen Environment
	Calibration Constant
Type Detection	Manual or Automatic (using sensor's built in calibration resistor)
Sensor Thread	M18 x 1.5

Measurements

Lambda	0.7 to 32.0
02	0 to 22%
A/F Ratio	Fuel dependant (see lambda range)
Accuracy	+-1.5% (sensor specific)

Sensor Heater

Outputs	1
Current	Max 8 Amp
Control	Bosch - Digital PID
	NTK - Constant Voltage
	NTK sensor requires at least 11V for proper operation of heater

Output

Analogue	0 - 5V DC Max, User Programmable
Output Type	Floating
Common Mode Range	-4.5 to 5.0 volts

Inputs

Digital	2 x User Programmable as RPM or PLM Enable (Operate)

Communications

Serial	CAN @ up to 1Mbit
	RS232

Display

Type	LCD 3.5 Digit
Digit Height	12.7mm
Lighting	Green LED Back Light

Processor

CPU	Motorola 68HC908AZ60
Speed	8MHz

Code Memory   60K Flash
Configuration Memory   1K EEPROM Field updateable

Connection
Connectors   2 x 9 Pin Dsub (commonly called D9)

Environment
Temperature Range   -10 to 70 Deg C

Case
Dimensions(WxHxD)   105x41x25 mm (Excluding Connector)
Weight   135grams

Appendices

Appendix A - Lambda to Air Fuel Ratio Table

Lambda	Air Fuel Ratio			
	Petrol	**Alcohol**	**LPG**	**Diesel**
0.70	10.3	4.5	10.9	10.2
0.75	11.0	4.8	11.6	10.9
0.80	11.8	5.1	12.4	11.6
0.85	12.5	5.4	13.2	12.3
0.90	13.2	5.8	14.0	13.1
0.95	14.0	6.1	14.7	13.8
1.00	14.7	6.4	15.5	14.5
1.05	15.4	6.7	16.3	15.2
1.10	16.2	7.0	17.1	16.0
1.15	16.9	7.4	17.8	16.7
1.20	17.6	7.7	18.6	17.4
1.25	18.4	8.0	19.4	18.1
1.30	19.1	8.3	20.2	18.9
1.35	19.8	8.6	20.9	19.6
1.40	20.6	9.0	21.7	20.3
1.45	21.3	9.3	22.5	21.0
1.50	22.1	9.6	23.3	21.8
1.55	22.8	9.9	24.0	22.5
1.60	23.5	10.2	24.8	23.2

Appendix B – PLM Wiring Details

Sensor Connector - Male D9

1	Battery +12 Power (*Note 2*)
2	Heater +
3	Rc
4	Ip
5	Sensor Common
6	Battery 0V Power
7	Heater –
8	Vs
9	Ipr

Auxiliary Connector – Female D9

1	CAN Hi (*Note 3*)
2	RS232 Tx
3	RS232 Rx
4	Digital Input 1
5	Comms 0V
6	CAN Lo (*Note 4*)
7	Digital Input 2
8	Analogue out + (*Note 5*)
9	Analogue out – (*Note 6*)

Note1:

Extension of Standard Sensor Loom

The length of the standard loom supplied for connection of the PLM to a sensor is 2.5m. Longer looms are available from MoTeC by request.

It is not recommended that the loom is extended by using a standard serial cable. These are unable to supply the current required by the sensor. If an extension is made, the wire must be at least 20 gauge.

Note 2:

If using a power supply other than the vehicle battery, start-up current for the sensor is up to 5A, though operating current is much lower than this, 0.5 – 1 Amps, depending on exhaust gas temperature.

Note 3:

For connection to an ADL, wire to pin 74 or 76. Can be spliced into an existing wire.

Note 4:

For connection to an ADL, wire to pin 73 or 75. Can be spliced into an existing wire.

Note 5:

Connect the Positive wire to the positive input on the measuring device.

Note 6:

Connect the Negative wire to the 0V reference point on the measuring device.

Appendix C - Sensor Wiring Details

Bosch LSU Sensor

Sensor Pin	Colour	PLM pin
1	Red	Ipr
2	Black	Vs
3	Yellow	Sensor Common
4	White	Heater +
5	Grey	Heater -
6		Ip
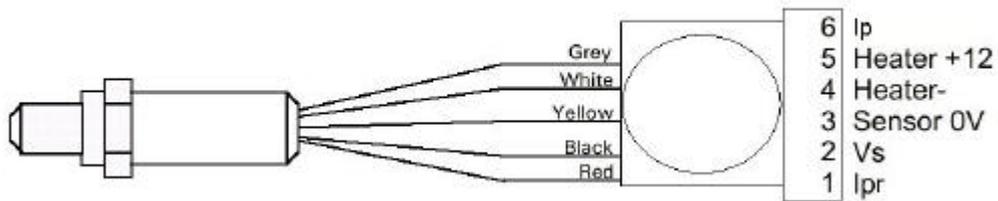
NTK – Uego Sensor

Sensor Pin	Colour	PLM pin
1	Orange	2 Heater +
2	Yellow	7 Heater -
3		Rc
4		Sensor Common
5		N/C
6	Red	Vs
7	White	Ip
8	Black	Sensor Common
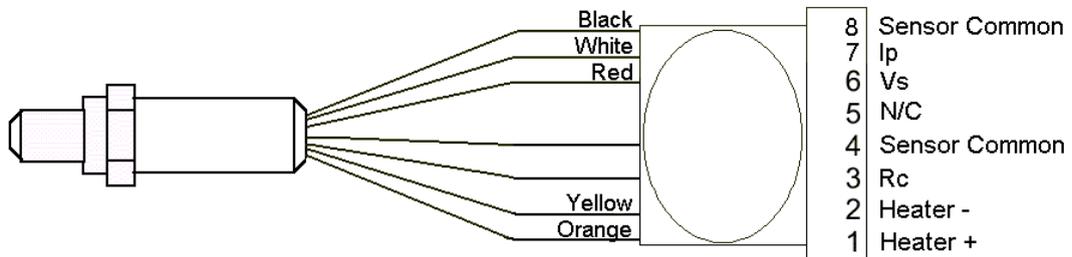
Appendix D – PLM Warm-up Codes

C-6   Sensor Protection Shutdown
C-5   User Stop
C-4   No Heater detected
C-3   Warm Up
C-2   Control Initialization
C-1   Checking Operation

Appendix E – PLM Diagnostic Codes

These are the diagnostic error groups that are sent to the ADL via the CAN link.

Diagnostic Group 1
1 : No Sensor
2 : Sensor Hot
4 : Sensor Cold
8 : Sensor Faulty
16 : Heater Drive Overload
32 : Warm Up
64 : Ref voltage out of range

Diagnostic Group 2
These codes are the same as those displayed by the PLM.
1 (C-1) - Checking Operation.
2 (C-2) - Control Initialization.
4 (C-3) - Warm Up.

8 (C-4) - No heater detected.
16 (C-5) - User Stop.

32 (C-6) - Sensor Protection Shutdown.

Appendix F – Glossary

CAN – Controller Area Network. High speed serial data bus common in automotive applications
Ip – Sensor pump cell current
Ipn – Normalised Ip
Vs – Sense voltage