

MoTeC

AFM1

Air Fuel Ratio Meter

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While every effort is taken to ensure correctness, no responsibility will be taken for the consequences of any inaccuracies or omissions in this manual.

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Specifications

Meter

Operating Voltage Range	7 to 16 V DC
Operating Current	0.3 A Max. (Excluding Sensor)
Reverse Voltage	- 24 V DC Max.
Transient Protection	10 Joules (100A / 10ms) (Clamping Voltage 24V)
Operating Temperature	0 to 60 deg C
Operating Humidity	0 to 80 % Non Condensing
Measurement Range	0.75 to 1.60 Lambda
Measurement Accuracy	± 1.5% 0.75 to 1.05 Lambda ± 2.5% 1.06 to 1.25 Lambda ± 5.0% 1.26 to 1.60 Lambda
Display Update Rate	3.5 Times per second
Response Time	< 150 msec (To 63 % of Final Reading)
Weight	575 g
Dimensions	142 x 48 x 96 mm (WxHxD)

Meter Analog Output

Output Type	Isolated (Floating)
Output Isolation	400 V DC Max.
Output Voltage Range	0 to 5 V DC Max. (Dependant on Range Selection)
Output Current	1 mA Max.
Response Time	100 ms 0.75 to 0.95 Lambda 150 ms 0.96 to 1.05 Lambda 50 ms 1.06 to 1.60 Lambda (To 63 % of Final Reading)

Sensor

Sensor Type	Wide Band
Heater Voltage	12 to 14 V DC
Heater Current	1.5 A Nominal (Hot) 5.0 A Max. (Cold)
Operating Temp	250 to 800 C (Heater ON) 450 to 930 C (Heater OFF)
* Life Time	> 500 Hrs (Unleaded Fuel) > 50 Hrs (Leaded Fuel)
Thread Type	M18 x 1.5

Note Life Time is dependant on a number of factors - See text.

Meter Operation

Introduction

The **MoTeC** Air Fuel Ratio 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 or Air Fuel Ratio for either Petrol, Alcohol, Gas or Diesel.

The Meter provides an Isolated Analog Output Voltage proportional to Lambda that may be connected to **MoTeC** Engine Management Systems for transmission over the **MoTeC** Radio Link or closed loop control of Air Fuel Ratio. Alternatively the Output may be connected to an Analog Meter or other measurement instrument such as a Data Logger or Chart Recorder.

Sensor Placement

The sensor should be placed in the side of the exhaust system and should protrude into the exhaust gas flow.

The sensor should 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.

The Sensor has an M18 x 1.5 Thread.

Sensor Life Time

The sensor life time is dependant on the type of fuel being used and the volume of gas flow over the sensor.

Leaded fuel will reduce the sensor lifetime substantially due to lead contamination of the sensor element.

The specifications give approximate lifetimes for Leaded and Unleaded fuel for a typical high performance engine. Longer lifetimes can be expected for less demanding applications.

Sensor Warm Up

The Sensor must be hot before any useful measurements can be taken.

The Sensor has an internal heater to heat the sensor quickly and ensure adequate temperature when exhaust gases are relatively cold (i.e. when the engine is under light load).

When the internal heater is used the sensor will normally give good readings within 2 minutes of applying power.

Power Supply

The Power supply must provide current for both the Meter and the Sensor Heater Element. The vehicle battery is usually the most convenient source of power.

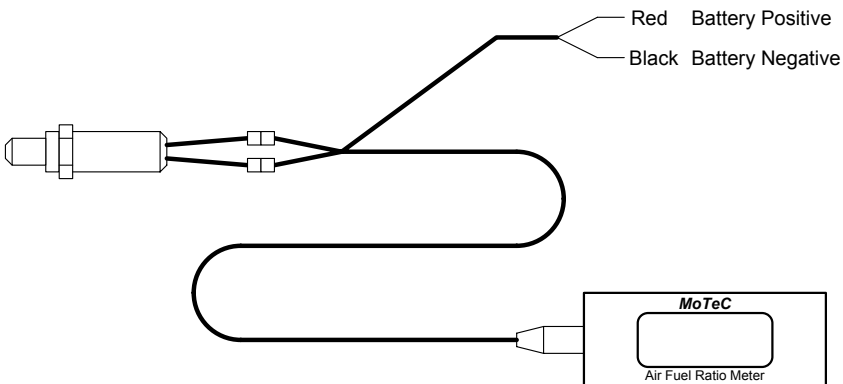
Connections

The lead supplied with the Meter should be connected between the Meter and the Sensor.

Power should be applied to the cable by connecting the Red Wire to Battery Positive and the Black wire to Battery Negative. This connection powers both the Meter and the Sensor Heater Element.

The Sensor has two connectors one is for the Sensor Element and the other for the Heater Element. If the exhaust temperature will exceed 800 deg C the Heater Element should NOT be connected.

Note If the Heater Element is not connected the sensor warm up time will be increased and the Sensor may not read correctly if the exhaust gasses are too cold - see specifications.



Refer to Appendix B if full wiring details are required.

WARNING Connecting the Meter Sensor Input to anything other than a **MoTeC** Sensor may render the meter inoperable requiring factory repair.

Lambda

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

Lambda 1.0 corresponds to stoichiometry i.e. when there is no excess fuel and no excess air.

Lambda > 1.0 => Excess Air (Lean)

Lambda < 1.0 => Excess Fuel (Rich)

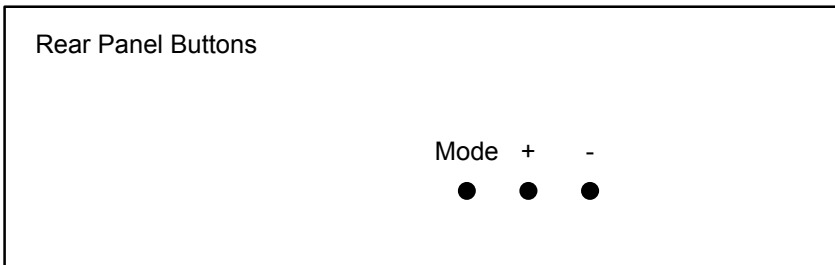
Lambda may be directly converted to Air Fuel Ratio for a specific fuel using a multiplication factor.

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

Display

The display may be set to Show Lambda or Air Fuel Ratio for either Petrol, Alcohol, Gas or Diesel.

Changing the Display Mode



The display mode may be changed at any time by pressing the MODE button on the rear of the Meter. As the mode is changed the display will momentarily show a code to indicate the new mode.

The Meter will remember which mode is selected even when turned off.

When power is applied to the Meter it will momentarily show the currently selected mode.

The display codes are as follows :

LA	Lambda	
AF P	Petrol	Air Fuel Ratio
AF A	Alcohol	Air Fuel Ratio
AF g	Gas	Air Fuel Ratio
AF d	Diesel	Air Fuel Ratio

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 misses 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 misses.

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

Analog Output

The Analog Output (3 Pin Connector) provides a voltage proportional to Lambda.

The Analog Output may be connected to **MoTeC** Engine Management Systems for transmission over the **MoTeC** Radio Link or closed loop control of Air Fuel Ratio.

Alternatively the Output may be connected to an Analog Meter or other measurement instrument such as a Data Logger or Chart Recorder.

The Output is an Isolated (or Floating) type (i.e. Not Ground Referenced). Both positive and negative wires must be connected.

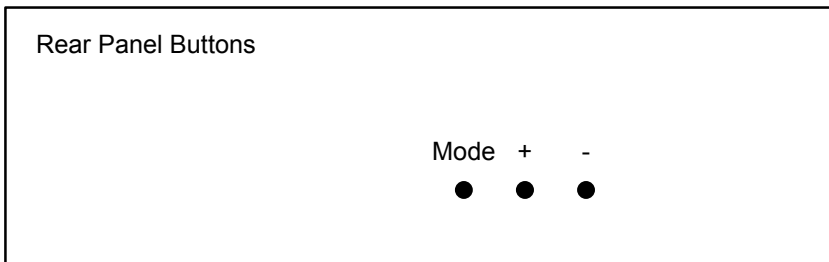
Refer to Appendix C for Wiring Details.

Setting the Output Voltage Range

The Analog Output Voltage Range may be configured to suit a number of different measurement devices.

Appendix D Shows the Output Voltage Ranges for the different modes.

Note that different Output Voltage Ranges may be required for different types of **MoTeC** ECUs



To enter the Range Select Mode hold down the MODE button as the power is applied to the meter. The display will then show the currently selected range (AO 1 to AO 9). To change the range press the MODE button until the desired range appears.

Cycle the Meter power to resume normal Operation

Output Fine Adjustment

To allow for inaccuracies in the measuring device the Analog Output voltage gain may be adjusted $\pm 10\%$.

A. Adjustment During Range Selection

The Analog Output may be adjusted while in the Range Select Mode (i.e. While The Display is Showing AO 1 to AO 9).

During Range Selection the Analog Output voltage will be set to a predetermined level which is dependant on the selected range.

Appendix E shows the voltage level and corresponding Lambda value for the various output modes.

The + and - buttons may be used to adjust the output voltage to give the correct reading on the measurement device.

B. Adjustment During Normal Operation

The + and - buttons may be used to adjust the output voltage to give the correct reading on the measurement device.

Adjust so that the reading on the measuring device corresponds exactly to the reading on the Meter display.

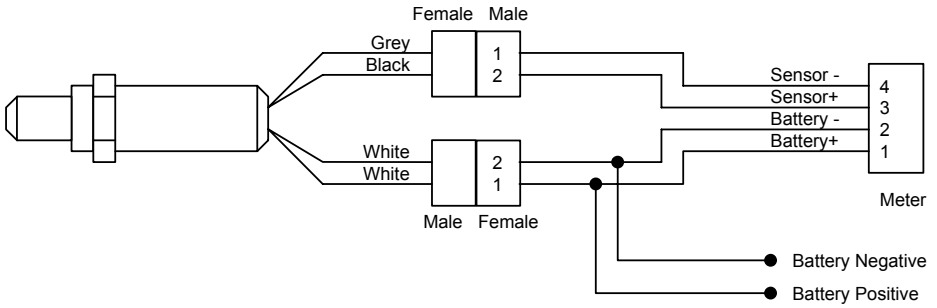
Note The adjustment should be checked at two or more points covering the extremes of the normal operating range.

Appendices

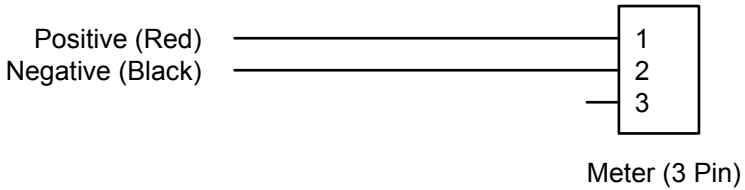
Appendix A - Lambda to Air Fuel Ratio Table

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 - Sensor Wiring Details



Appendix C - Analog Output Wiring Details



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

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

Appendix D - Analog Output Modes

Mode	Use	Lambda		
		0V	1.6V	5V
AO 1	MoTeC 2D/3D-V4	0.50		1.75
AO 2	MoTeC 2D/3D-V3 & M4	0.00	1.60	
AO 3	General Purpose	0.75		1.00
AO 4	General Purpose	0.75		1.25
AO 5	General Purpose	0.75		1.75
AO 6	General Purpose	0.70		0.95
AO 7	General Purpose	0.70		1.20
AO 8	General Purpose	0.70		1.70
AO 9	Through Connection (Exact Sensor Volts)	N/A		N/A

Note The Maximum measurable value of Lambda is 1.60 therefore Modes 2, 5 and 8 will never reach 5Volts.

Appendix E - Analog Output Calibration

Mode	Voltage	Lambda a
AO 1	4.0V	1.5
AO 2	1.0V	1.0
AO 3	3.0V	0.9
AO 4	2.5V	1.0
AO 5	3.75V	1.5
AO 6	4.0V	0.9
AO 7	3.0V	1.0
AO 8	4.0V	1.5
AO 9	0.8V	N/A

Appendix E - Error Codes

Error No	Meaning
1	High Sensor Voltage - Possible short to Battery Voltage
2,3,4,5,6,7	Consult <i>MoTeC</i>

Notes

Notes