ECM ENGINE CONTROL
AND MONITORING

Lambda 𝒫𝑅𝒪™

Air-Fuel Ratio Meter

Instruction Manual

Table of Contents

Introduction

Lambda Pro

Lambda Pro is a powerful and compact engine development tool that sets a new standard in air-fuel ratio instrumentation.

Lambda Pro combines the following features into a small and easy-to-use package:

- Displays in Lambda and AFR Units
- Wide range of operation: Lambda: 0.55   to   1.75
  AFR (gasoline):   8.0   to   25.5
  AFR (alcohol)[1]:   3.6   to   11.3
- Maximum and minimum AFR recording
- Simulated O_2 sensor output for use with electronic engine management systems
- Easy calibration in air
- 0 to 5 volt linearized output for use with data acquisition systems
- 11 to 28 VDC operation

Lambda Pro was designed to be to fuel systems what a timing light is to ignition systems: a valuable and easy-to-use tool.

---

[1]   AFR for other fuels and % O_2 available upon request.

Lambda Pro Components List

The following items are included with the Lambda Pro package:

Item No.	Description	Part Number
1.	Lambda Pro	1200A
2.	Lambda Sensor	1200A-1
3.	Wiring Adapter[2], 6"	1200A-2
4.	Instrument Wiring Harness, 13'	1200A-3A
5.	12VDC Battery Power Clamp-on Adapter[3], 1.5'	1200A-3B
6.	O_2 Sensor Simulator Cable, 13'	1200A-4
7.	Instruction Manual	1200A-5
8.	Carrying Case	1200A-6
9.	Calibration Screwdriver	1200A-7
10.	Sensor Boss and Plug	1200A-8

---

[2] A right-angled (to the right) Wiring Adapter (P/N 1200A-2R) is available.
[3] An AC Power Supply (P/N 1200A-9), a 12VDC Cigarette Lighter Adapter (P/N 1200A-3C), and a 12VDC Mating Adapter Kit (P/N 1200A-3D) are available.

Important Operation Notes

1. Before installing the Lambda sensor, apply a small amount of non-lead containing antiseize compound to its threads. Do not get the compound on the sensor's tip.

2. Do not operate an engine for more than three minutes with the Lambda sensor in the exhaust and Lambda Pro's power off. If the sensor is off in a running engine, soot and water will condense in the sensor and may reduce its sensitivity.

3. Do not use the Lambda sensor in exhaust systems in which water is sprayed into the exhaust. Water striking the sensor may cause permanent sensor damage.

4. Do not put the Lambda sensor in a heavily sooting or oil-burning engine.

5. Use of the Lambda sensor with leaded fuels may reduce the sensitivity of the sensor.

6. Do not put the Lambda sensor in exhausts in which the temperature is greater than 950 deg. C (1742 deg. F) or the pressure is not between 0.8 to 1.3 atm.

7. Route and cable-tie Lambda Pro's wires away from hot or moving objects and ignition wires.

8. Do not remove or attach the Lambda sensor from the instrument harness with Lambda Pro on.

9. Do not drop the Lambda sensor onto a hard surface.

10. Do not expose the Lambda sensor to flammable substances.

11. Do not attempt to wash the Lambda sensor with any solvent or compressed air.

How to Use

Hook-up and Simulated O$_2$ Output

Location of the Lambda Sensor

The Lambda sensor should be located approximately 12" from the exhaust valve(s) of the engine, between the engine and the catalytic converter (if any). A location further from the engine may be used as long as it is at least ten times the exhaust pipe diameter upstream of the end of the exhaust system. For example, with a 2 1/2" diameter exhaust pipe, the sensor should be at least 25" upstream of the end of the exhaust. The problem with locations further downstream than ten diameters is that air may be trapped in the exhaust giving leaner than actual readings. This especially occurs at low exhaust flowrates. Lambda sensor mounting locations far from the engine expose the sensor to more liquid water during start-up and should be avoided.

When choosing a Lambda sensor location, take into consideration engine movement, ground clearance, and wire routing.

Install the Lambda sensor by lightly coating its threads with a non-lead containing antiseize compound and tighten it to 30 ±3 ft-lbf (40 ±4 Nm). Attach the sensor to the instrument wiring harness and route the harness to where Lambda Pro's readout will be located. Use cable ties to keep the harness away from hot or moving objects and ignition wires. The harness is connected to the wiring adapter which in turn is connected to Lambda Pro. The wiring adapter should be left attached to Lambda Pro.

Do not modify the harness or wiring adapter and replace them if they are damaged.

Installation of the Sensor Boss

The Lambda sensor is mounted in the engine's exhaust by threading it into a M18X1.5mm boss that is cast, welded, or brazed onto the engine's exhaust pipe. This thread size is identical to that of most exhaust oxygen sensors (O$_2$ sensors) used in production automobiles with 3-way exhaust catalysts.

The sensor boss as simple as a M18X1.5mm jam nut can be used. These nuts are available from a good fastener store. To mount the boss, first drill a 1/2" diameter hole in the desired location. Wire-brush the area around the hole and clamp the boss over the hole. Weld or braze the boss to the exhaust pipe. After the boss is attached to the exhaust, tap the treads to clean them and file the top of the boss to provide a flat surface for sealing. When the Lambda sensor is not being used, an 18mm spark plug (ex. Champion D15Y or Autolite 124) can be used to plug the hole. Do not use the Lambda sensor to plug the hole when Lambda Pro is not being used.

Using the Production O$_2$ Sensor Location and the O$_2$ Sensor Simulator

Since the Lambda sensor uses the same thread size as most production O$_2$ sensors, the production mounting hole can be used. However, if the production O$_2$ sensor is not connected to the engine control module (ECM), the ECM may go into "back-up" mode. Lambda Pro avoids this problem by providing a simulated O$_2$ sensor output that can be fed into the ECM.

The simulated O$_2$ sensor output is a 0V (lean) to 1V (rich) signal that switches at Lambda=1.0. This is the same switch point as the production O$_2$ sensor. The simulated O$_2$ sensor output is available at the red banana plug connector of the instrument wiring harness. Connection between that connector and the vehicle's O$_2$ sensor signal wire (part of the vehicle's wiring harness) is made with the O$_2$ sensor simulator cable. One end of the cable connects to the instrument wiring harness and the other end is used to pierce the O$_2$ sensor signal wire to the vehicle's ECM. Note that the production O$_2$ sensor is both electrically and physically disconnected from the vehicle when the simulated O$_2$ sensor output is being used.

When using the simulated O$_2$ sensor feature, three things must be kept in mind:

1. The vehicle's ECM may have a feature to detect if the O$_2$ sensor's heater is operating properly. If this is the case, an electrical connection between the O$_2$ sensor's heater wires and the vehicle's wiring harness must be made.

2. The vehicle's ECM may have a feature to detect if the O$_2$ sensor is operating properly by pumping current into and out of the O$_2$ sensor. Depending on the sophistication of the feature, it may be that the stock O$_2$ sensor must be left alone and another mounting location be used for the Lambda sensor.

3. The O$_2$ sensor simulator was designed to match as closely as possible the output of the vehicle's production O$_2$ sensor. However, the O$_2$ sensor simulator output cannot be expected to match all vehicle's O$_2$ sensor outputs under all operating conditions.

Selecting AFR Units

The default units of Lambda Pro are Lambda but AFR (for gasoline) and AFR (for alcohol) can be selected for numerical display. Upon request, ECM can provide Lambda Pros that display %O$_2$ or AFR for other fuels.

To select units other than Lambda, hold the red record button down when turning Lambda Pro on. The numeric display will loop through the sequence: "LAb" (Lambda), "gAS" (AFR for gasoline), "ALC" (AFR for alcohol). To select a particular unit, release the record button when the unit is being displayed. The display will then show the lower limit (analog output 0V value), the stoichiometric point (analog output 1.875V value), and the upper limit (analog output 5.0V value) for the chosen units. Lambda is shown on the discrete bar graph regardless of the units chosen.

After the units are chosen (or the default accepted), Lambda Pro will begin a 60 second count-down while the sensor reaches its operating temperature.

Maximum and Minimum AFR Recording

To start recording the maximum and minimum values, press the red record button. The decimal point of the display will start to flash showing that the recording feature has been activated.

While Lambda Pro is displaying the engine's Lambda (or AFR), it keeps a memory of the maximum and minimum values it measures. To see the maximum and minimum values, press the record button once to show "Hi=" and once again to show the maximum value. Pressing the record button twice again will result in the display of "Lo=" followed by the minimum value recorded. The maximum (Hi) and minimum (Lo) values will flash when they are shown. This is to avoid confusion with normal operation. Pressing the record button once after the minimum value is shown will return Lambda Pro to normal (non-recording) operation.

Analog Output

Lambda Pro has a 0V to 5V linearized output suitable for input into a data acquisition system. The 0V, 1.875V and 5V Lambda (or AFR) values are shown on the display during start-up. The analog output steps from 0V to 1.875V to 5V during this display for verification of proper connection to the data acquisition system.

The analog output is available from the female BNC connector on the wiring adapter. The shell of the connector is signal ground and it is electrically connected to the power source ground.

Calibration

Calibration of Lambda Pro and the Lambda sensor requires that the sensor be held in air for 20 minutes following power-up. To bring the unit into calibration, adjust the calibration potentiometer on the right-hand side of Lambda Pro using the calibration screwdriver provided. The screwdriver must be inserted approximately 1" inside Lambda Pro to reach the potentiometer. **First turn the potentiometer until the LEDs are toggling between the center LED (1.00λ) and the LED immediately to its left (ie. slightly rich) and the display is toggling between "AIR" and "CAL". Then turn the potentiometer slightly clockwise until the toggling stops and just the center LED and "CAL" are displayed.**

Application Notes

Lambda Pro will give you insight into your engine's fueling system (fuel injection or carburetor) that you may never have had before. Here are some things that you may see:

1. During engine warm-up of an electronically controlled engine, the engine may be fueled rich and oxygen pumped into the exhaust via the air pump. This is for the quick warm-up of the production O_2 sensor and the catalytic converter. When this occurs, the measured AFR will be leaner than the actual AFR because air is entering the exhaust not through the engine but via an external path.

2. During throttle tip-in, you will see the AFR momentarily go lean and then rich. During throttle tip-out, you will see the AFR momentarily go rich and then lean. The initial lean (for tip-in) and rich (for tip-out) AFRs are due to the fact that the fuel responds more slowly than the air. The subsequent rich (for tip-in) and lean (for tip-out) AFRs are due to the carburetor or fuel injection system.

3. During a long (approximately 5 seconds or more), foot-off-the-pedal deceleration of a vehicle with a manual transmission, the fuel injection may be turned off by the engine control module (ECM). This will result in Lambda Pro displaying "Air" or "CAL" because just air will be pumped through the engine. If the recording feature is enabled, the maximum Lambda or AFR value recorded will be the upper range value of the instrument.

4. For vehicles with 3-way exhaust catalysts, the ECM will vary the fuel pulse duration to oscillate the AFR around Lambda=1. This is to maximize the effectiveness of the catalyst in reducing emissions.

5. Most production ECMs operate the engine nominally at stoichiometric (Lambda=1). This is because the 3-way exhaust catalyst is most efficient in reducing pollutants at this value. However, when maximum power is requested from the engine (wide-open-throttle), the ECM will change the Lambda control point to approximately 0.7 (or AFR=10 for gasoline). This is the fueling for maximum power. However it is not the fueling for minimum emissions so you may find that in the future, production ECMs will maintain a stoichiometric mixture (Lambda=1) under wide-open-throttle conditions also.

6. After a fuel injected engine is shut off, Lambda Pro will display a very high value (i.e. Lambda=1.7). This is because the injection of fuel is stopped with the ignition but the engine pumps a little air before it stops, thus diluting the exhaust from its running condition.

Specifications and Limits

Measurements and Accuracy

Units	Range	Accuracy
Lambda	0.55 to 1.75	±0.01 (stoichiometric)
		±0.02 (elsewhere)
AFR (gasoline)	8.0 to 25.5	±0.15 (stoichiometric)
		±0.50 (elsewhere)
AFR (alcohol)	3.6 to 11.3	±0.07 (stoichiometric)
		±0.22 (elsewhere)

Recording Specifications

Maximum and minimum values over user-defined duration.

Input Specifications and Limits

Maximum Exhaust Gas Temperature: 950 deg. C, 1742 deg. F.
Exhaust Gas Pressure Range: 0.8 - 1.3 atm.

Installation

Thread Size: M18X1.5mm. Lightly coat with non-lead containing antiseize.
Hex Size: 22mm.
Tightening Torque: 30 ±3 ft-lbf, 40 ±4 Nm.

The Lambda sensor's thread size is identical to that of most O_2 sensors used in production vehicles.

Output Specifications and Limits

Analog Output:

- 0V at Lambda = 0.55 or AFR (gasoline) = 8.0 or AFR (alcohol) = 3.6
- 5V at Lambda = 1.75 or AFR (gasoline) = 25.5 or AFR (alcohol) = 11.3
- Output Impedance: 500 Ohm
- Output Connector: Female BNC, Signal = Center, Ground = Shell

Simulated O$_2$ Sensor Output:

- 0V at Lambda and AFRs lean of stoichiometric
- 1V at Lambda and AFRs rich of stoichiometric
- Switch point at stoichiometric
- Output Impedance: 112K Ohm
- Wiring: Red Banana Plug = Positive, Ground via instrument harness

General Information

Power: 11 to 28 VDC at 9.5A (surge), 2A (continuous)

      Pins 1, 2: +11 to 28 VDC   Pins 3, 4: Ground

Fuse: Internal, automatically resetable

Dimensions: 7 1/2 " x 4" x 1 1/8",
             191mm x 102mm x 29mm (W x H x D)

Weight: 12 oz., 340 gm.

Troubleshooting

If Lambda Pro reads "SEn" when it is operating, the Lambda sensor is not connected or is broken. Lambda sensors are not repairable.

If Lambda Pro reads "bAt" when it is operating, the battery voltage is either too low (less than 11V) or too high (greater than 28V). Proper battery voltage must be used to avoid damage to Lambda Pro and the Lambda sensor.

If Lambda Pro displays erroneous information (i.e. not numbers or information), one of two conditions exists:

1. The unit is being confused by noisy power or operating in an electrically noisy environment. In some situations, a timing light might create a noise problem. Keeping the Lambda Pro and its wiring harness away from the engine's ignition wires will help avoid this source of electrical noise.

2. Lambda Pro must be returned to the factory for repair. There are no user-repairable components within Lambda Pro. The warranty is void if Lambda Pro is opened. Contact ECM before returning Lambda Pro to the factory.

Safety Warnings

In installation and use of this product, comply with the National Electrical Code and any other applicable Federal, State, or local safety codes.

Always wear eye protection when working near engines, vehicles, or machinery.

During installation, turn off the power and take all other necessary precautions to prevent injury, property loss, and equipment damage. Do not apply power until all wiring is completed.

Never work on a running engine.

When installing Lambda Pro's cabling and sensor on a stopped engine, it is best to think-out your moves before you make them.

Route and cable-tie all cables away from hot, moving, sharp, high energy (spark), and caustic objects.

Take into consideration the movement of the engine, chassis, and wind buffeting when instrumenting the engine.

Clear tools away from the engine before starting.

Operate the engine only in a well ventilated area and never when you or one of your co-workers is tired.

When operating the Lambda Pro in a moving vehicle, the operator should keep his or her eyes on the road.

One measure of professionalism is how much you and your co-workers can accomplish without an injury. Always be at your professional best. Think and act with safety in mind.

Warranty and Disclaimers

WARRANTY

The products described in this manual, with the exception of the Lambda sensor, are warranted to be free from defects in material and workmanship for a period of 365 days from the date of shipment to the buyer. Within the 365 day warranty period, we shall at our option repair such items or reimburse the customer the original price of such items which are returned to us with shipping charges prepaid and which are determined by us to be defective. This warranty does not apply to any item which has been subjected to misuse, negligence or accident; or misapplied; or modified; or improperly installed.

The Lambda sensor is considered an expendable part and as such cannot be covered by a warranty.

This warranty comprises the sole and entire warranty pertaining to the items provided hereunder. Seller makes no other warranty, guarantee, or representation of any kind whatsoever. All other warranties, including but not limited to merchantability and fitness for purpose, whether express, implied, or arising by operation of law, trade usage, or course of dealing are hereby disclaimed.

The warranty is void if Lambda Pro is opened.

LIMITATION OF REMEDY

Seller's liability arising from or in any way connected with the items sold and/or services provided shall be limited exclusively to repair or replacement of the items sold or refund of the purchase price paid by buyer, at seller's sole option. In no event shall seller be liable for any incidental, consequential or special damages of any kind or nature whatsoever, including but not limited to lost profits arising from or in any way connected with items sold and/or services provided to buyer, whether alleged to arise from breach of contract, express or implied warranty, or in tort, including without limitation, negligence, failure to warn or strict liability. In no event shall the company's liability to buyer arising out of or relating to the sale of any product or service exceed the purchase price paid by buyer to the company for such product or service.

PRODUCT CHANGES

We reserve the right to discontinue a particular product or to make technical design changes at any time without notice.

ECM **ENGINE CONTROL**
AND MONITORING

Los Altos, CA 94023-0040 • USA • (408) 734-3433 • Fax: (408) 734-3432

www.ecm-co.com