



# ALM LSU ADV Manual

Accurate Lambda Meter  
With built-in LED display

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Check before you power on ALM-LSU-ADV:

- The oxygen sensor is installed in the right way; or if it's left in the free air, make sure it's dry and it's not close to the inflammable materials.
- The ALM-LED is correctly connected to DC power supply or 12V battery;

## ALM-LED includes parts:



### List of ALM-LED parts

- ◆ Small ALM controller
- ◆ Built-in LED display
- ◆ Harness (60in default, 120in optional)
- ◆ Bosch LSU ADV sensor
- ◆ Sensor plug and bung
- ◆ Serial communication cable
- ◆ USB to serial converter (included)
- ◆ CD - documents and ALM GUI software

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## Chapter 1 ALM-LED Product Overview

ALM (Accurate Lambda Meter) is an air-fuel-ratio (AFR) meter which uses the Bosch LSUADV wideband oxygen sensor and Bosch integrated circuit chip CJ125 to accurately measure the AFR or lambda for variant combustion engines.

ALM-ADV is a version of ALM that has a built-in LED display instead of a separate gauge. This version has all the ALM functions plus the built-in LED. The rugged enclosure makes it perfectly an engine tuning instrumentation either in the lab environment or in the vehicle. The LED display is very bright and even striking directly under the sun light. There are 4 digits, including 3 float digits, compared to a typical 3 digit after-market gauge. It can be configured to display AFR, Lambda, or O2 concentration.

The advantages of ALM-LSU-ADV: save you a gauge, and make the whole package more compact, and you get higher resolution of the display, and the configurable display variable. In some applications, you don't have a console to mount your round gauge. This LED box is perfect to sit anywhere flat.

Again, all our ALM have the high accuracy and fast response characteristics, which are the root of our design at the very beginning.

Furthermore, it has the new feature of CAN bus communication as optional. This is a more advanced feature for professional engine controls where CAN bus is used widely and AFR signal can be broadcasted on the CAN bus.

First, ALM uses the LSU-ADV wideband sensor.

Second, Bosch chip CJ125 is the integrated chip (IC) specifically designed for LSU-ADV Sensors. Bosch's own wideband controller, "Lambda Tronic", uses CJ125 driver chip. In fact, Bosch uses this chip wherever a LSU sensor is used. The CJ125 and LSU sensor are mated-pair by Bosch. Presumably LSU sensors work the best with CJ125 chips.

See here for Bosch Motorsport's wideband controller, LT4:

[http://www.bosch-motorsport.de/en/de/produkte/catalog\\_products\\_1\\_760313.php](http://www.bosch-motorsport.de/en/de/produkte/catalog_products_1_760313.php)

The link may be updated by Bosch, please use the link on our website.

Together, LSU ADV and CJ125 make our ALM a more accurate lambda meter in the automotive aftermarket.

Products	Communication	Display	O2 Sensor Channels supported	ANOUT(Range)	O2 Sensor Supported	Exhaust temperature sensor	Exhaust pressure sensor	Engine Speed Input	Virtual narrow band o2 sensor output(NBOU T)
<u>ALM-Gauge</u>	RS232	AFR Gauge	1	YES (0 ~ 5v)	LSU ADV(default)/4.9	NO	NO	YES	YES
<u>ALM-B-AN OUT</u>	SCI(0 ~ 5v)	NO	1	YES (0 ~ 5v)	LSU ADV(default)/4.9	NO	NO	NO	NO
<u>ALM-B-CAN</u>	CAN	NO	1	NO	LSU ADV(default)/4.9	NO	NO	NO	NO
<u>ALM-B-RS485</u>	RS485	NO	1	NO	LSU ADV(default)/4.9	NO	NO	NO	NO
<b><u>ALM-LSU-ADV</u></b>	<b>RS232</b>	<b>LED (4 bit)</b>	<b>1</b>	<b>YES (0 - 5v)</b>	<b>LSU ADV</b>	<b>NO</b>	<b>NO</b>	<b>YES</b>	<b>YES</b>
ALM-LED	RS232	LED (4 bit)	1	YES (0 - 5v)	ADV(default)/LSU4.9	NO	NO	YES	YES
<u>ALM-CAN</u>	CAN	NO	1	NO	LSU ADV(default)/4.9	NO	NO	NO	NO
<u>ALM-CAN-II</u>	CAN	NO	2	NO	LSU ADV(default)/4.9	NO	NO	NO	NO
<u>ALM-II</u>	RS232	LCD(128*64)	2	YES (0 - 5v)	LSU ADV(default)/4.9	NO	NO	YES	YES
ALM-LD	RS232/CAN/USB	LCD(640*480)	2	YES (0 - 10v)	LSU ADV(default)/4.9	YES	YES	YES	YES

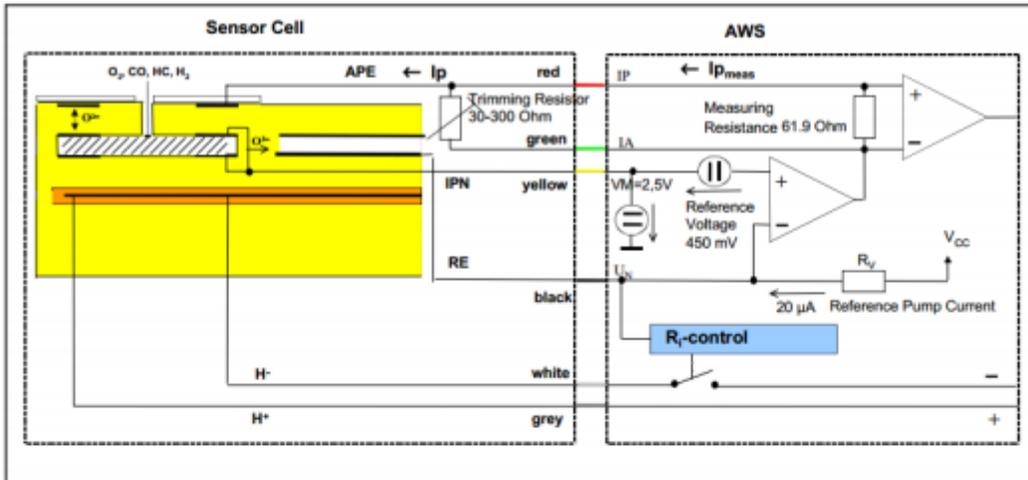
Note: Blue font represents the current user manual supported of ALM units.

Note: If you want to know the ALM of other types which use LSU-ADV sensor, please click on the underlined black font.

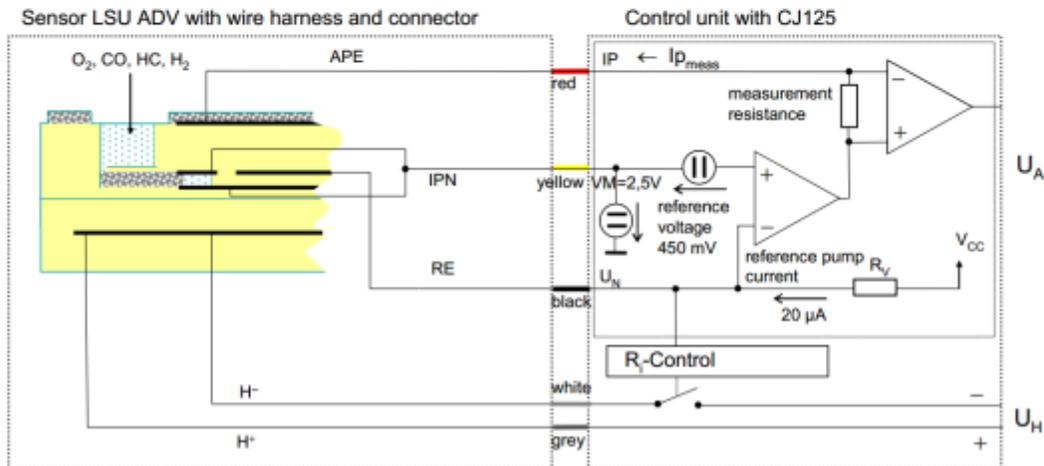
## Chapter 2 The comparison of LSU ADV with LSU 4.9

### 2.1 Structure Comparison

LSU ADV and LSU 4.9 are basically the same in structure. As shown in the picture below, their reference sources are both a reference pump current equivalent to the fixed air-fuel ratio, there is no longer any form of natural gas in the oxygen sensor inside. Therefore, the final design becomes: The actual pump current and a reference pump current are compared in order to keep oxygen balance in the monitoring room. The actual pump current is still able to represent the air-fuel ratio signal. Its reference source is a calibrated reference pump current. This reference pump current will not change in any environment and time, this ensures that the measurement accuracy of the oxygen sensor.



### LSU-4.9 Electrical Connectivity Diagrams

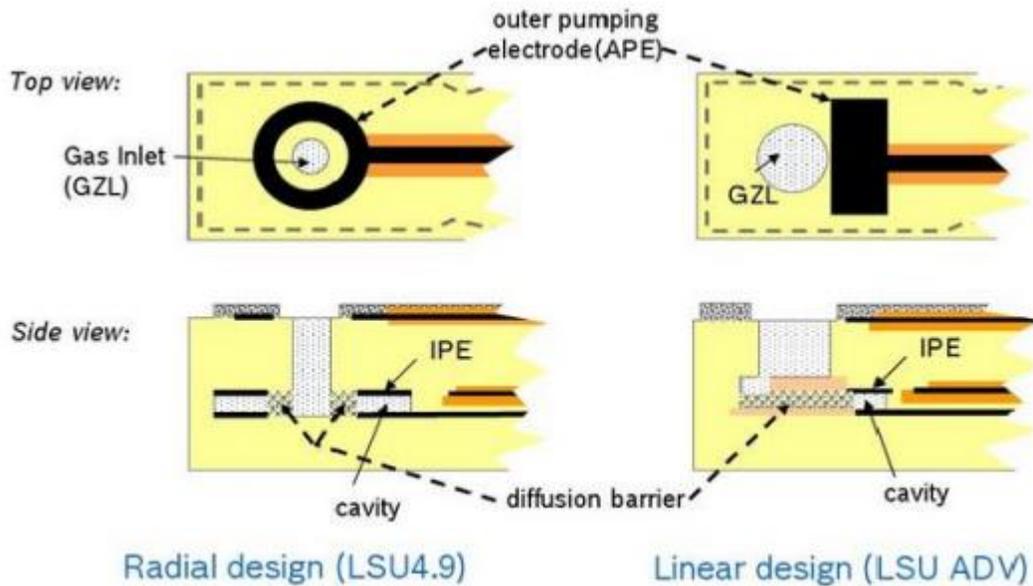


### LSU-ADV Electrical Connectivity Diagrams

However, based on the basis of LSU 4.9 sensor, LSU ADV made some improvement in the internal structure. LSU ADV sensor uses new structure design, improve the heating efficiency and reduce power consumption. This makes the oxygen sensor access to the operating temperature quickly.

**2.2 LSU ADV has improved in the following areas:**

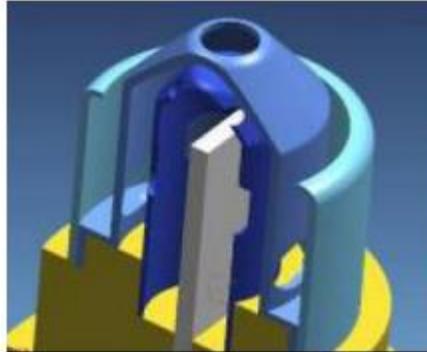
**2.2.1 Upgrade the sensor unit**



The core of the oxygen sensor is sensing element shown on the above Figure. LSU ADV use the new generation of sensing unit, which enhance the heating efficiency and the stability of the sensor unit under thermal shock.

## 2.2.2 Increase the protective coating

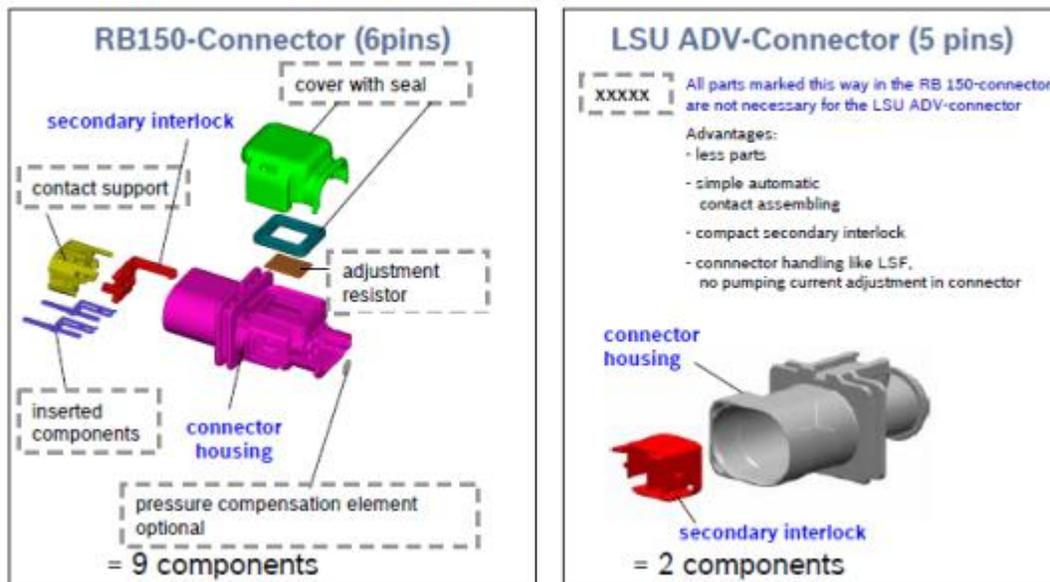
Compared with LSU 4.9, LSU ADV has three casing protection structure on the probe. LSUADV reduces demands on heating voltage, while reducing the damage to the sensor from the soot in exhaust gas, which can effectively reduce the carbon deposition on the probe.



## 2.2.3 The freedom to choose connectors

LSU ADV 5-wire form, it may be freely selected connector without having to use the BOSCH connector. Customers can use their own connectors for their system. Customers only need to cut LSU ADV lines directly and connect them to their own system. Compared with LSU 4.9's 6-wire, the IA-line is reduced. That is, remove the trim resistor on the connector. Reducing the harness system is conducive to diagnose faults (OBD), at the same time, removing the trim resistors also improves the fault tolerance of calibration data.

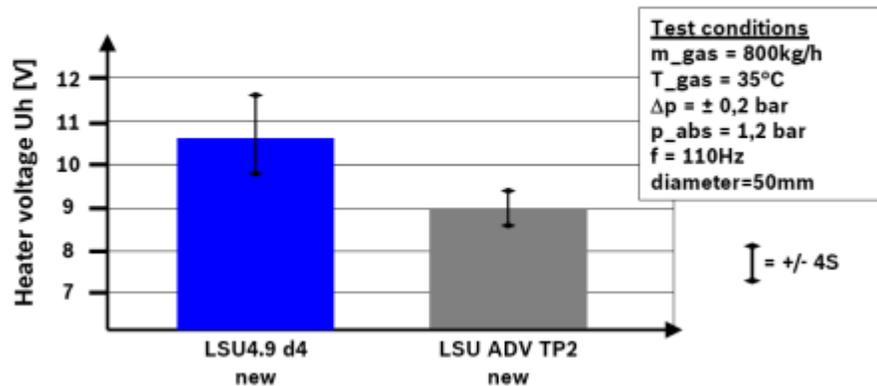
### Connector for LSU ADV



### 2.2.4 Improve the heating efficiency and reduce heating voltage

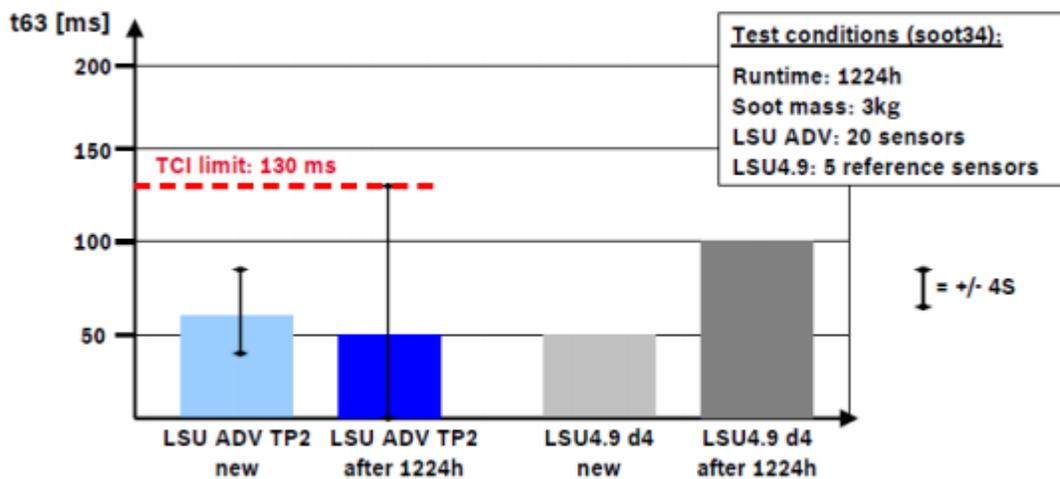
The power of the heating element are 8.7W (LSU ADV) and 7.5W (LSU4.9) at steady state. The heating time for LSU4.9 is 10s, from cold start to the sensor reaches its normal operating temperature, but LSUADV only needs 5s, its heating efficiency is double. It is worth mentioning that, LSU ADV significantly reduces the heating voltage.

#### Heater voltage under high mass flow



### 2.2.5 Extend the service life

After using for a long time (1224 hour), the response speed of LSU 4.9 slowed down obviously, the response time is doubled. But there are not any significant changes in the LSUADV. It even has improved response times. As shown below:



### 2.2.6 LSU ADV can operate in a wider temperature range

Compared to LSU 4.9, LSU ADV's sensing unit can keep a good feature in a wider operating temperature range

### 2.2.7 The comparison of working parameters

Compare items	LSU ADV	LSU 4.9
Operating temperature	785°C	780°C
System supply voltage	10.8 V to 16.5 V	10.8 V to 16.5 V
Nominal heater power at 7.5 V heater supply at thermal equilibrium in air	8.7W	7.5W
Heating response speed	Fast	Slow
Switch-on time	≤ 5 s	≤10 s
Withstand thermal shock	Stronger	Weaker
Connector	Freedom of choice	Stationary
Nominal heater cold resistance at room temperature for new sensor, including cable and connector 20 °C	2.6Ω ± 0.6Ω	3.2Ω
Minimum heater cold resistance at -40°C-40°C	1.6Ω	1.8Ω
Heater voltage during condensation water phase	V <sub>h,eff</sub> =1.8V...2.0V	V <sub>h,eff</sub> ≤2V
Maximum permissible effective heater voltage V <sub>H,eff</sub> to reach the operating point	short time ≤30 sec (200h cumulated time): V <sub>H,eff</sub> ≤12 V continuous: V <sub>H,eff</sub> ≤11 V	short time ≤30 sec (200h cumulated time): V <sub>H,eff</sub> ≤13 V continuous: V <sub>H,eff</sub> ≤12 V
Maximum system supply voltage	≤16.5V	≤16.5V
Minimum system supply voltage	-----	≥10.8V
Permanent temperature exhaust gas	≤980°C	≤930°C
Pre-turbo application	YES	NO
Lifetime	150,000 miles 15 years	150,000 miles 15 years
Sensor trimming	Trimming of sensor element	Trim resistor in connector housing

## Chapter 3 ALM-LSU-ADV technical specifications

### Power supply

- ◆ Input voltage range DC 9V~15 V (12V Typical)
- ◆ Input current 70mA typical plus the heater current
- ◆ Polarity protection Reverse polarity protected, & over voltage protected
- ◆ Load Dump Clamp Maximum Voltage

### Sensors

- ◆ Compatible LSU-ADV
- ◆ Number of Sensors One
- ◆ Free air calibration No need (it measures the free air O2%)

### Accuracy

- ◆ Lambda range  $\lambda = 0.5 \sim \infty$  (Gasoline AFR: 7.35 to free air)
- ◆ Lambda accuracy  $\pm 0.008 @ \lambda = 1.00$   
 $\pm 0.01 @ \lambda = 0.80$   
 $\pm 0.05 @ \lambda = 1.70$
- ◆ Air/Fuel Ratio Fuel dependent (see lambda range and accuracy)
- ◆ Oxygen concentration range -21% ~ 21%

### Heater

- ◆ Control Built-in PID control with CJ125
- ◆ Current Typical 1A; Peak 3.5A
- ◆ Heater return (H-) Standalone Heater return wire

### Response time

- ◆ 5ms updating rate (everything finished in 5ms)
- ◆ 0-5v analog output in 5ms updating rate;
- ◆ CAN bus message in 10ms broadcasting rate
- ◆ SCI message in 20ms broadcasting rate

### Output (default)

- ◆ Lambda analog output 0~5V user programmable
- ◆ Analog accuracy  $\pm 0.005V$  error with a 10-bit DAC chip
- ◆ Simulated narrow band oxygen sensor output

### Input

- ◆ RPM input Acquisition fuel injection signal (or 12V single pulse signal)

### Communications

- ◆ Advanced CAN bus communications (optional)
- ◆ RS232 or USB (via a converter) for logging or programming
- ◆ User-friendly PC software for data acquisitions and analysis

### Display

- ◆ 4 digit LED display
- ◆ Including 3 digit floating numbers
- ◆ AFR, lambda, O2% configurable

**Main-Processor**

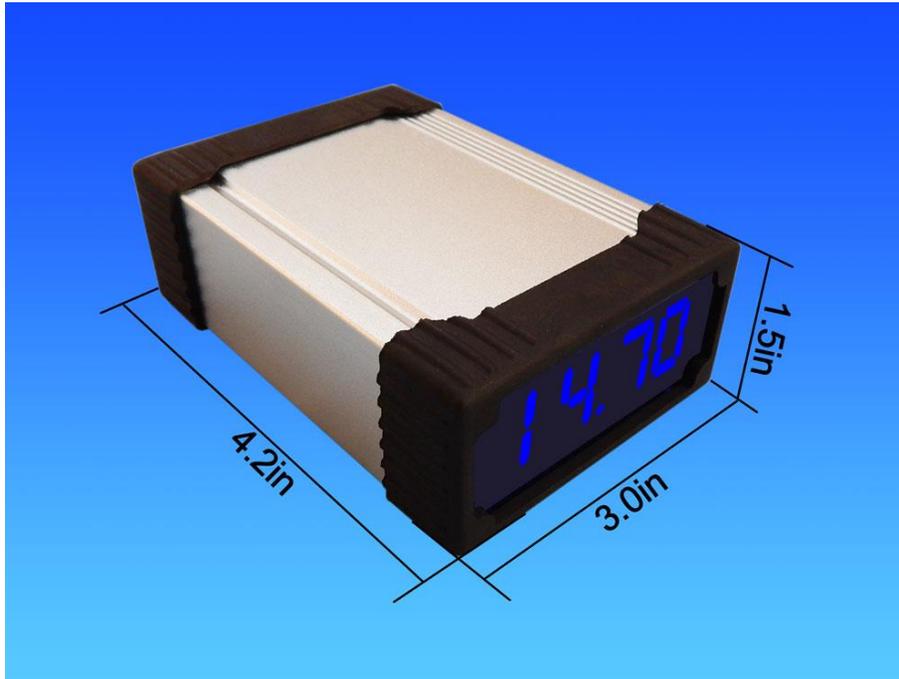
- ◆ CPU S12P Freescale MC9S12P128 16-bit micro-processor  
(Auto industry rated)
- ◆ Speed 32MHz
- ◆ Memory 128k Flash, 6k RAM, 4k Data

**Special features**

- ◆ On-Board-Diagnosis and error report
- ◆ Self-learning of part-to-part variations, aging effect
- ◆ Working with different types of fuels (gasoline, diesel, E85, etc.)

**General**

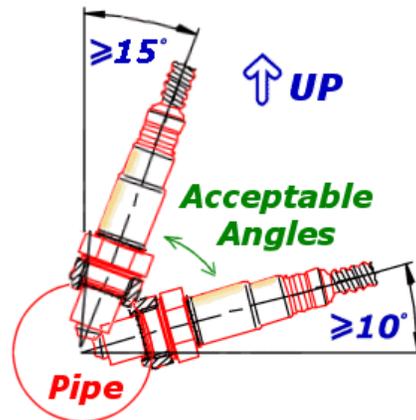
- ◆ Temperature range -40°C ~ 125°C
- ◆ Dimensions 4.2" x 3.0" x 1.5"

**Chapter 4 Appearance and dimension**

## Chapter 5 Protect your oxygen sensor

### Installation

Correct installation of the oxygen sensors is a must to avoid sensor damage. It protects the oxygen sensor from condensations and gives the sensor longer life. It also can make the measurement more accurate. The sensor body should be perpendicular to the exhaust gas flow, and it should also be tilted in the range of  $10^{\circ}$ ~ $75^{\circ}$  from the horizontal line (see below figure). The typical tilt-angle is  $30^{\circ}$ . The sensor head should be close to the center of the exhaust pipe.



After finding the right location on the exhaust pipe, drill a hole of 18 mm in diameter. Weld the sensor bung on it.

**Note: do not weld the bung with the sensor in it.**

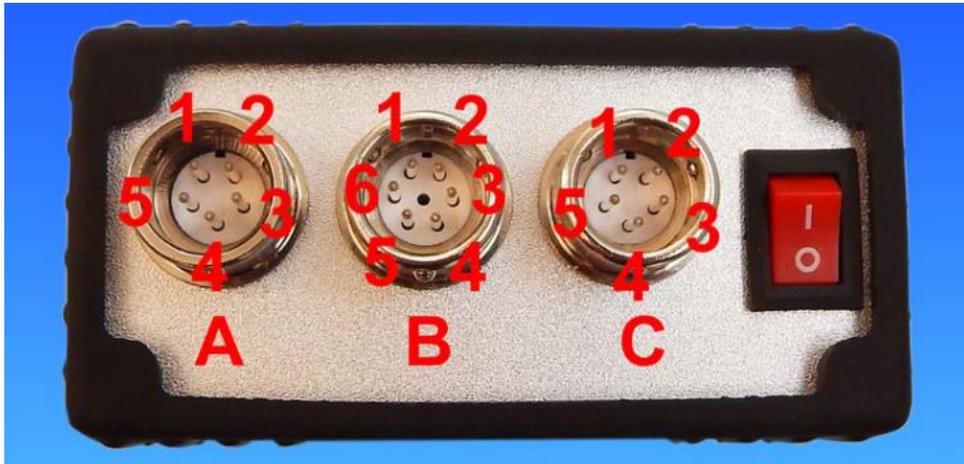
Note, if your vehicle has a Bosch switching oxygen sensor (LSF) on your vehicle, you can just un-plug the LSF, and plug-in the wideband LSU sensor into the hole. Bosch LSU and LSF have the same size of the thread.

### More User Notes

- ⚠️ LSU sensors are not designed to work with leaded gasoline. Using LSU sensor with leaded gasoline will reduce the sensor life.
- ⚠️ With the LSU sensor installed in the exhaust pipe, whenever the engine is running, please also run ALM-LSU-ADV which controls the LSU heater. Otherwise, long-time-running engine with LSU sensor not heated can cause damage of the sensor.
- ⚠️ LSU sensor is preferred to run within the temperature range of  $500\sim 900^{\circ}\text{C}$ , the best temperature is  $785^{\circ}\text{C}$ . Too high temperature ( $>1030^{\circ}\text{C}$ ) will cause damage of the sensor. Refer to Bosch LSU-ADV data for more details about the variant temperature requirements.  
<http://www.etas.com/en/downloadcenter/5858.php>
- ⚠️ Avoid heating the LSU sensor before the engine is running. At the engine start, there may be condensations in the exhaust gas, which can cause damage of the sensor. The preferred order: start the engine first, then immediately turn on the ALM-LSU-ADV, which will ramp up the heating power smoothly.

## Chapter 6 ALM-LSU-ADV hardware connections

### 6.1 ALM-LSU-ADV main connector pin-out



Connector	Pin #	Wire#	Name	Description	Min	Max
Connector A	1	Gray	TXD	Serial communication port	-15V	15V
	2	Purple	RPM	Injection signal input	0V	12V
	3	yellow	RXD	Serial communication port	-15V	15V
	4	Green	NO2OUT	Simulated narrow band oxygen sensor output	0V	1V
	5	Black	GND-R	Ground (Reference ground)	0V	0V
Connector B	1	Red	IP	wideband oxygen sensor input	—	—
	2	Yellow	VM		—	—
	3	White	H-		—	—
	4	Grey	H+		—	—
	5	Green	Reserve		—	—
	6	Black	UN		—	—
Connector C	1	Black	GND-R	Ground (Reference ground)	0V	0V
	2	Red	+12V	+12V Power supply	9V	15V
	3	Black	GND-R	Ground (Reference ground)	0V	0V
	4	Blue	ANOUT	Lambda linear analog output (fine)	0V	5V
	5	Black	GND-H	Ground (Heater circuit ground)	0V	0V

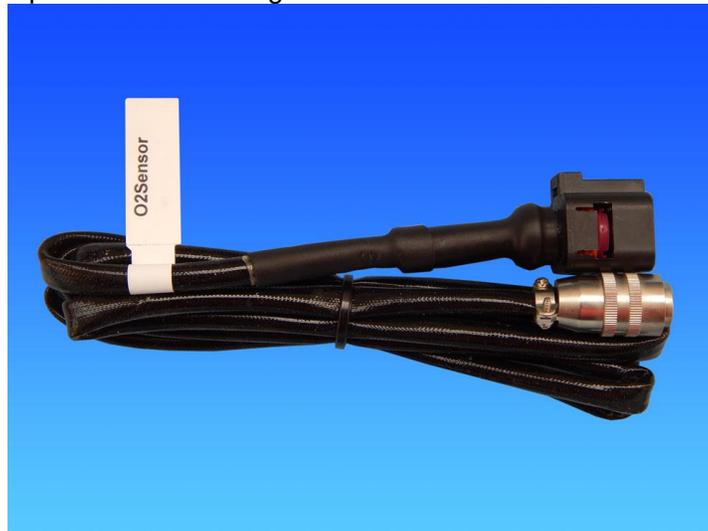
**LSU sensor connector:**



**Note:** The pin-out of LSU-ADV are the same as the LSU-4.9 , but the 5<sup>th</sup> pin(IA) of LSU-ADV is reserved.

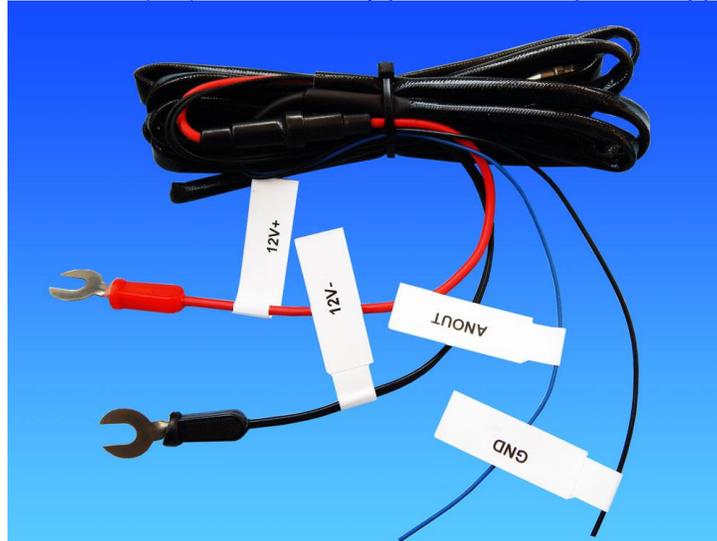
## 6.2 Installation Procedures

- 1) Plug-in the three connectors from the harness into ALM-LSU-ADV.
- 2) Connect the 6-pin LSU ADV mating connector to the O2 sensor.



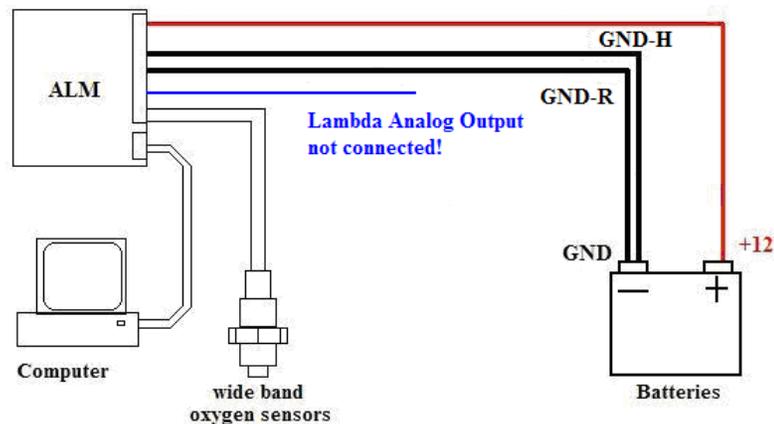
Connector to the O2 sensor

- 3) Connect the 12V+ wire (red) to 12V battery plus or the DC power supply +;



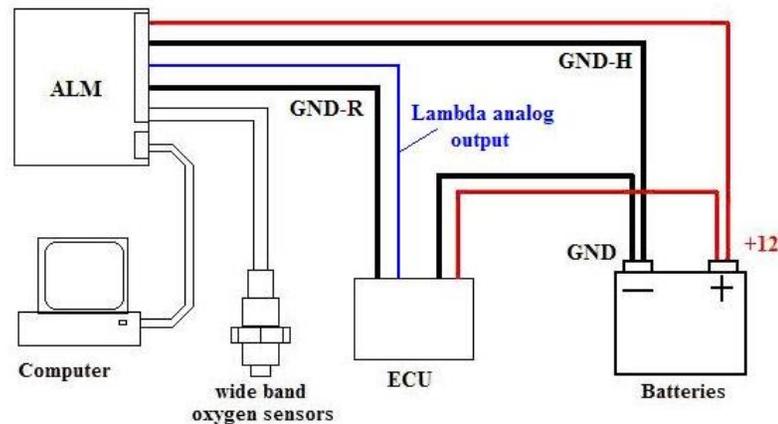
Power supply and ANOUT

- 4) Connect the 12V- wire (Black) to 12V battery minus or the DC power supply - ;  
 5) If you do not want to output the lambda analog signal to your ECU, connect the GND-R (**reference ground, pin4**) to the 12V battery minus or DC power supply ground.  
 Example of the ALM running alone:

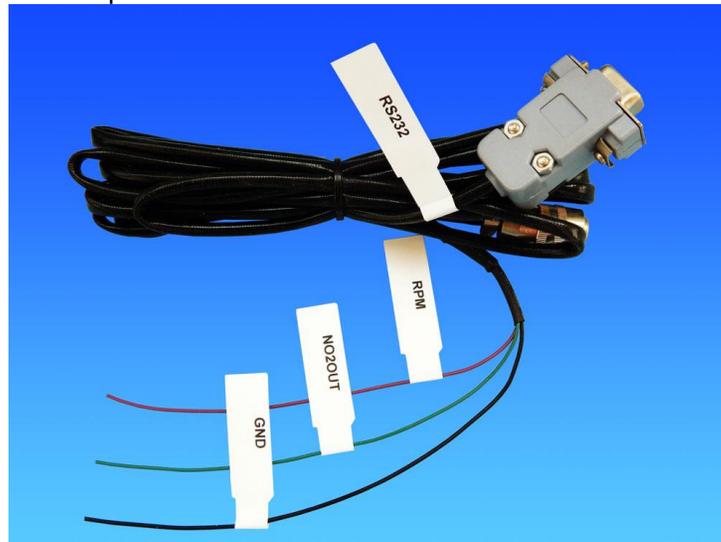


- 6) **If you want to output the lambda analog signal to your ECU, connect the ALM-LSU-ADV"ANOUT" wire to your ECU analog input, and then you must connect the ALM-LSU-ADV"GND-R" (reference ground, pin4) to the ECU analog GND (ECU generally has an analog ground).**

Example of connecting the ALM's analog output to an ECU as the feedback signal:



- 7) Optional: RPM input to ALM-LSU-ADV. Splice the injector-driver wire on the ECU side (usually low-side-driver type), and tap the ALM-LED RPM input wire to it. Use the electrical tape to wrap it.



RPM, COM and NBO2OUT

- 8) Optional: Connect an analog narrowband oxygen sensor output (NBO2OUT) to the OEM's ECU, which can prevent some OEM's ECU from turning on the alarm light. Note, the OEM NB O2 sensor can be different from each other, and it's your responsibility to figure out how to connect the wires correctly.
- 9) Optional: connect ALM-LSU-ADV to your laptop / PC via the serial communication cable (DB9 connector). If your computer does not have a serial port, you can use Ecotrons USB-RS232 converter.
- 10) Users can set the ANOUT analog output to correspond to AFR, Lambda, or oxygen concentration. We will set it in our factory according to the users' requirement. The standard ANOUT output is AFR. If users want it to output lambda or O2%, users can modify it by using ALM GUI. Connected ALM-Board to computer, click Settings→ALM Parameters, open ALM Parameters window. You can select what you want to modify the ANOUT output and Burn to ALM.

Users can use the ALM GUI software to connect the ALM-LSU-ADV. This software can display Lambda, AFR, O2%, O2 sensor temperature; calibration ANOUT and set ANOUT

output range; read fault codes; record and playback data, etc.

About ALM GUI usage, please refer to the [ALM GUI Manual].

### 6.3 ALM-LSU-ADV-CAN

ALM-LSU-ADV-CAN is ALM-LSU-ADV with CAN bus version, which is based on the ALM-LSU-ADV adding CAN bus function. This is a more advanced feature for professional engine controls where CAN bus is used widely. ALM-LSU-ADV-CAN supports all the functions of CAN bus designed by ECOTRONS, and AFR/lambda/O2% can be broadcasted on the CAN bus.



ALM-LSU-ADV-CAN pin-out is same with the ALM-LSU-ADV. The connection can reference ALM-LSU-ADV.

If you want to connect ALM-LSU-ADV-CAN with CAN bus, please connect the CAN wire correctly.

**Dark Green** wire is CAN-L; **Yellow** wire is CAN-H.



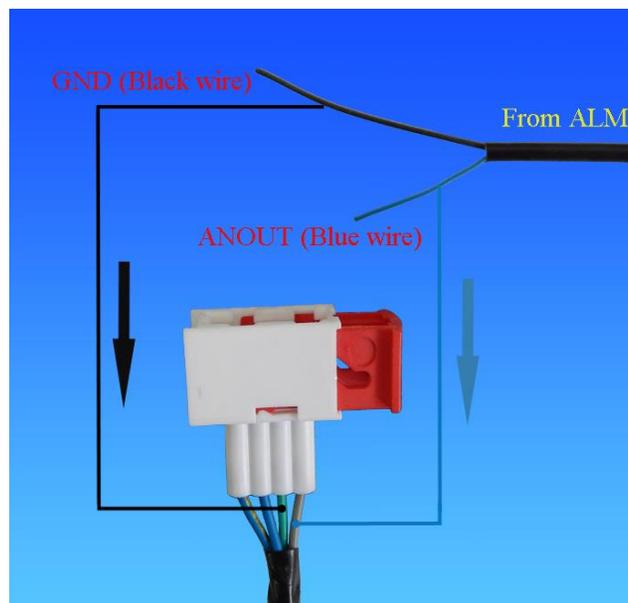
About CAN communication protocol, please refer to the [ALM Communication Protocol -

## 6.4 Connection ALM to ECU

There are 2 ways to connect ALM to (Ecotrons) ECU:

- Connected via NB O2 connector.
- Connected via performance switch. We recommend the first.

### 6.4.1 ALM connection via NB O2 connector



From **left** to **right** in the picture:

- ◆ Heater circuit - (Blue-Yellow)
- ◆ Heater circuit + (Blue)
- ◆ Reference Ground (Green)
- ◆ O2in - O2 sensor input (Gray-Black)

Our ALM-LSU-ADV harness comes with 2 wires:

ANOUT (Blue) - analog output representing the lambda

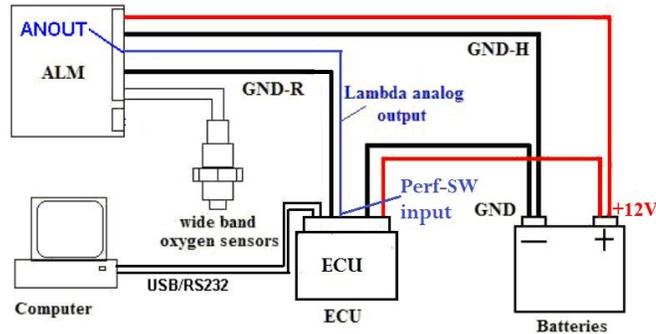
GND (Black) - reference ground

You need to connect the ANOUT (Blue) to O2in (Gray-Black) and GND (Black) to Ground (Green).

### 6.4.2 Connect ALM to ECU via performance switch

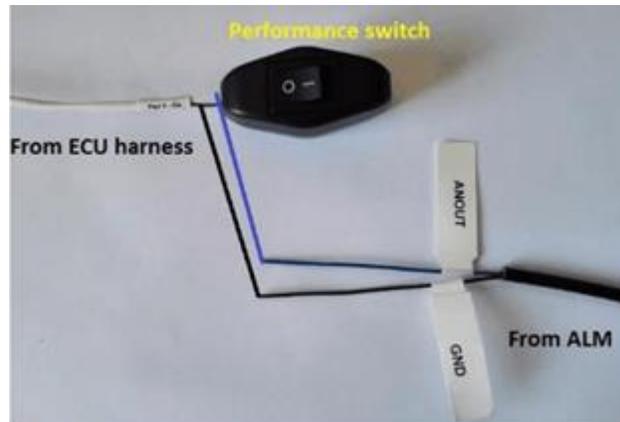
For EFI systems without narrow-field oxygen sensors, the user needs to connect the linear analog output of the ALM to the performance change switch of the EFI system. Then the ECU

can read the Lambda value. The connection diagram is shown below.



The following is the connection procedure for connecting the analog output of the ALM to the input of the ECU performance changeover switch:

- 1) The user needs to set the performance change switch to the "O" side; otherwise, the ECU will not read to the correct analog input;
- 2) ALM'S ANOUT (blue line) is connected to the white line of the Performance-Switch
- 3) ALM'S analog GND (black line) is connected to GND (green line) of the Performance-Switch
- 4) ANOUT the output voltage from 0V to 5V, and does not need to be modified; it will be varied in accordance with the variation of the lambda.



Note: The performance switch is normally not used for fuel switching. And you can set the performance switch to the "I" side at any time after disconnecting the ALM.

## 6.5 ANOUT Calibration

Lambda mode, ANOUT used to indicate changes in lambda, the default setting:

0.00 Volt at Lambda 0.50

5.00 Volt at Lambda 2.00

The screenshot shows the 'ALM Parameters Settings' window. In the 'O2 Sensor 1 Linear Relation' section, the 'Vol1 at Lambda 1' is set to 0.50 and 'Vol2 at Lambda 2' is set to 2.00. The 'Lambda' radio button is selected, while 'AFR' and 'O2%' are unselected. The 'Enable diagnostics of Linearized analog output' checkbox is also checked. Other sections include 'Fuel Type' (Gasoline), 'ALM Hardware Version' (Number of Sensors: 1, Hardware Version: ALM-Gauge), 'Stroke' (Number of Strokes: 4), 'Select Voltage Input' (Vin1, Vin2, MAP, EGT), and 'MAP Sensors' (1 Bar, 2.5 Bar, Burn To ALM).

AFR mode, ANOUT used to indicate changes in AFR, the default setting:

0.00 Volt at AFR 7.35

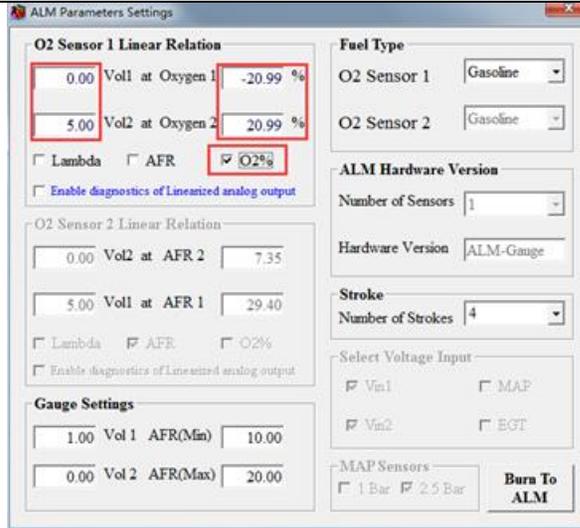
5.00 Volt at AFR 29.4

The screenshot shows the 'ALM Parameters Settings' window. In the 'O2 Sensor 1 Linear Relation' section, the 'Vol1 at AFR 1' is set to 7.35 and 'Vol2 at AFR 2' is set to 29.4. The 'AFR' radio button is selected, while 'Lambda' and 'O2%' are unselected. The 'Enable diagnostics of Linearized analog output' checkbox is also checked. Other sections include 'Fuel Type' (Gasoline), 'ALM Hardware Version' (Number of Sensors: 1, Hardware Version: ALM-Gauge), 'Stroke' (Number of Strokes: 4), 'Select Voltage Input' (Vin1, Vin2, MAP, EGT), and 'MAP Sensors' (1 Bar, 2.5 Bar, Burn To ALM).

O2% mode, ANOUT used to indicate changes in O2%, the default setting:

0.00 Volt at O2% -20.99

5.00 Volt at O2% 20.99



If customers want to modify these parameters, customers can refer to ALM GUI Manual. The ALM GUI can communicate using either COM or USB.

<http://www.ecotrons.com/files/ALM%20GUI%20Manual.pdf>

Note: The limit range of analog voltage is 0-5v. The value of lambda is 0.5-16. The low voltage must match the low Lambda. You can't make 5V match 0.5 Lambda. AFR and O2% are the same as with Lambda.

## Chapter 7 DTC table

Below is the Diagnostic Trouble Code table. ALM-LSU-ADV has on-board-diagnostics capability to detect most common errors. The first thing user should do when ALM-LSU-ADV is not working appropriately is to read DTC.

Trouble Code	Description	Solutions
E1	Internal communication error	Contact the manufacturer
E2	Internal register error	Contact the manufacturer
E3	LSU yellow wire (VM) short to power	<ol style="list-style-type: none"> <li>1. Check the harness for short-to-power</li> <li>2. Change the LSU</li> </ol>
E4	LSU yellow wire (VM) short to GND	<ol style="list-style-type: none"> <li>1. Check the harness for short-to-ground</li> <li>2. Change the LSU</li> </ol>
E5	LSU black wire (UN) short to power	<ol style="list-style-type: none"> <li>1. Check the harness for short-to-power</li> <li>2. Change the LSU</li> </ol>
E6	LSU black wire (UN) short to GND	<ol style="list-style-type: none"> <li>1. Check the harness for short-to-ground</li> <li>2. Change the LSU</li> </ol>
E7	LSU green wire (IA) short to power	<ol style="list-style-type: none"> <li>1. Check the harness for short-to-power</li> <li>2. Change the LSU</li> </ol>
E8	LSU green wire (IA) short to GND	<ol style="list-style-type: none"> <li>1. Check the harness for short-to-ground</li> <li>2. Change the LSU</li> </ol>
E9	Operating voltage too low	Check the power supply to the ALM spec.
E10	Heater circuit damaged	Contact the manufacturer
E11	Heater circuit short to power	Contact the manufacturer
E12	Heater circuit short to GND	<ol style="list-style-type: none"> <li>1. Check the harness for short-to-ground</li> <li>2. change LSU</li> <li>3. Contact the manufacturer</li> </ol>