



# ALM-Gauge Manual

Accurate Lambda Meter  
\_\_\_with a separate gauge

V2.5

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Check before you power on ALM-Gauge:

- 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-Gauge is correctly connected to DC power supply or 12V battery;

**ALM-Gauge includes parts:****List of ALM parts**

- ◆ Small ALM controller
- ◆ 52mm digital LED gauge (optional)
- ◆ Harness (60in default, 120in optional)
- ◆ Bosch LSU 4.9 sensor
- ◆ Sensor plug and bung
- ◆ USB to serial converter (included)
- ◆ CD - documents and ALM GUI software

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## Chapter 1 ALM-Gauge Product Overview

ALM (Accurate Lambda Meter) is an air/fuel ratio (lambda) meter which uses Bosch LSU 4.9 wideband oxygen sensor and Bosch driver chip CJ125 to accurately measure the exhaust air/fuel ratio (AFR) of variant combustion engines.

ALM-Gauge has a 52mm digital LED display header, used to display the AFR value, and the gauge is optional, customers can choose to use their own gauge. This version has all the features of ALM. The controller box has the size of 4"x2.6"x1". It has a primary 0-5v linear analog output which can be used as the feedback control signal for an ECU.

First, ALM uses the more advanced LSU 4.9 wideband sensor. And it can also use LSU ADV sensor by using the ALM GUI to set.

Second, Bosch chip CJ125 is the integrated chip (IC) specifically designed for LSU 4.9 Sensors. Bosch's own wideband controller, "LambdaTronic", 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 4.9 and CJ125 make our ALM a more accurate lambda meter in the automotive aftermarket.

Besides air/fuel ratio measurement, ALM-Gauge provides some supplemental functions which make your measurement or tuning more convenient: linear analog output to your ECU; LED digital display; engine RPM probe, data logging with a serial communication to a PC, etc.

| 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) |
|------------------|---------------|------------------|------------------------------|---------------------|-----------------------------|----------------------------|-------------------------|--------------------|--|
| <b>ALM-Gauge</b> | <b>RS232</b>  | <b>AFR Gauge</b> | <b>1</b>                     | <b>YES (0 ~ 5v)</b> | <b>LSU 4.9(default)/ADV</b> | <b>NO</b>                  | <b>NO</b>               | <b>YES</b>         | <b>YES</b>                                   |
| ALM-B-AN OUT     | SCI(0 ~ 5v)   | NO               | 1                            | YES (0 ~ 5v)        | LSU 4.9 (default)/ ADV      | NO                         | NO                      | NO                 | NO   |
| ALM-B-CAN        | CAN           | NO               | 1                            | NO                  | LSU 4.9 (default)/ ADV      | NO                         | NO                      | NO                 | NO   |
| ALM-B-RS485      | RS485         | NO               | 1                            | NO                  | LSU 4.9 (default)/ ADV      | NO                         | NO                      | NO                 | NO   |
| ALM-LED          | RS232         | LED (4 bit)      | 1                            | YES (0 - 5v)        | LSU 4.9 (default)/ ADV      | NO                         | NO                      | YES                | YES  |
| ALM-CAN          | CAN           | NO               | 1                            | NO                  | LSU 4.9 (default)/ ADV      | NO                         | NO                      | NO                 | NO   |
| ALM-CAN-II       | CAN           | NO               | 2                            | NO                  | LSU 4.9 (default)/ ADV      | NO                         | NO                      | NO                 | NO   |
| ALM-II           | RS232         | LCD(128*64)      | 2                            | YES (0 - 5v)        | LSU 4.9 (default)/ ADV      | NO                         | NO                      | YES                | YES  |
| ALM-LD           | RS232/CAN/USB | LCD(640*480)     | 2                            | YES (0 - 10v)       | LSU 4.9 (default)/ ADV      | YES                        | YES                     | YES                | YES  |

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

## Chapter 2 ALM-Gauge technical specifications

### Power supply

- ◆ Input voltage range DC9V~15 V (12V Typical)
- ◆ Input current 90mA typical plus the heater current
- ◆ Polarity protection Reverse polarity protected
- ◆ Load Dump Clamp Maximum Voltage 33V

### Sensors

- ◆ Compatible LSU 4.9 (Support LSU ADV, LSU 4.2 capable but not recommended)
- ◆ Number of Sensors One
- ◆ Free air calibration No need (we measure the free air O2)

### Measurement

- ◆ Lambda range  $\lambda = 0.5 \sim \infty$
- ◆ Lambda accuracy  $\pm 0.008 @ \lambda = 1.00$   
 $\pm 0.01 @ \lambda = 0.80$   
 $\pm 0.05 @ \lambda = 1.70$
- ◆ Air/Fuel Ratio accuracy 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-) Separate wire from Ground

### Response time

- ◆ 5ms updating rate
- ◆ 0-5v analog output in 5ms updating rate;
- ◆ SCI message in 20ms broadcasting rate

### Output

- ◆ Lambda analog output 0~5V user programmable
- ◆ Analog accuracy  $\pm 0.005V$  error with a 10-bit DAC chip
- ◆ Second Lambda analog output 0~5V for a third party gauge, user programmable
- ◆ Narrow band O2 sensor simulated 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

- ◆ 52mm digital LED display gauge
- ◆ Accurate to one decimal place
- ◆ Display AFR

**Main-Processor**

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

**Special features**

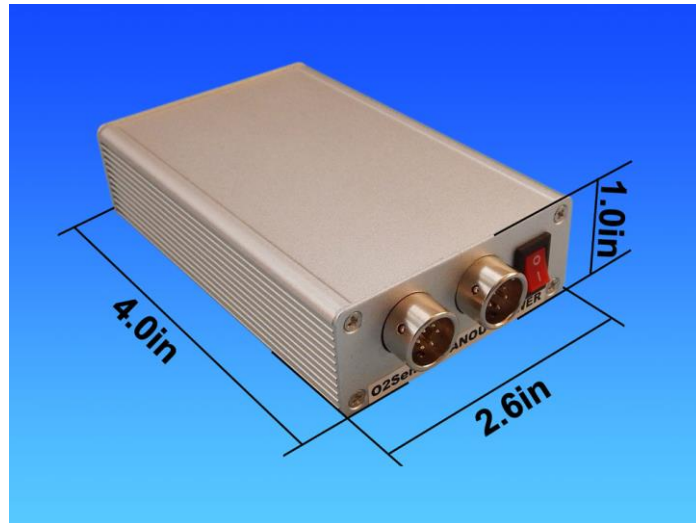
- ◆ On-Board-Diagnosis and error report
- ◆ Self-learning of part-to-part variations, aging effect
- ◆ Working with different types of fuels (gasoline, diesel, E85, etc.)

**General**

- ◆ Temperature range -25°C ~ 70°C
- ◆ Dimensions 4.0" x 2.6" x 1.0"



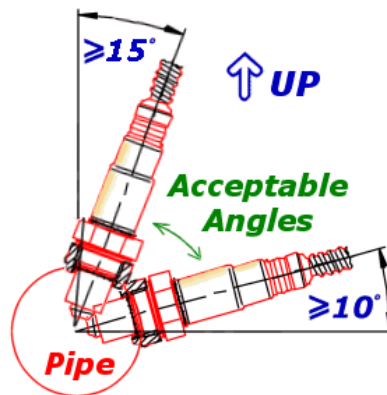
### Chapter 3 Appearance and size



## Chapter 4 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.**

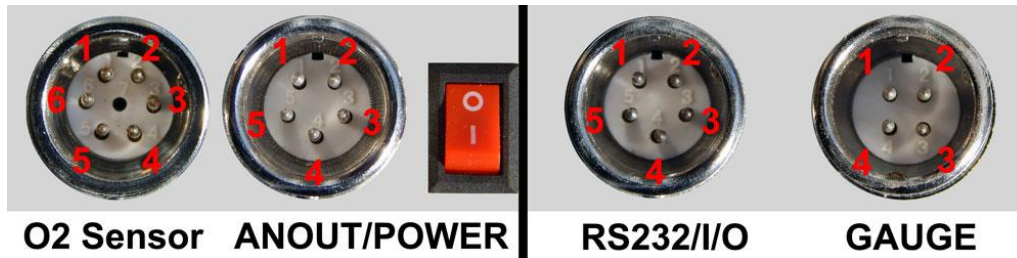
Note, if you vehicle has a Bosch switching oxygen sensor (LSF) on your vehicle, you can just un-plug the LSF, and plug-in the wideband LSU sensor into the hole. Bosch LSU and LSF have the same size of the thread.

### 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-Gauge, 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  $500\text{--}900^{\circ}\text{C}$ , the best temperature is  $780^{\circ}\text{C}$ . Too high temperature ( $>1030^{\circ}\text{C}$ ) will cause damage of the sensor. Refer to Bosch LSU4.9 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-Gauge, which will ramp up the heating power smoothly.

## Chapter 5 ALM-Gauge hardware connection

### 5.1 ALM-Gauge main connector pin-out



| Connector       | Pin# | Wire#  | Name   | Description                                  | Min  | Max |
|-----------------|------|--------|--------|--|------|-----|
| RS232/<br>I/O   | 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  |
| GAUGE           | 1    | Yellow | +12V   | +12V Output                                  | 12V  | 12V |
|                 | 2    | Red    | +12V   | +12V Output                                  | 12V  | 12V |
|                 | 3    | Black  | GND-R  | Ground                                       | 0V   | 0V  |
|                 | 4    | Green  | GAUGE  | coarse analog output to the gauge (optional) | 0V   | 1V  |
| ANOUT/<br>POWER | 1    | Black  | GND-R  | Ground (Heater circuit 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  |
| O2 Sensor       | 1    | Red    | IP     | wideband oxygen sensor input                 | —    | —   |
|                 | 2    | Yellow | VM     |  | —    | —   |
|                 | 3    | White  | H-     |  | —    | —   |
|                 | 4    | Grey   | H+     |  | —    | —   |
|                 | 5    | Green  | IA     |  | —    | —   |
|                 | 6    | Black  | UN     |  | —    | —   |

**LSU sensor connector:**


**Note:** LSU4.9 pin-out numbers are different than LSU4.2, but they have the same color scheme. The pin-out of LSU-4.9 are the same as the LSU-ADV, but the 5<sup>th</sup> pin(IA) of LSU-ADV is reserved.

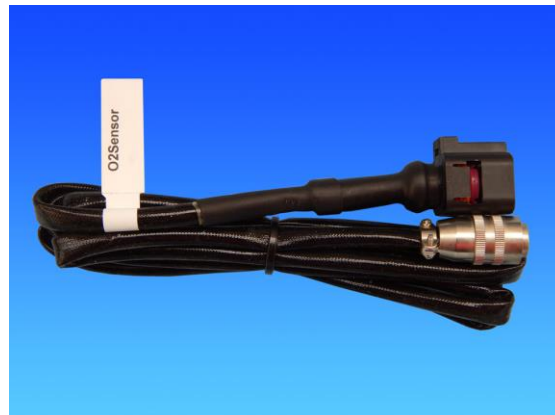
## 5.2 Installation Procedures

- 1) Plug-in the four connectors from the harness into ALM-Gauge, Connect Gauge to your ALM-Gauge.



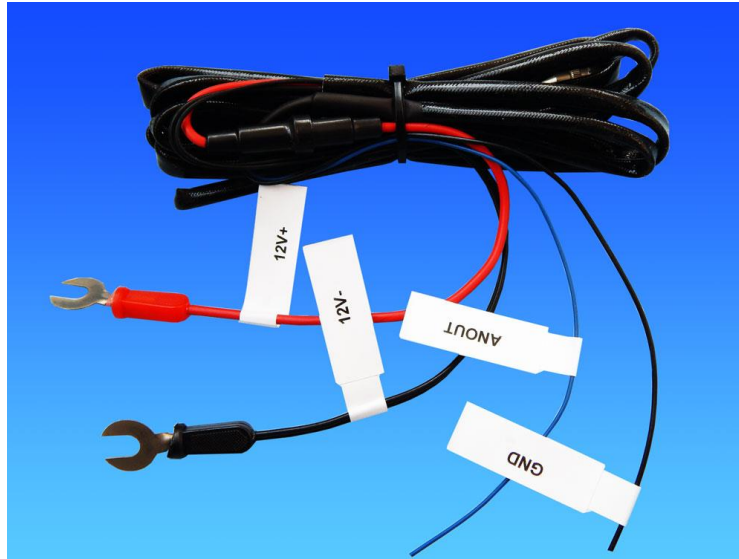
Gauge

- 2) Connect the 6-pin LSU 4.9 mating connector to the O2 sensor.



Connector to the O2 sensor

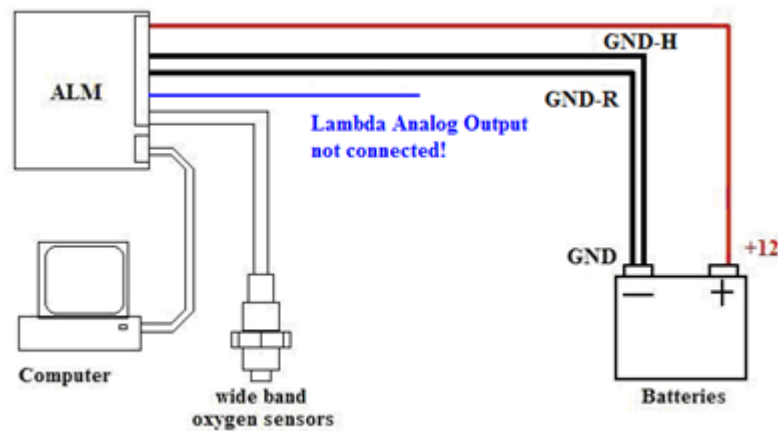
- 3) Connect the 12V+ wire (red) to 12V battery plus or the DC power supply +;



Power supply and ANOUT

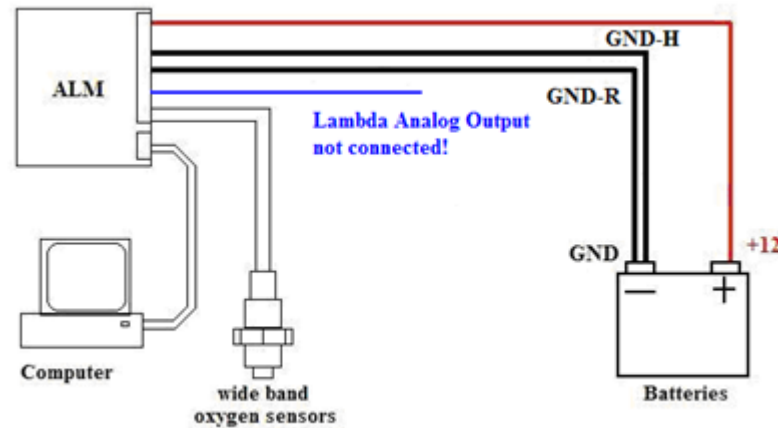
- 4) Connect the 12V- wire (Black) to 12V battery minus or the DC power supply- ;
- 5) If you do not want to output the lambda analog signal to your ECU, connect the GND-R (reference ground, pin4) to the 12V battery minus or DC power supply ground.

Example of the ALM running alone:

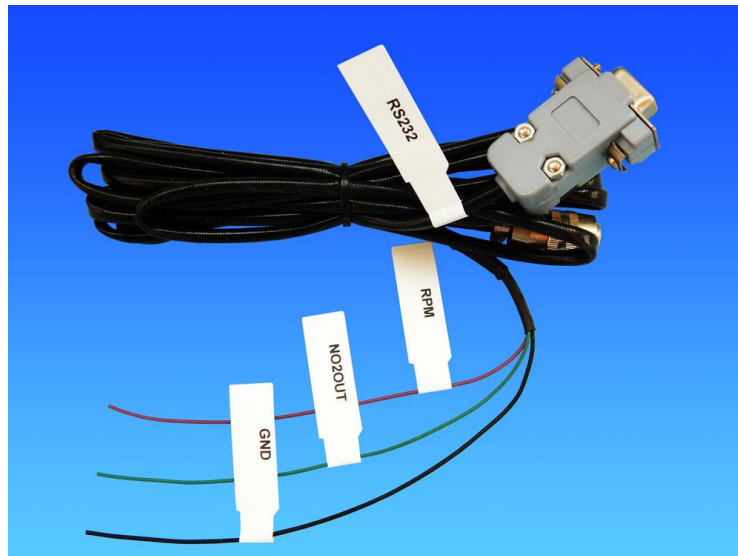


- 6) If you want to output the lambda analog signal to your ECU, connect the ALM-Gauge lambda analog output to your ECU analog input, and then you must connect the ALM-Gauge GND (reference ground, pin4) to the ECU analog GND (most likely your ECU has a sensor ground for analog inputs).

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



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



RPM, COM and NBOU

- 8) Optional: connect an analog narrowband oxygen sensor output (NBOU) to the OEM's ECU, which can prevent some OEM's ECU from turning on the alarm light. Note, the OEM switching 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-Gauge to your laptop / PC via the serial communication cable (DB9 connector). If your computer does not have a serial port, you need an extra 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 O<sub>2</sub>%, users can modify it by using ALM GUI. Connected ALM-Gauge 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-Gauge. 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.

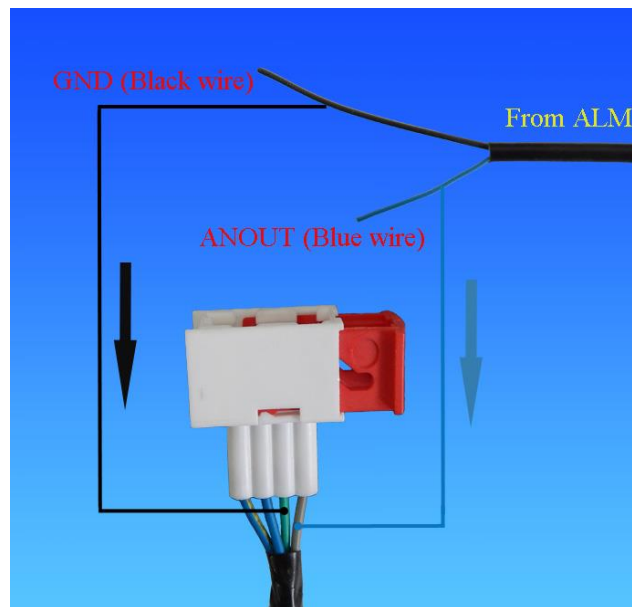
<http://www.ecotrons.com/support/>

## 5.3 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 connection.

### 5.3.1 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-Gauge harness comes with 2 wires:

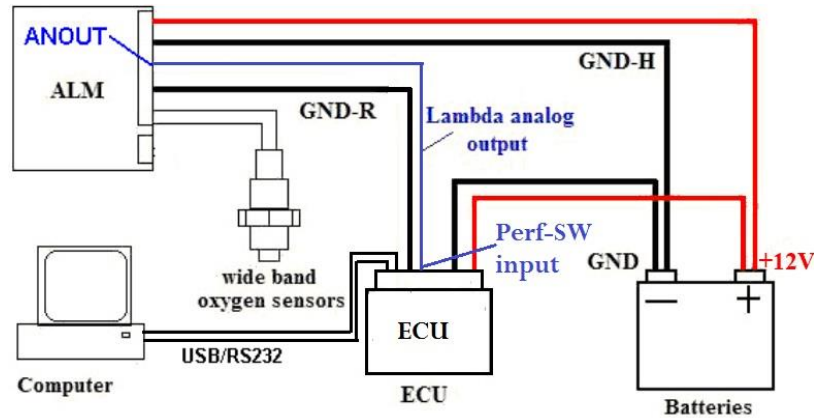
ANOUT (Blue) - analog output representing the lambda

GND (Black) - reference ground

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

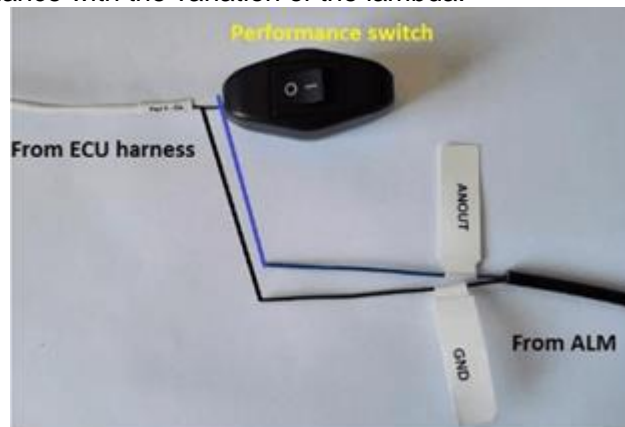
### 5.3.2 Connect ALM to ECU via performance switch

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 switch:

- 1) The user needs to set the performance 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.



## 5.4 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 'Lambda' radio button is selected. The calibration points are: 0.00 Volt at Lambda 0.50 and 5.00 Volt at Lambda 2.00. Other settings include Fuel Type: Gasoline, O2 Sensor 2: Gasoline, ALM Hardware Version: ALM-Gauge, Number of Sensors: 1, Stroke: 4, and Gauge Settings: Vol 1 AFR(Min) 10.00, Vol 2 AFR(Max) 20.00.

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 'AFR' radio button is selected. The calibration points are: 0.00 Volt at AFR 7.35 and 5.00 Volt at AFR 29.4. Other settings include Fuel Type: Gasoline, O2 Sensor 2: Gasoline, ALM Hardware Version: ALM-Gauge, Number of Sensors: 1, Stroke: 4, and Gauge Settings: Vol 1 AFR(Min) 10.00, Vol 2 AFR(Max) 20.00.

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 the chapter 2.4 of ALM GUI Manual.

<http://www.ecotrons.com/support/>

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 same with Lambda.

## Chapter 6 DIGITAL AIR/FUEL RATIO MONITOR (Gauge)

### 6.1 Specification

1. Input Voltage: 0 ~ 1v
2. Display Range: digital type is from 20.0AFR to 10.0AFR; the maximum value or the minimum value is displayed, if the value out off the display range.
3. Accurately of digital type: Every 0.5 AFR .

### 6.2 Application

- A. When at the start, Red LED (for VOLT only) will light up and digital display will show the value of voltage for approximately 30 seconds. After then, the digital display will show the value of AIR/FUEL. Every 10 minutes show the voltage at 30 seconds.
- B. When the voltage is lower than 11.0v, Red LED (for VOLT only) will shine and the digital display will show the voltage value and keeping shine to warning.
- C. When the value of AIR/FUEL is lower than 10AFR or higher than 20AFR over 3 seconds, the digital display will keeping shine to warning.

## Chapter 7 DTC table

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

| 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> |