ECM ENGINE CONTROL AND MONITORING

EGR 5230

EGR/Dual Lambda/O_2 Analyzer

Instruction Manual

11/08/2017

Printed in the United States of America.

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Introduction

The EGR 5230

The EGR 5230 is a very compact exhaust gas recirculation (EGR) ratio measurement device with the following features:

- Measures both volume and mass-based EGR ratios
- Can be used in diesel and spark ignition engines
- EGR measurement response time of less than one second
- Minimally intrusive to engine with no sampling pumps
- Also measures lambda, O_2 (intake and exhaust), pressure (intake and exhaust)
- Can be used as a dual-channel, pressure-compensated lambda meter
- Wide range of operation: %EGR : 0 to 100
  λ : 0.4 to 25.0
  AFR : 6.0 to 364.0
  Φ : 0.04 to 2.5
  $\%O_2$[1] : 0.0 to 25.0
  FAR[2] : 27 to 1667
- Displays in EGR, λ (Lambda), AFR (Air-Fuel Ratio), Φ (Equivalence Ratio), $\%O_2$[1], and FAR[2] (Fuel-Air Ratio) units
- Pressure compensation for EGR, λ, AFR, Φ, $\%O_2$, and FAR
- Can specify any fuel type by H:C, O:C, and N:C ratios, including H_2
- Intake and exhaust pressure measurement range: 0 to 517 kPa (75 Psia)
- All sensor parameters available for display and output
- Easy O_2 sensor calibration using ambient air
- Calibration data for O_2 stored in sensors' connector
- Calibration data for pressure stored in sensors' connector (for EGR analyzers using LambdaCANp modules only)
- Six programmable 0 to 5 VDC analog outputs
- CAN output and .dbc generation software
- Up to 100 m between sensors and display possible
- "Lockout" feature for front panel of display
- Power on/off can be controlled by external "key" signal
- 11-28 VDC and 95-250 VAC[3] operation

The first generation of EGR analyzers used LambdaCAN modules and 4-terminal pressure sensors. The latest uses LambdaCANp modules and 8-terminal pressure sensors.

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[1] For stoichiometries richer than Lambda=1, negative $\%O_2$s are displayed. This convention is useful with lean-burn engines (ex. diesel) that will occasionally operate rich.

[2] FAR x 10000 is displayed. This is the most commonly used way to express FAR. For example, with an H:C=1.85 fuel, Lambda=1 is FAR=686.8.

[3] With optional P/N 04-01 AC/DC Power Supply

Theory of Operation

There are two commonly-use definitions of EGR ratio: volumetric (molar) and gravimetric (mass).

$$\%EGR_v = 100 \cdot v_e / (v_a + v_e)$$

$$\%EGR_m = 100 \cdot m_e / (m_a + m_e)$$

where:

$\%EGR_v$ = volumetric (molar) exhaust gas recirculation, percent
$\%EGR_m$ = gravimetric (mass) exhaust gas recirculation, percent
v_e = volume of exhaust gas inducted into the engine
v_a = volume of air from the atmosphere inducted into the engine
m_e = mass of exhaust gas inducted into the engine
m_a = mass of air from the atmosphere inducted into the engine

Historically, EGR ratio has been determined by CO_2 concentration measurements in the intake and exhaust of the engine. In a similar manner, O_2 concentrations in the intake and the exhaust of the engine can be used to calculate EGR ratio. When the CO_2 (or O_2) concentrations used are wet (i.e. water included in concentration calculations), "wet EGR" is calculated. When the CO_2 (or O_2) concentrations used are dry (i.e. water not considered in concentration calculations), "dry EGR" is calculated. "Dry EGR" is influenced by the lambda of the engine because the $\%H_20$ in the exhaust varies with lambda. The EGR 5230 analyzer reports "wet EGR".

One issue that must be dealt with when using ceramic oxygen sensors to measure O_2 concentration is the sensitivity of the sensor to pressure. Information from the EGR 5230's pressure sensors is used to correct the EGR, λ, AFR, Φ, $\%O_2$, and FAR measurements.

Figure 1 shows the EGR 5230 analyzer attached to an engine. One O_2 sensor and one pressure sensor are located in the intake manifold and one O_2 sensor and one pressure sensor are located in the exhaust. The EGR ratio is calculated for the location of the intake O_2 sensor. Relocating the intake O_2 sensor to different locations in the intake manifold may show the true variations of EGR ratio in the manifold. The O_2 and pressure sensors located in the exhaust can be located upstream or downstream of the turbocharger. To minimize pressure and temperature effects on the sensors, it is preferred that they be located downstream.

Exhaust gases find their way back into the intake via the EGR valve (external EGR) and the intake valve (internal EGR). During throttled engine operation, even with the EGR valve closed, a non-zero %EGR can be measured due to this intake flow. The EGR 5230 cannot differentiate between the two EGR flows. It just measures the %EGR at the location of the intake O_2 sensor. This is better than classical CO2-based EGR analyzers that draw a sample from the intake manifold. These classical analyzers are influenced by both EGR flows and also modify the EGR characteristics of the engine due to their suction.

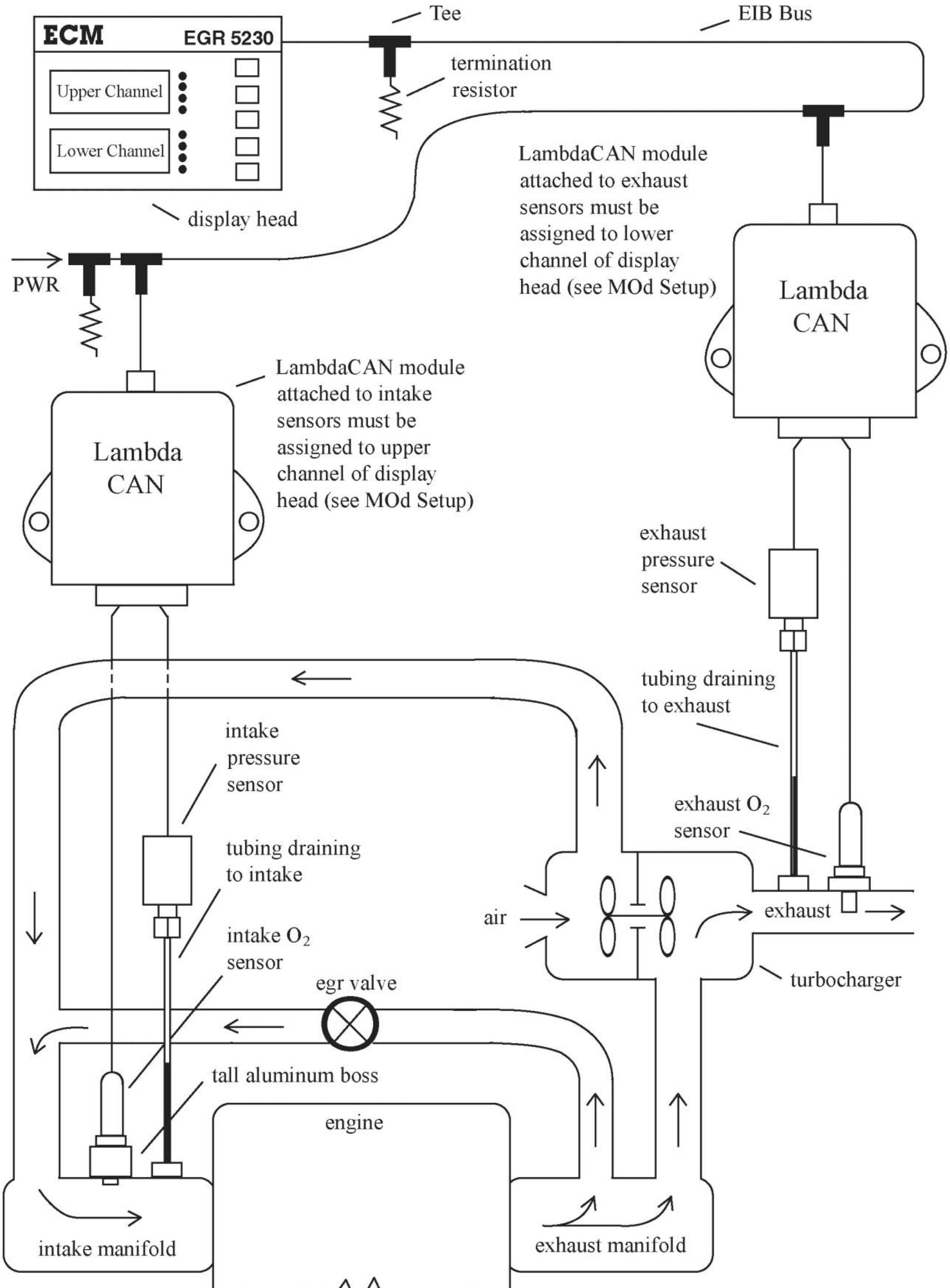


Figure 1: EGR 5230 Installed on Engine

EGR 5230 Kit Contents

The following items are in the EGR 5230 kit:

Item No.	Description	Part Number
1.	EGR 5230 Display Head	01-03
2.	LambdaCANp Module, (2 required)	02-08
	(P/N 02-01 LambdaCAN Modules supplied with earlier analyzers)	
3.	Lambda (O_2) Sensor, Bosch LSU 4.2, Type P, (2 req.)	05-05
4.	Pressure Sensor with ¼" tube fitting (USA), Type P, or Pressure Sensor with 6 mm tube fitting (Metric), Type P. These sensors have 8-terminal connectors. (2 required)	07-10 07-11
	(P/N 07-05 (USA) or P/N 07-06 (Metric) Pressure Sensors required for earlier analyzers that use LambdaCAN Modules. These sensors have 4-terminal connectors.)	
	All pressure sensors manufactured by TE for ECM.	
5.	Pressure Line Assembly, ¼" dia., 28" long, (USA), or Pressure Line Assembly, 6 mm, 711 mm, (Metric) (2 required)	12-08 12-11
6.	Eurofast 12 mm Cable, 4 m	09-01
7.	Eurofast 12 mm Cable, 2 m, (2 required)	09-02
8.	Flexi-Eurofast 12 mm Cable, 0.3 m, (4 required)	09-04
9.	Eurofast "T", (5 required)	09-05
10.	Eurofast Termination Resistor, (3 required)	09-06
11.	Module Y Cable (2 required)	10-34
	(P/N 10-21 Y Cable required for earlier analyzers that use LambdaCAN Modules)	
12.	Lambda Cable, 1 m, (2 required)	10-02

13.	Pressure Cable, 1 m, (2 required) These cables have 8-terminal connectors. (P/N 10-04 Pressure Cables required for earlier analyzers that use LambdaCAN Modules. These cables have 4-terminal connectors.)	10-35
14.	DC Power Cable, Banana Plugs	11-16
15.	Female Eurofast to DB9F	11-05
16.	Key-on Cable, 2 m	11-08
17.	18 mm x 1.5 mm Mild Steel (MS) Boss and Stainless Steel (SS) Plug	12-02
18.	18 mm x 1.5 mm Tall Aluminum (Al) Boss, Copper (Cu) Gasket, and Al Plug	12-04
19.	¼" NPT Mild Steel (MS) Boss and Brass Plug (USA), or ¼" ISO Mild Steel (MS) Boss and Brass Plug (Metric)	12-05 12-12
20.	¼" NPT Aluminum (Al) Boss and Brass Plug (USA), or ¼" ISO Aluminum (Al) Boss and Brass Plug (Metric)	12-07 12-14
21.	5200 Series Analyzer and Module Manuals and Configuration Software, CD	13-01

Appendix A contains a list of all 5200 series instruments parts.

Operating the EGR 5230

The EGR 5230 measures the EGR ratio at the location of the intake O_2 sensor and does not modify or average the EGR in the intake manifold because there isn't any sample pumping (i.e. unlike CO_2-based EGR ratio measurement systems). Putting the sensors in the engine gives the analyzer a fast response (i.e. again, unlike CO_2-based EGR ratio measurement systems). Therefore, the EGR 5230 may uncover EGR variations in the intake manifold that are otherwise hidden by other measurement systems. Keep this in mind when using the EGR 5230.

The O_2 and pressure sensors are factory calibrated. The user recalibration of the O_2 sensors is performed via the SPAN function. The O_2 sensor calibrations are stored in a reprogrammable memory chip in the sensor's connector.

The pressure sensors in the latest EGR analyzers (that use LambdaCANp modules) also have their calibration stored in a reprogrammable memory chip in the sensor's (8-terminal) connector. The pressure sensors in earlier EGR analyzers (that use LambdaCAN modules) do not have the memory chip in the sensor's (4-terminal) connector. The calibration for these sensors (N, C) is contained on a label attached to the pressure sensor's harness. These numbers must be manually entered into the display head for the upper (intake) and lower (exhaust) channels (see CAL, P, N, C). Pressure sensors must be sent back to ECM for recalibration.

Initial Calibration Upon Installation

Before using the EGR analyzer in a new installation (i.e. a new engine or a new intake O_2 sensor location), the system should be calibrated. Calibration consists of SPANing the intake and exhaust O_2 sensors. There is more than one way to calibrate the EGR analyzer. Below are listed three calibration methods. The first method is the most preferred, the second is not as good as the first, and the third is not as good as the second. The greater the pressure pulsations the O_2 sensors are exposed to, the greater the difference in accuracy between the three methods. Pressure pulsations are greater for engines with lesser cylinders (ex. 1-cylinder engine versus 8-cylinder engine), at lower engine speeds, and are greater the closer the O_2 sensors are mounted to the valves of the engine (i.e. in an individual port runner).

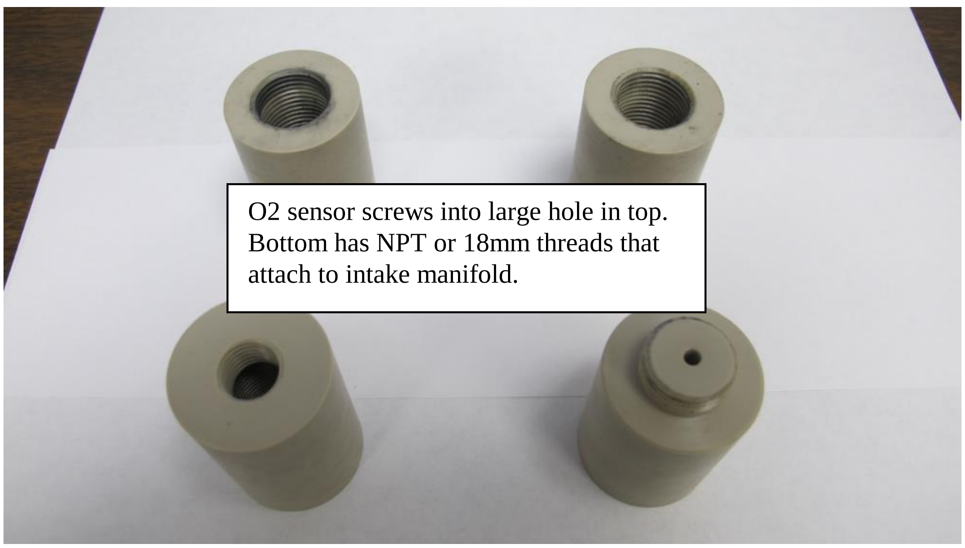
1. (Most preferred) With the intake O_2 and pressure sensors installed in the intake of the engine, run the engine with the EGR valve closed until the engine is warm. Shut the fuel off and motor the engine for 5~10 seconds. Stop the engine, wait 1 minute, and then SPAN the intake O_2 sensor (while still mounted in the intake). SPAN the exhaust O_2 sensor outside the engine in ambient air. Pressure sensors must be installed with the O_2 sensors.

2. SPAN the intake and exhaust O_2 sensors in ambient air. Pressure sensors must also be held in ambient air.

3. With the intake O_2 and pressure sensors installed in the intake of the engine, run the engine with the EGR valve closed until the engine is warm. SPAN the intake O_2 sensor in the intake with the engine running. SPAN the exhaust O_2 sensor outside the engine in ambient air. Pressure sensors must be installed with the O_2 sensors.

After SPANing the intake O_2 sensor, the EGR analyzer automatically assigns O2IZ (intake O_2 value at zero EGR) the intake O_2 span value. Under most circumstances, this O2IZ value need not be modified. However, sometimes after calibrating using method #1, the analyzer will show a non-zero EGR value while the engine is running (versus motoring) with the EGR valve closed. This can be due to valve overlap EGR (i.e. internal EGR) or EGR valve leakage. To zero out the %EGR reading, program the O2IZ value to the intake O_2 value displayed when the EGR valve is closed.

Sometimes the intake O2 sensor will show a %O2 value greater than the ambient %O2 in a running engine. This source of error is caused by the intake O2 sensor cooling down. Check that the intake O2 sensor is mounted using the tall (P/N 12-04 boss). A short boss will put too much of the O2 sensor into the intake resulting in excessive sensor cooling. In cases where intake O2 sensor cooling or excessive drifting/aging is a problem with the P/N 12-04 boss, alternative sensor mounting techniques can be used. For example, the peek spacers shown below. Contact ECM (support@ecm-co.com, or 408-734-3433 (California, USA) for more information.



In-Use Recalibration

With use, O_2 sensors will age. This aging typically results in the O_2 sensor reading low. The effects of aging can be cancelled out by recalibrating (i.e. SPAN) the O_2 sensor.

It is impossible to predict the rate of O_2 sensor aging but it is easy to identify it by operating the O_2 sensor in the condition it was SPANed at and checking the accuracy of the reading. Most often the aging is slow, requiring the SPANing of the O_2 sensors every 100 hours of use or more. Aging typically occurs faster in the intake O_2 sensor than in the exhaust O_2 sensor.

Before recalibrating the intake O_2 sensor, it is recommended that it be operated in the exhaust O_2 sensor position of a running engine for about 10 minutes. This removes some of the material causing the aging which helps maximize the interval between required recalibrations. Sometimes with highly-used O_2 sensors, the interval between required recalibrations will become unacceptably short. When this occurs, the O_2 sensor should be RGENed, then SPANed (see **CAL (Calibrate) Option**).

How to Use

Hooking up the EGR 5230

The EGR 5230 analyzer kit consists of 4 parts:

1. The display head
2. The modules[1]
3. The sensors
4. Cabling

The EGR 5230 is unique in that it puts the control modules close to the sensors. There are several advantages of doing this; the main ones are: improvements in signal-to-noise ratio, simplified cabling, and an almost unlimited sensor-to-display head distance.

The cable between the display head and modules is called the EIB (ECM Instrument Bus) and carries signal and power. There must be a termination resistor at each end of the EIB. The EIB can be powered at either the module end (Figure 2) or the display head end (Figure 3). To minimize the power voltage drop on the EIB, it is preferable to power the EIB from the end closest to the modules because that is where most of the power is being consumed (by the O_2 sensors). It doesn't matter what the order of the intake and exhaust modules on the EIB is.

Branches/drops to display head(s) and module(s) are made from tees attached to the EIB. Up to 32 display heads and modules (total) can exist on the same EIB. The EIB cable, tees, and termination resistors are industry-standard Eurofast 12 mm. The EIB can be extended to a length of 100 m.

The EGR 5230 can be turned on and off by the PWR button on the front of the display head or by a voltage signal (2.7 - 32 V) applied to the KEY connector on the back of the display head. The current requirements of this voltage signal are very low (100 uA).

After being turned on, the display head will test both displays and all leds and then show:

1. The display head's serial number
2. The version of the display head's software
3. The calibration date of the display head (MM.DD YYYY)
4. The serial number (see Figure B1) of the lambda module assigned to the upper channel (intake) and the serial number of the lambda module assigned to the lower channel (exhaust).
   "…." means no lambda module has been assigned to that channel
5. "Rotating wheels" and sensor countdowns as they warm up
6. Parameter data from the lambda module assigned to that channel

Figures 4 through 6 show details and part numbers of components in Figures 2 and 3. Optional components are also shown.

[1] Modules can be setup in EIB Mode or Stand-alone Mode. When the modules are used with a display head, they must be in EIB mode. See Appendix B for more information.

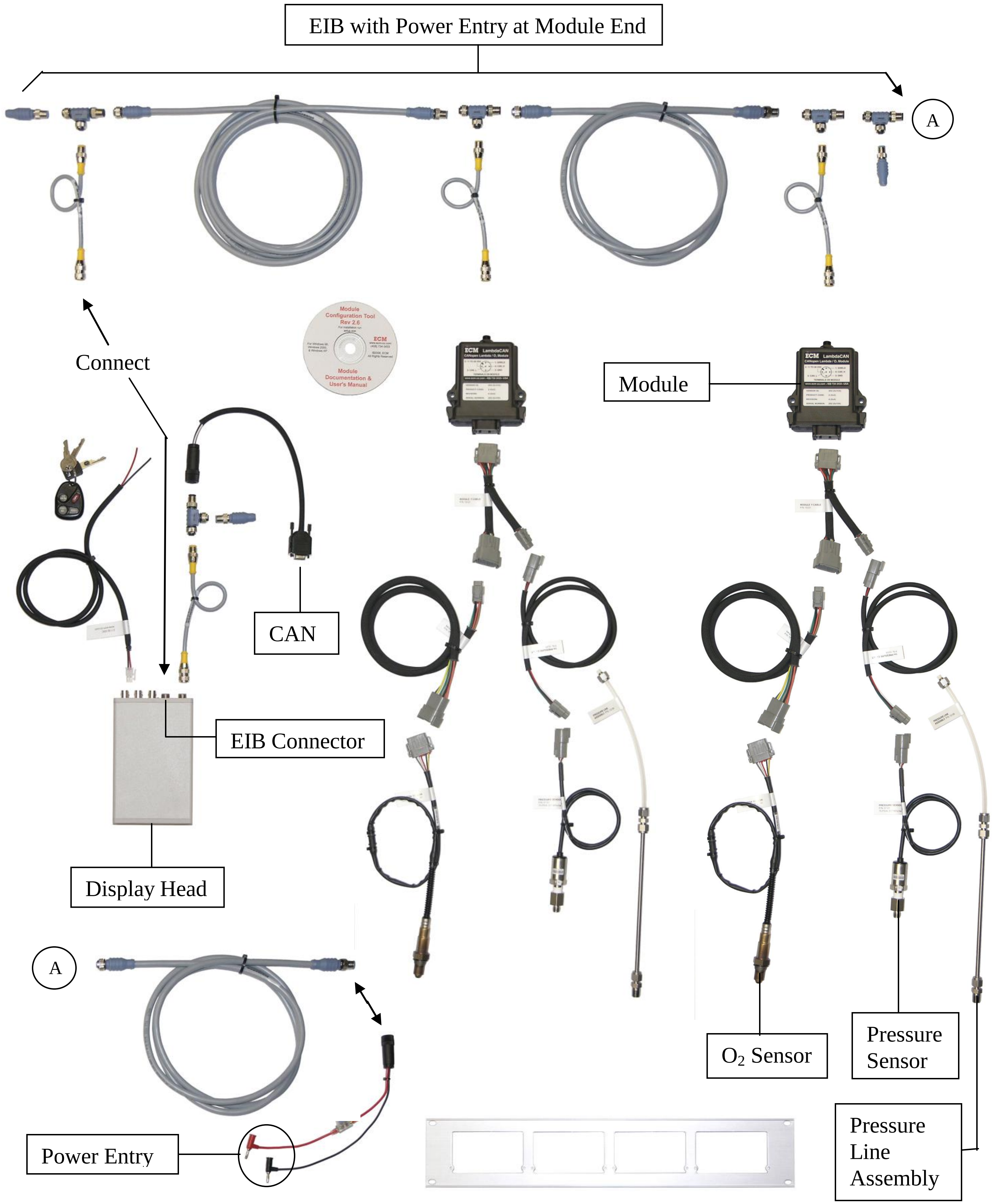


Figure 2: EGR 5230 with Power Entry at Module End

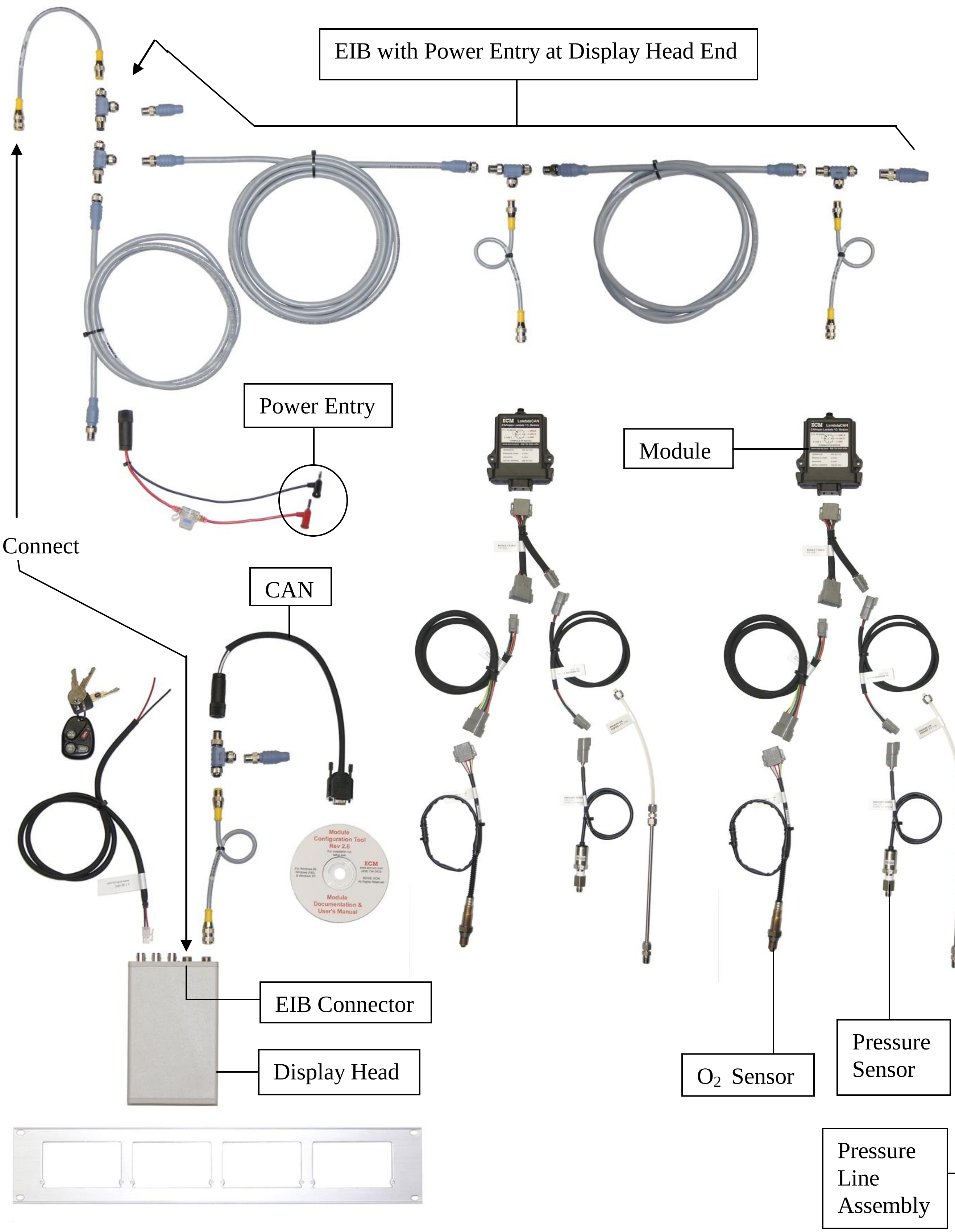


Figure 3: EGR 5230 with Power Entry at Display Head End

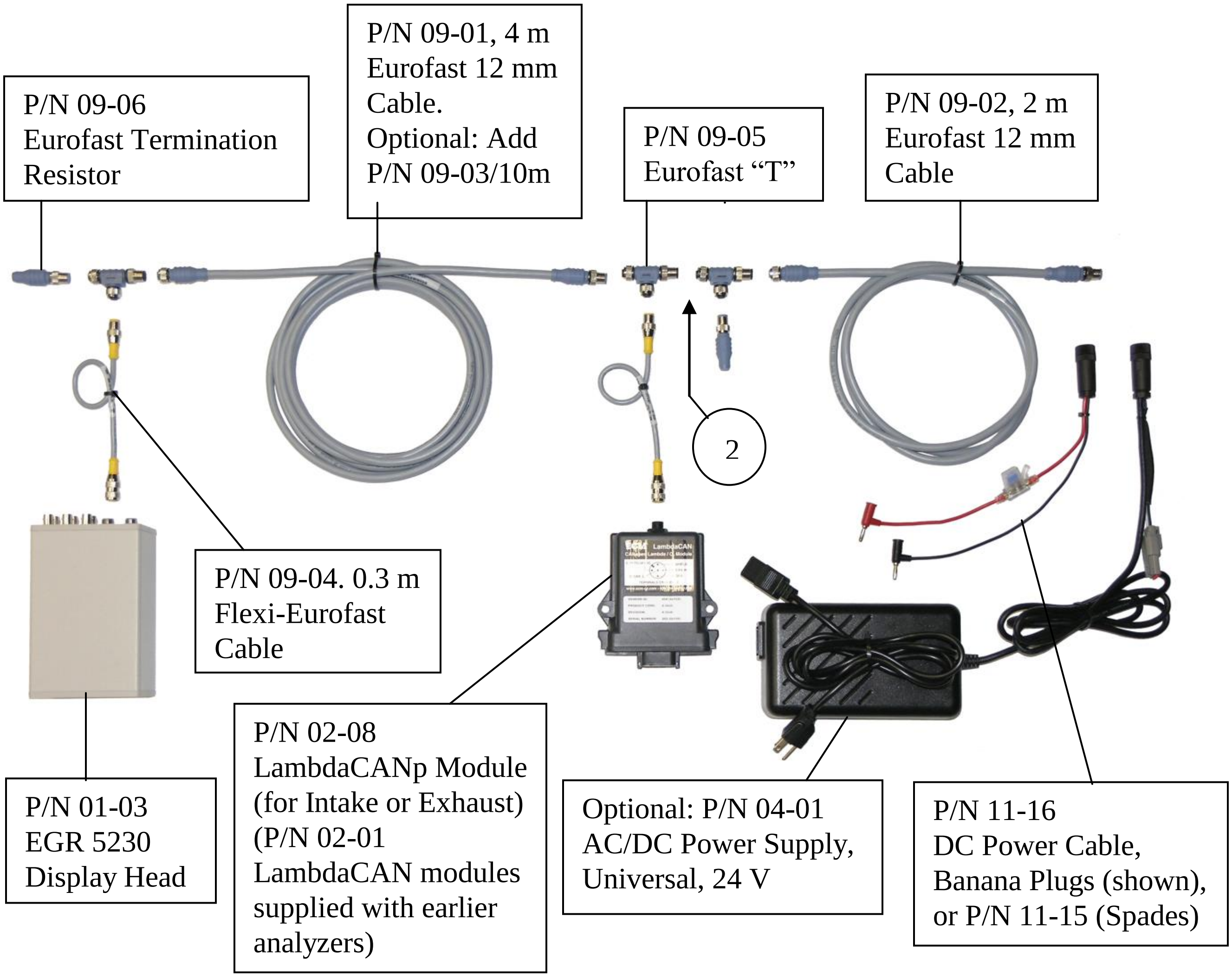


Figure 4a: Part Numbers of Components on EIB

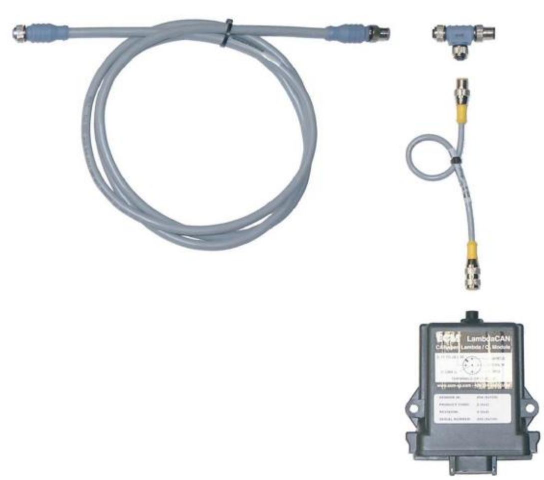


Figure 4b: Add above in Location "2" for Exhaust or Intake Module

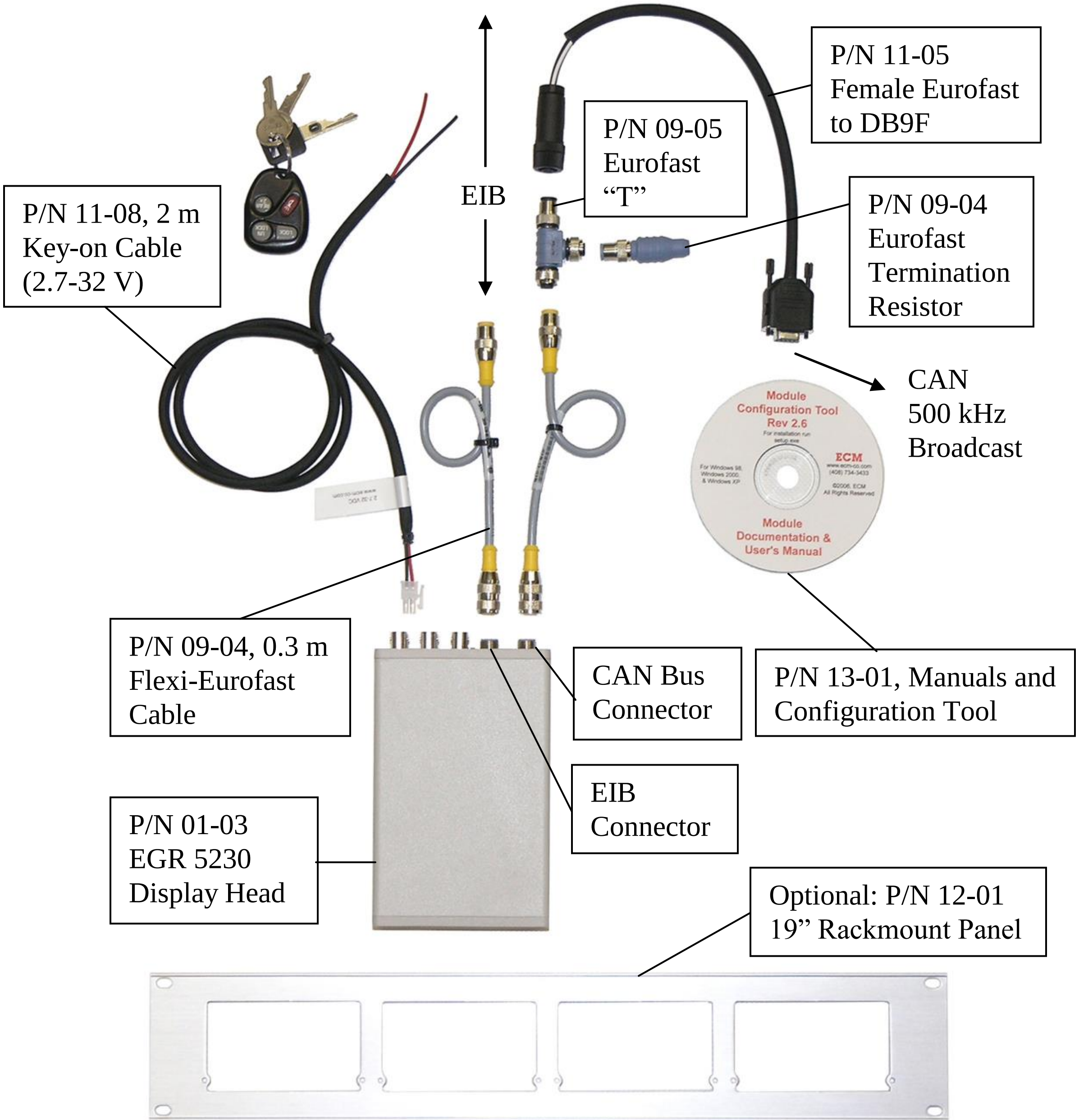


Figure 5a: Part Numbers of Components near Display Head

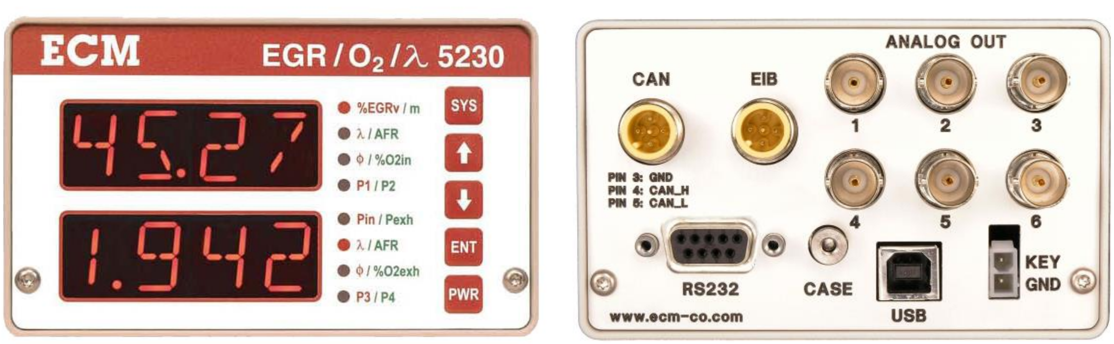


Figure 5b: Front and Back of Display Head

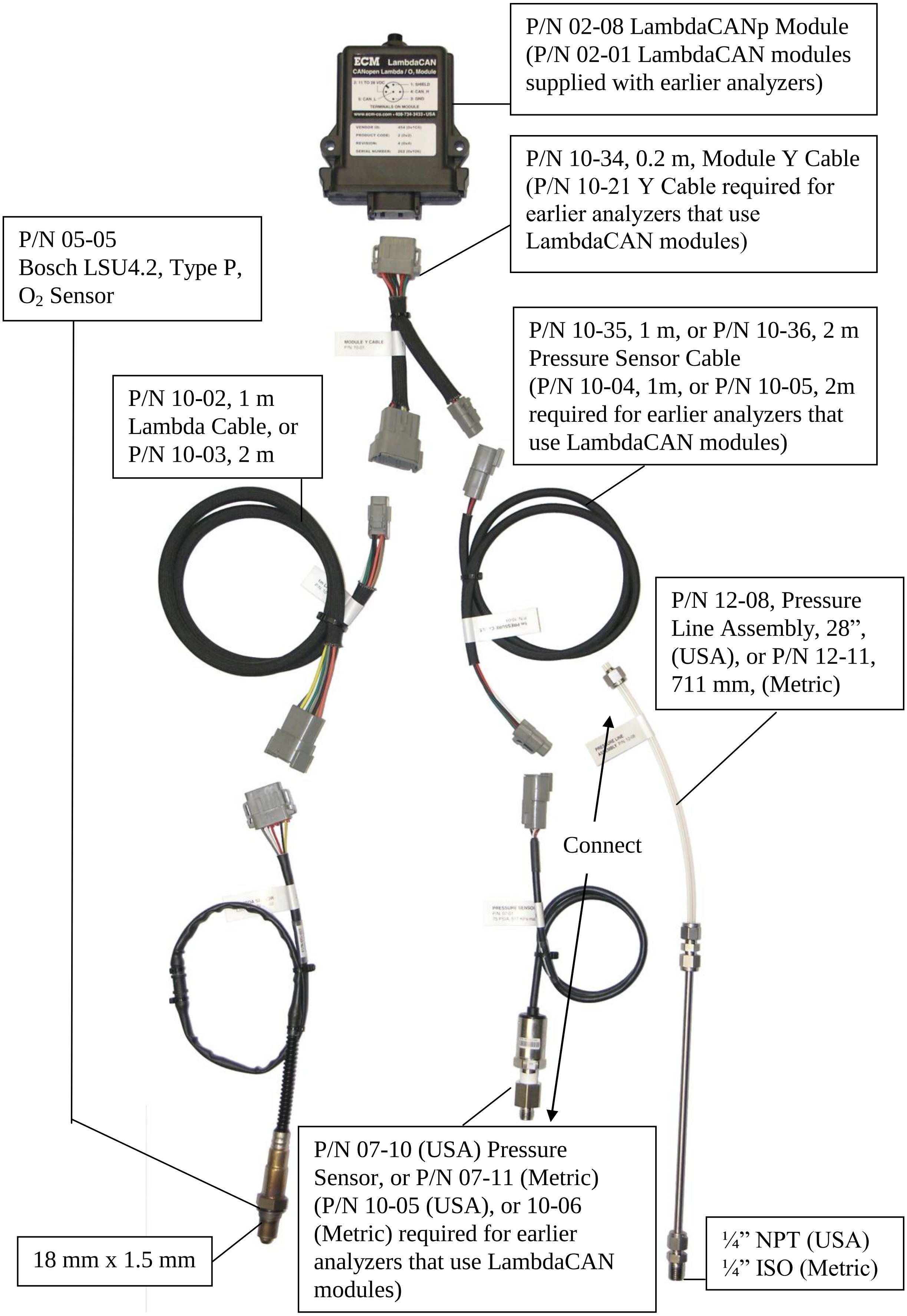


Figure 6: Part Numbers of Components near Module

Mounting the O_2 Sensors and Pressure Sensors

◆ **O_2 Sensors**

- Thread is 18 mm x 1.5 mm.
- Mount intake O_2 sensor using tall aluminum 18 mm boss (P/N 12-04, see Figure 7) to the intake manifold where the %EGR is to be measured.
- Mount the exhaust O_2 sensor using the short steel 18 mm boss (P/N 12-02) between 300 mm from exhaust valve and ten exhaust diameters upstream of exhaust end. Preferentially mount downstream of turbocharger and upstream of exhaust catalyst.
- Do not exceed 850 °C gas temperature at location of O_2 sensors.
- Mount where condensed material will not collect on the O_2 sensors.
- Run tap into mounting bosses after welding and occasionally to clean threads.
- Put antiseize on threads and lightly tighten O_2 sensors.
- Do not operate engine with O_2 sensors not being powered. This may permanently damage them.
- Route O_2 sensor cables away from hot, moving, sharp, or high voltage (spark) wires.

◆ **Pressure Sensors**

- Thread is ¼" ISO (Metric) or ¼" NPT (USA).
- Mount intake pressure sensor aluminum boss (P/N 12-14 (Metric) or 12-07 (USA)) within 50 mm of intake O_2 sensor.
- Mount exhaust pressure sensor steel boss (P/N 12-12 (Metric) or 12-05 (USA) within 50 mm of intake O_2 sensor.
- Do not mount pressure sensors directly to engine or they will overheat and fail. Always use the supplied stainless steel/teflon pressure line assemblies (P/N 12-11 (Metric) or 12-08 (USA)) between the mounting boss and the pressure sensor. The stainless steel end goes towards the engine. Put antiseize on the threads.
- Do not modify the length or diameter of the pressure line assemblies.
- Do not allow condensed material to collect in the pressure line assemblies.
- Locate pressure sensor where temperature is between -20 and 80 °C.
- Run tap into mounting bosses before screwing in pressure line assemblies.
- Route pressure sensor cables away from hot, moving, sharp, or high voltage (spark) wires.

P/N 12-04, 18 mm x 1.5 mm Tall Aluminum Boss, Copper (Cu) Gasket, and Aluminum Plug.
For Intake O_2 Sensor.

P/N 12-07, ¼” NPT Aluminum Boss and Brass Plug, (USA), or
P/N 12-14, ¼” ISO tapered Aluminum Boss and Brass Plug, (Metric).
For Intake Pressure Sensor.

P/N 12-02, 18 mm x 1.5 mm Mild Steel Boss and Stainless Steel Plug. For Exhaust O_2 Sensor.

P/N 12-05, ¼” NPT Mild Steel Boss and Brass Plug, (USA), or
P/N 12-12, ¼” ISO tapered Mild Steel Boss and Brass Plug, (Metric).
For Exhaust Pressure Sensor.

Figure 7: Intake and Exhaust O_2 and Pressure Mounting Bosses and Plugs

Front Panel and the "SYS" Key

The EGR 5230 display head can be thought of as two single-channel display heads in one package. The intake lambda module (attached to intake O_2 and pressure sensors) is assigned (via the **MOd Setup Option**) to the upper display, upper four leds, and analog outputs 1, 2, 3 (i.e. the upper channel) and the exhaust lambda module (attached to exhaust O_2 and pressure sensors) can be assigned (via the **MOd Setup Option**) to the lower display, lower four leds, and analog outputs 4, 5, 6 (i.e. the lower channel). If no module is assigned to a channel, "…." appears on that channel's display. The same module cannot be assigned to both channels. More than two lambda modules can exist on the EIB but a given display head can only show data from two of them.

The display head has two modes of operation: RUN (when measurements or error codes are displayed) and SYS (where the instrument is set-up). The SYS key toggles between the modes.

When in RUN mode, the parameter being displayed is indicated by leds to the right of the display. There are four leds for each display and each led can be red or green. The first six parameters ($\%EGR_v$, $\%EGR_m$, λ, AFR, Φ, $\%O_{2in}$ for upper display), (P_{in}, P_{exh}, λ, AFR, Φ, $\%O_{2exh}$ for lower display) are fixed and two (P1, P2 for upper), (P3, P4 for lower) are programmable from the list of parameters in Table 2. The ↑ and ↓ keys select which of the eight parameters for each channel is displayed (unless the display is LOCKed, see below).

While in RUN mode, pressing the ENT key will toggle between the ↑ and ↓ keys changing parameters on one channel's display to changing parameters on the other channel's display.

In RUN mode, four things other than data can be displayed:

1. "ERR" and "####" where "####" is an error code. See **Appendix C**.
2. "…." which means that a lambda module has not been assigned to that channel. See **MOd Setup Option**.
3. "----" which means that the display head has an internal problem.
4. "XXXX" which means that the display is not receiving any data.
5. "Rotating wheels" and sensor countdowns

When first entering SYS mode, either "MOd" will be on the upper display or "LOCK" will be on the lower display. If "MOd" is displayed, the ↑ and ↓ keys will roll through the setup options (see Table 1). First the options for the upper channel are shown on the upper display, followed by identical options for the lower channel on the lower display, ending with the global CONF (Configuration) setup. Pressing the ENT key will select the displayed setup option and allow its programming.

If "LOCK" is displayed, the display head has been locked and neither the parameters displayed nor the instrument setup can be changed until it is unlocked. Appendix E describes how to LOCK and unLOCK the display head.

Setup Option	Level 1	Level 2	Function
MOd(i,x)			**Select module S/N [NONE]**
RATE			**Set display update rate [FAST]**
FUEL			**Program fuel H:C,O:C,N:C and if H2 [1.85, 0,0, NO]**
AOUT	**A1 (upper channel)**		**Program analog output 1 [EGRv, 0, 100]**
	A2 (upper channel)		**Program analog output 2 [O2 (intake), -25, 25]**
	A3 (upper channel)		**Program analog output 3 [P (intake, KPA), 0, 500]**
	A4 (lower channel)		**Program analog output 4 [LAM (exhaust), 0.4, 25]**
	A5 (lower channel)		**Program analog output 5 [O2 (exhaust), -25, 25]**
	A6 (lower channel)		**Program analog output 6 [P (exhaust, KPA), 0, 500]**
dISP	**P1 (upper channel)**		**Program upper display parameter P1 [FAR (intake)]**
	P2 (upper channel)		**Program upper display parameter P2 [P (intake, KPA)]**
	P3 (lower channel)		**Program lower display parameter P3 [FAR (exhaust)]**
	P4 (lower channel)		**Program lower display parameter P4 [EGRm]**
CAL(i,x)	**O2**	**SPAN**	**Calibrate O_2 sensor**
		FACT	**Reset O_2 sensor to factory calibration**
		RGEN	**Regenerate the O_2 sensor (LambdaCANp only)**
		AGEF	**Show age factor for O_2 sensor**
		EXIT	
	EGR	**O2IZ**	**Enter intake O_2 at zero EGR [calibration (SPAN) O_2 value]**
	P	**UNIT**	**Choose pressure units [KPA]**
		N, C	**Enter pressure sensor cal numbers (LambdaCAN only)**
	AVG	**ILAM**	**Program Ip1, %O_2, λ, AFR, Φ, FAR averaging [0.375]**
		PLAM	**Program P (pressure) averaging [0.375]**
		AEGV	**Program EGRv averaging [0.293]**
		AEGM	**Program EGRm averaging [0.293]**
		AO2I	**Program intake O_2 (for EGR) averaging [0.025]**
		AO2E	**Program exhaust O_2 (for EGR) averaging [0.025]**
		APIN	**Program intake pressure (for EGR) averaging [0.005]**
		APEX	**Program exhaust pressure (for EGR) averaging [1]**
	SKEW	**P**	**Program gain and offset modifier [1,0]**
		AFR	**Program gain and offset modifier [1,0]**
		PHI (Φ)	**Program gain and offset modifier [1,0]**
		FAR	**Program gain and offset modifier [1,0]**
		LAM (λ)	**Program gain and offset modifier [1,0]**
		O2	**Program gain and offset modifier [1,0]**
		EGRv	**Program gain and offset modifier [1.0]**
		EGRm	**Program gain and offset modifier [1,0]**
CONF	**LEdS**		**Set display intensity [3333]**
	1V4V		**Hold analog outputs at 1V and 4V**
	CAN		**Program CAN addresses, RATE, BAUd, produce .dbc file**
	LOCK		**Lock display**
	FACT	**RST**	**Reset all but FUEL, O2IZ, N, C, AVG, and O2 sensor user…**
		EXIT	**…calibration to [factory defaults]**

MOd, RATE, FUEL, AOUT, dISP, and CAL appear on the upper display for the intake module and the lower display for the exhaust module. AEGV to APEX only on upper display. CONF appears only on lower display and is for global display head setup. All entries must be followed by the ENT key.

Table 1: Menu Tree for the EGR 5230
[Default values given within square parentheses]

MOd (Module) Setup Option

In MOd setup, the serial number of the lambda module assigned to the upper (MOdi) or lower channel (MOdx) is entered. The serial number is written on a label on the module (see Figure B1). The module attached to the intake O_2 and pressure sensors must be assigned to the upper channel and will send information to the upper display and the analog outputs 1, 2, and 3. The module attached to the exhaust O_2 and pressure sensors must be assigned to the lower channel and will send information to the lower display and the analog outputs 4, 5, 6.

After entering MOd (i.e. press ENT when "MOd" is displayed), the serial numbers of the available modules on the EIB will displayed. Select using ↑ and ↓ followed by the ENT key.

RATE Setup Option

Different display update rates can be assigned to the upper and lower displays. The selected display update rate does not affect the analog output update rate or the CAN transmission rate.

FUEL Setup Option

Fuel H:C, O:C, and N:C ratios and whether or not the fuel is H_2 can be programmed. These entries should be the same for both channels if both modules are used in the same engine. The ENT, ↑, and ↓ keys are used for programming. If you get into trouble when programming, press the SYS key twice to exit and re-enter setup to try again. Fuel H:C, O:C, and N:C ratios and whether or not the fuel is H_2 is information stored in the LambdaCANp (or LambdaCAN) module.

AOUT (Analog Output) Setup Option

The display head has six 0 to 5V programmable analog outputs. The analog outputs are updated every 5 ms based on information sent to it by a lambda module every 5 ms. 5 ms is the maximum rate and is not programmable. The module averages the data before it is sent at this 5 ms rate. There is one programmable averaging filter for Ip1, λ, AFR, Φ, $\%O_2$, FAR (ILAM) and one for pressure (PLAM). The programmable averaging filter for EGR_v is AEGV. The programming averaging filter for EGR_m is AEGM. See **CAL Setup Option** (AVG Suboption) for more information.

Parameter information from the module assigned to the upper channel can be sent to analog outputs 1, 2, and 3. Parameter information from the module assigned to the lower channel can be sent to analog outputs 4, 5, and 6.

The parameter selected to drive an analog output can be anything from Table 2.

Here is an example of setting analog output 2 (i.e. A2):

1. Press the SYS key until "MOd" is displayed.
2. Press the ↓ key until "AOUT" is on the top display. Then press the ENT key.
3. Press the ↓ key until "A2" (analog output 2) is on the display. Then press the ENT key.
4. Press the ↑ and ↓ key until the parameter (see Table 2) that will drive A2 is displayed. Then press the ENT key.

5. When 0V is displayed, press ENT. Using the ↑, ↓, and ENT keys, set the parameter value that you want to result in an analog output voltage of 0V on analog output 2. The first time you do this, it may be a little tricky. You are setting one digit at a time and for some numbers, the display will shift to the left so you can set the right-most digits. If you get into trouble when programming, press the SYS key twice to exit and re-enter setup to try again.
6. When 5V is displayed, press ENT. Using the ↑, ↓, and ENT keys, set the parameter value that you want to result in an analog output voltage of 5V on analog output 2.
7. When "AOUT" is displayed, press SYS to return to RUN mode.

Name Displayed	**Full Parameter Name**	**Parameter Description**
O2R	%O2real (%)	%O2 before addition of Delta O2 Table
IP1	Ip1 (mA)	Pressure compensated O2 sensor pumping current
RPVS	RPVS (ohms)	O2 sensor internal VS cell resistance
VHCM	VH Commanded (V)	Desired heater voltage commanded by the module
VS	VS (V)	O2 sensor internal VS cell voltage
VP1P	VP+ (V)	O2 sensor pumping voltage
VSW	Vsw (V)	Supply voltage measured at the module
VH	VH Measured (V)	Actual heater voltage at the module
TEMP	Circuit Board Temp (°C)	Temperature of the module circuit board
IP1R	Ip1raw (bits)	O2 sensor pumping current (unsigned integer format)
PR16	Praw16 (bits)	16 bit Pressure sensor output voltage (unsigned integer format)
ERFL,UERF	Error bit flags (bits)	Module error flags (unsigned long format)
ERCd,UERC	ECM CANOpen Error Code	ECM CANOpen Error Code
PR10	Praw10 (bits)	10 bit Pressure sensor output voltage (unsigned integer format)
PCF	Pressure Correction Factor	O2 sensor pressure compensation correction factor x 10000
PCFE		ECM diagnostic parameter
O2E		ECM diagnostic parameter
IP1E		ECM diagnostic parameter
PE		ECM diagnostic parameter
P	P (mmHg)	Pressure sensor measured pressure (absolute) in mmHg
LAMR	LAMBDAreal	Lambda before addition of Delta Lambda Table
AFR	Air-Fuel Ratio	Air-Fuel ratio calculated using LAMBDA
PHI	PHI	PHI = 1/LAMBDA
FAR	FAR*10000	FAR = (1/AFR) * 10000
LAM	LAMBDA	Lambda after addition of Delta Lambda Table
O2	O2 (%)	%O2 after addition of Delta Lambda Table
IP1X	Ip1 non Pcomp (mA)	Non-pressure compensated O2 sensor pumping current
EGRv	%EGR (volume-based)	Exhaust Gas Recirculation ratio percentage (volume-based)
EGRm	%EGR (mass-based)	Exhaust Gas Recirculation ratio percentage (mass-based)
PVLT	P (V)	Raw volts from pressure sensor
PKPA	P (kPa)	Pressure sensor measured pressure (absolute) in kPa
PBAR	P (bar)	Pressure sensor measured pressure (absolute) in bar
PPSI	P (psi)	Pressure sensor measured pressure (absolute) in psi
PERF	Pressure error bit flags	Pressure sensor bit flags (LambdaCANp only)
PERC	CANopen error code	CANopen pressure sensor error code (LambdaCANp only)

Table 2: Parameter List for the EGR 5230

dISP (Display) Setup Option

Parameter information from the lambda module assigned to the upper channel, EGR_v, and EGR_m, can be displayed as parameters P1 and P2. Parameter information from the lambda module assigned for the lower channel, EGR_v, EGR_m, and PIN (intake pressure) can be displayed as parameters P3 and P4.

The parameter selected as P1, P2, etc can be anything from Table 2.

Here is an example of setting displayed parameter P2:

1. Press the SYS key until "MOd" is displayed.
2. Press the ↓ key until "dISP" is on the top display. Then press the ENT key.
3. Press the ↓ key until "P2" is on the display. Then press the ENT key.
4. Press the ↓ key until the parameter (see Table 2) that will be P2 is displayed. Then press the ENT key.
5. When "dISP" is displayed, press SYS to return to RUN mode.

If in the above example, displayed parameter P4 was being programmed, dISP, P4, and your entries will be shown on the bottom display.

CAL (Calibrate) Setup Option

◆ O2

O_2 sensors supplied with the EGR 5230 are factory calibrated. This calibration is stored in a memory chip inside the sensor's connector. With use, O_2 sensors can age requiring recalibration to maintain measurement accuracy. The SPAN function allows the user to recalibrate the sensor using ambient air. This user calibration is also stored in the sensor's memory chip and is used instead of the factory calibration. The FACT function cancels the user calibration resulting in the factory calibration being used. Keep in mind that there is a SPAN function for the intake O_2 sensor and a SPAN function for the exhaust O_2 sensor.

SPAN (calibrate O_2 sensor)

To perform a span:

1. A span should be performed after the O_2 sensor has been on for at least 20 minutes.
2. Place the O_2 and pressure sensors in the calibration location (see **Initial Calibration Upon Installation** section).
3. Calculate the $\%O_2$ in air. The $\%O_2$ of air with no humidity is 20.945. This percentage decreases with increased humidity. To calculate the $\%O_2$ in non-zero humidity air, refer to Appendix D. 20.7 is a common number.
4. Press the SYS key until "MOd" appears.
5. Press the ↓ key until "CAL" is on the display of the channel to be calibrated. Then press the ENT key.
6. With "O2" on the display, press the ENT key.
7. With "SPAN" on the display, press the ENT key.
8. Using the ↑ and ↑ keys, change the display to show the $\%O_2$ in air determined in 3 (above). Press the ENT key.

9. When “CAL” is displayed, press SYS to return to RUN model. See **AGEF** (below).
10. The user calibration is written into the memory chip in the O_2 sensor’s connector and will be used to calculate EGR_v, EGR_m, $\%O_2$, λ, AFR, Φ, and FAR. If the O_2 sensor is removed and installed on another module, this user calibration will be used with the new module.

FACT (return to factory O_2 sensor calibration)

To return to the factory calibration for the O_2 sensor:

1. Make sure the O_2 sensor is attached to the module.
2. Press the SYS key until “MOd” appears.
3. Press the ↓ key until “CAL” is on the display of the channel to be calibrated. Then press the ENT key.
4. With “O2” on the display, press the ENT key.
5. Press the ↓ key until “FACT” is on the display. Press the ENT key. The user calibration of the O_2 sensor is erased and the factory calibration will be used to calculate EGR_v, EGR_m, $\%O_2$, λ, AFR, Φ, and FAR. The O_2 sensor age factor (AGEF) will be reset to “1.00”.

RGEN (regenerate O_2 sensor), (only for later analyzers that use LambdaCANp modules)

This function reconditions the O_2 sensor which may restore its original calibration and reduce its drift rate. The O_2 sensor must be SPANed after a regeneration and the regeneration process will lead you to “SPAN” (see 10, below). To regerate:

1. Make sure the O_2 sensor and pressure sensor are attached to the module.
2. Press the SYS key until “MOd” appears.
3. Press the ↓ key until “CAL” is on the display of the channel to be regenerated. Then press the ENT key.
4. With “O2” on the display, press the ENT key.
5. Press the ↓ key until “RGEN” is on the display. Press the ENT key.
6. With “VOLT” on the display, press the ENT key. Using the arrow keys, program the value shown below for the Sensor P/N being regenerated. Then press the ENT key.
7. With “TIME” on the display, press the ENT key. Using the arrow keys, program the value shown below for the Sensor P/N being regenerated. Then press the ENT key.
8. Do not exceed the recommended VOLT or TIME values.
9. Rotating wheels will appear on the display for the duration of “TIME” (seconds) followed by “SPAN”. Pressing “SYS” will abort the process.
10. With “SPAN” on the display, press the ENT key and follow the span procedure described above.

Sensor P/N	VOLT	TIME
05-05	12	60

AGEF (O_2 sensor age factor)

After the O_2 sensor has been user-calibrated, data from this calibration is compared to data taken from the sensor when it was new. From this, a parameter (AGEF) is calculated that indicates the relative sensitivity of the sensor compared to when it was new. If AGEF is 1.00, the sensor's sensitivity has not changed. AGEF goes down with use. When the AGEF is 0.75 or below, it is recommended that the lambda sensor be replaced. AGEF is reset to "1.00" after the FACT option (see above) has been executed.

◆ **EGR**

O2IZ is the "intake O_2 value at zero EGR". After SPANing the intake O_2 sensor, the EGR analyzer automatically assigns O2IZ the intake O_2 span value. Under most circumstances, this O2IZ value need not be modified. However, sometimes after calibrating the analyzer using method #1 (see **Initial Calibration Upon Installation** section), the analyzer will show a non-zero EGR value while the engine is running (versus motoring) with the EGR valve closed. This can be due to valve overlap EGR (i.e. internal EGR) or EGR valve leakage. To zero out the %EGR reading, program the O2IZ value to the intake O_2 value displayed when the EGR valve is closed.

◆ **P**

UNIT

Select display units for pressure. The programmable units are PSIA, KPAA, MMHG (mmHg), and BAR. All pressures shown are absolute (i.e. not gauge) and their units can be set independently for the intake and exhaust sensors.

N, C (only for earlier analyzers that use LambdaCAN modules)

Pressure sensor calibration numbers (N and C) must be entered for each pressure sensor in earlier analyzers that use LambdaCAN (versus LambdaCANp) modules. These pressure sensors have 4-terminal connectors. There are "N" and "C" values for the intake pressure sensor and "N" and "C" values for the exhaust pressure sensor. These values must match those written on a label on the pressure sensor.

Pressure sensors used with newer EGR analyzers have 8-terminal connectors and a memory chip containing the sensor's calibration is in the connector. This calibration is read by the LambdaCANp module. Therefore there is no need to manually enter calibration numbers.

Pressure sensors cannot be user-calibrated but can be recalibrated by ECM.

◆ **AVG**

Raw data is sampled from the O_2 and pressure sensors every 5 ms. This data is averaged by the lambda module every 5 ms before being sent to the display head every 5 ms. For the parameters Ip1, %O_2, λ, AFR, Φ, FAR, the averaging filter is ILAM (one ILAM for intake O_2, one ILAM for exhaust O_2) . For pressure, the averaging filter is PLAM (one PLAM for intake pressure, one PLAM for exhaust pressure). For EGR, averaging filters are AEGV, AEGM, AO2I, AO2E, APIN, APEX are used. The parameter(s) that the averaging filters (also called recursive averaging filters or digital low-pass filters) act on are given in Table 1 and how the averaging filters are used is shown by Equation 1. All ten averaging filters (2 ILAMs, 2 PLAMS, AEGV, AEGM, AO2I, AO2E, APIN, APEX) are user programmable, can be assigned values from 0.001 (heavy averaging) to 1 (no averaging).

$$\text{ParameterAverage}_{t+5ms} = \alpha \times \text{Parameter}_{t+5ms} + (1 - \alpha) \times \text{ParameterAverage}_{t} \quad \text{[Equation 1]}$$

where:

$\text{ParameterAverage}_{t+5ms}$ = the parameter average at time "t+5ms"
α = averaging filter (one of ILAM, PLAM, AEGV, AEGM, AO2I, AO2E, APIN, APEX)

Note:

Parameter_{t+5ms} = the raw sampled parameter value at time "t+5ms"
$\text{ParameterAverage}_{t}$ = the parameter average at time "t"

AEGV, AEGM, AO2I, AO2E, APIN, APEX are only programmable on the upper channel.

The default averaging filter values are given within square parentheses in Table 1. These values and the length of the pressure line assemblies should not be modified without first consulting ECM.

◆ **SKEW**

SKEW allows the parameters %O_2, λ, AFR, Φ, FAR, P (pressure), EGR_v, EGR_m each to be modified by a programmable transform of the form:

$$\text{ParameterSkewed} = M \times \text{Parameter} + B \quad \text{[Equation 2]}$$

where:

ParameterSkewed = %O_2, λ, AFR, Φ, FAR, P, EGR_v, or EGR_m after being skewed
Parameter = %O_2, λ, AFR, Φ, FAR, P, EGR_v, or EGR_m before being skewed
M = Skewing gain. The default values for M are 1.000.
B = Skewing offset. The default values for B are 0.000.

EGR_v and EGR_m only on the upper channel . The skewed parameters are displayed and output (i.e. analog outputs, CAN).

CONF (Configure) Setup Option

CONF setup appears at the end of the setup list for the lower channel. To enter CONF, press the SYS key until “MOd” appears on the upper display, press the ↓ key until “CONF” appears on the bottom display, and then press the ENT key. CONF relates to display head (as opposed to lambda module or sensor) setup.

◆ LEdS

The display intensity is programmable. Press the ENT key when “LEdS” appears on the lower display, press the ↑ or ↓ keys until the display intensity is suitable, press ENT, and press SYS to return to RUN mode.

◆ 1V4V

This feature commands a 1 V (when “1V” is on lower display) or 4 V (when “4V” is on lower display) output on all six analog outputs. This feature is useful when troubleshooting the interface with an external data acquisition device.

◆ CAN

Figure 5a shows cabling connected to the back of the display head for CAN communication. Depending on where the display head appears in your CAN bus, the termination resistor may have to be present or removed.

The CAN data communicated is:

1. What is being sent to analog output 1
2. What is being sent to analog output 2
3. What is being sent to analog output 3
4. What is being sent to analog output 4
5. What is being sent to analog output 5
6. What is being sent to analog output 6
7. What is being sent to the upper display (but not averaged by display)
8. What is being sent to the lower display (but not averaged by display)
9. An error code for the upper channel. See **Appendix C**.
10. An error code for the lower channel. See **Appendix C**.
11. An auxiliary code for the upper channel.
12. An auxiliary code for the lower channel.

It is important to note that if a parameter that is being displayed is changed (by pressing the ↑ or ↓ key), the CAN data will be changed also to that newly displayed parameter for 7 or 8 (above). Similarly for an analog output. LOCKing the display head can be used to avoid this problem.

The CAN data is broadcast at 500 kHz in the following format:

CANid	byte 0	byte 1	byte 2	byte 3	byte 4	byte 5	byte 6	byte 7
CID1	What is being sent to analog output 1				What is being sent to analog output 2			
CID2	What is being sent to analog output 3				What is being sent to analog output 4			
CID3	What is being sent to analog output 5				What is being sent to analog output 6			
CID4	What is being sent to upper display				What is being sent to the lower display			
ERCd	Error code for upper display/channel				Error code for lower display/channel			
	Error Code Low	Error Code High	Aux. Code	Pressure Err Code Low[1]	Error Code Low	Error Code High	Aux. Code	Pressure Err Code Low[1]

[1] For LambdaCANp modules only.

Each of the eight parameters in CID1 to CID4 is a single-precision 32 bit floating point number that conforms to the IEEE-754 standard. All eight of these parameters are transmitted on the CAN bus least significant byte first (Intel format). Parameters 1 through 8 (everything except error codes) sent on the CAN bus are averaged ("AVG"d, see **CAL Setup Option**).

Error codes are transmitted with address ERCd. The error codes are 16 bit integers that refer to those listed in Appendix C. The error codes are transmitted on the CAN bus least significant byte first (Intel format). The auxiliary code is the countdown number appearing on the channel's display. If there is no error or active countdown, an error message is not broadcast.

Addresses CID1 through CID4 and ERCd are user programmable. Refer to **Appendix F** on how to program them and how to produce a .dbc file (which requires a PC running the supplied Configuration Tool Software"). This .dbc file can be used with programs accepting the VectorCAN .dbc format.

The rate at which CAN data is sent can be programmed via the "RATE" parameter under "CAN". The allowable range is 5ms to 9999ms with 5ms being the default.

The CAN baud rate is programmed via the "BAUd" parameter under "CAN". 500K is the default.

◆ LOCK

"LOCK" locks the selection of displayed parameters and instrument setup. When locked, the display head can just be turned on and off. It cannot be modified unless unlocked. Refer to Appendix E for more information.

◆ FACT

"FACT" (in the **CONF Setup Option**) resets the display head to the default setup. The default setup is shown [in square parentheses] in Table 1. "FACT" (in the **CONF Setup Option**) does not reset FUEL, O2IZ, pressure sensor calibration numbers N and C, the ten averaging filters, nor does it cancel a user calibration of the O_2 sensors. To cancel a user calibration of an O_2 sensor use "FACT" in the CAL Setup Option.

Specifications and Limits

Measurements and Accuracies

Parameter	Range	Response Time	Accuracy
$\%EGR_v$, $\%EGR_m$	0 to 100	< 1 sec. [4]	±0.5% (absolute)
Lambda (λ)	0.4 to 25	< 150 ms [5]	±0.6% (at λ=1) ±0.9% (avg, elsewhere)
AFR	6 to 364[1]	< 150 ms [5]	±0.6% (at λ=1) ±0.9% (avg, elsewhere)
Equivalence Ratio (Φ)	0.04 to 2.5	< 150 ms [5]	±0.6% (at λ=1) ±0.9% (avg, elsewhere)
FAR	27 to 1667[1,2]	< 150 ms [5]	±0.6% (at λ=1) ±0.9% (avg, elsewhere)
$\%O_2$	-25 to 25%[3]	< 150 ms [5]	±0.1 % (absolute)
Pressure	0 to 517 kPa/75 Psia	< 50ms [6]	±0.25 Psia ±1.7 kPa

[1] AFR and FAR range given for a fuel with an H:C ratio of 1.85.
[2] FAR x 10000 is displayed. This is the most commonly used way to express FAR.
For example, with an H:C=1.85 fuel, Lambda=1 is FAR=686.8.
[3] For stoichiometries richer than Lambda=1, negative $\%O_2$s are displayed.
This convention is useful with lean-burn engines (ex. diesel) that occasionally operate rich.
[4] The response time is effected by averaging filters AEGV,AEGM,AO2I,AO2E,APIN,APEX
See **CAL Setup** for more information.
[5] The response times are affected by averaging filter ILAM (for Ip1, $\%O_2$, λ, AFR, Φ, FAR).
See **CAL Setup** for more information.
[6] The response times are affected by averaging filter PLAM (for P).
See **CAL Setup** for more information.

Sensor Limits and Specifications

◆ **O_2 Sensor**

Gas Temperature Range: 0 - 850 °C, 32 - 1562 °F

Maximum Temperature: 950 °C, 1742 °F

Maximum Rate of Temperature Change: 50 °C/s, 122 °F/s

Fuel Composition:

H:C ratio range: 1.00 - 10.00, or Hydrogen (H_2)
O:C ratio range: 0.00 - 10.00
N:C ratio range: 0.00 - 1.00

gasoline: 1.70 < H:C < 2.10, O:C=0.0, N:C=0.0, (1.75 or 1.85 are commonly used)
methanol: H:C=4.0, O:C=1.0, N:C=0.0
ethanol: H:C=3.0, O:C=0.5, N:C=0.0
propane: H:C=2.67, O:C=0.0, N:C=0.0
methane: H:C=4.0, O:C=0.0, N:C=0.0

Maximum allowable levels of fuel "Impurities":

Lead: 0.012 gm/gal., 0.003 gm/ltr.
Phosphorous: 0.0008 gm/gal., 0.00027 gm/ltr.
Sulfur: 0.035% by weight

Do not use the O_2 sensor in a heavily-sooting or crankcase-oil-burning engine because these conditions will shorten the life of the sensor.

Thread Size: 18mm x 1.5 mm. Lightly coat with non-lead containing antiseize compound. The O_2 sensor's thread size is identical to that of the exhaust gas oxygen (EGO) sensors used in current production automobiles with 3-way exhaust catalysts.

Hex Size: 22 mm

Tightening Torque: 40 ±4 Nm, 30 ±3 ft-lbf for exhaust O_2,
4 ±1 Nm, 3 ±1 ft-lbf for intake O_2

◆ **Pressure Sensor**

Note: Must attach to engine via pressure sensor tubing only!
Do not directly attach to the engine or pressure sensor damage will result.

Diaphragm Material: Stainless steel

Maximum Pressure: 200 Psia, 1379 kPa (absolute)

Operating Temperature Range: -40 to 105 °C

Thread on Pressure Sensor: ¼" NPT

Fitting on Pressure Sensor: Swagelok SS-400-7-4 to mate with ¼" tube (USA) or
Swagelok SS-6MO-7-4 to mate with 6 mm tube (Metric)

◆ Pressure Sensor Tubing

Note: Stainless steel end of tubing towards engine. Teflon end towards pressure sensor.

Mating Thread with Engine: ¼" NPT (USA) or ¼" ISO tapered (Metric)

Tubing Assembled Length: 28" (USA) or 711 mm (Metric)

Tubing Diameter: ¼" (USA) or 6mm (Metric)

Nut, Front Ferrule, Back Ferrule at Pressure Sensor end of Tubing:
Swagelok SS-402-1, SS-403-1, SS-404-1 (USA) or
Swagelok SS-6M3-1, SS-6M4-1, SS-6M2-1 (Metric)

Union between Stainless Steel and Teflon Tubing: Swagelok SS-400-6 (USA) or
Swagelok SS-6MO-6 (Metric)

Fitting on Engine End of Tubing: Swagelok SS-400-1-4, ¼" tube to ¼" NPT (USA) or
Swagelok SS-6MO-1-4RT, 6 mm tube to ¼" ISO tapered (Metric)

Output Specifications

◆ Analog Outputs

Output Range (linearized in displayed units): 0 to 5 VDC, 20 mA max.

Output Impedance: 2.66 kΩ

Bits Resolution: 12 bits

Update Rate: 5 ms

Isolation: Electrically isolated from power supply ground.
All analog output grounds common.

◆ CAN

Protocol: Broadcast

Rate: Programmable (5 ms default)

Speed: Programmable (500 kHz default)

Isolation: Electrically isolated from power supply ground

General Specifications

◆ **Power**

DC: 11 to 28 VDC

Current Draw: 0.5 A (display), 1.2 A steady-state (per module and sensors),
On start-up, O_2 sensor and module may draw as much as 4 A for 30 s.

Case Ground: The EGR 5230 display head case is connected to power ground via a 2.15 kΩ resistor.

◆ **Key-on Signal**

"ON" Voltage Level: 2.7 to 32 VDC

Current Draw: 100 uA

◆ **Environment**

Display Head: -40 to 85 °C, 100% humidity non-condensing, display head is not sealed

Module: -55 to 125 °C, 100% humidity, module is sealed, IP67

◆ **Dimensions and Weight**

Display Head: 108 mm x 64 mm x 178 mm, 4 ¼" x 2 ½" x 7", (W x H x D)
676 gm, 24 oz

Module: 120 mm x 37 mm x 143 mm, 4 ¾" x 1 ½" x 5 ¾", (W x H x D)
244 gm, 8.7 oz

Appendix A: 5200 Series Instruments Parts List

01 Display Heads (Just display head. Must add cables, etc.)

01-01 NOx 5210 (just head, no module, no cable, no sensor)
01-02 Lambda 5220 (just head, no module, no cable, no sensor)
01-03 EGR 5230 (just head, no module, no cable, no sensor)
01-04 dashCAN (includes cable and T)
01-05 dashCAN+ (6 analog outputs, includes cable and T)
01-06 dashCANc (includes cable and T)
01-07 NOx/NH3 (just head, no module, no cable, no sensor)
01-08 dashCAN2 (2 analog outputs, includes cable and T)

02 CAN Modules (just module)

02-01 LambdaCAN (just module, no sensor, no cables)
02-02 NOxCAN (for original sensor, just module, no sensor, no cables)
02-03 NOxCAN-G (for "G" sensor just module, no sensor, no cables)
02-04 LambdaCANc (just module, no sensor, no cables)
02-05 appsCAN (just module, no cables)
02-06 baroCAN (just module, no sensors, no cables)
02-07 NOxCAN-T (for "T" sensor, just module, no sensor, no cables)
02-08 LambdaCANp (just module, no sensor, no cables)
02-09 LambdaCANd (just module, no sensor, no cables)
02-10 gpCAN (just module, no cables)
02-11 COCO2CAN (just module, no sensor, no cables)

03 Simulators, Heater

03-01 LambdaCAN Sensor Simulator (just module, no cable)
03-02 NOx Sensor Simulator (just module, no cable)
03-03 Ceramic Sensor Heater (just module, no cable)
03-04 NOxg Sensor Simulator (just module, no cable)
03-05 NOxt Sensor Simulator (just module, no cable)
03-06 LambdaCANp Sensor Simulator (just module, no cable)

04 Power Supplies

04-01 AC/DC Power Supply, Universal, 24V, 4A
04-02 Vboost Supply, 10~14VDC to 24VDC @ 14.5A
04-03 30A AC/DC Power Supply, 24V, 100~240VAC
04-04 15A AC/DC Power Supply, 15V, 120VAC
04-05 60A AC/DC Power Supply, 15V, 120VAC

05 Linear O2 (Lambda) and CO/CO2 Sensors

05-01 NTK 6 mA
05-02 Bosch LSU4.2
05-03 Bosch LSU4.9

05-04 NTK 4 mA
05-05 Bosch LSU4.2, Type P
05-06 Delphi OSL
05-07 NTK 4mA Cofired (ZFAS-U2)
05-08 Bosch LSU4.9, Type P
05-09 Bosch ADV
05-10 NTK, 6mA, Type P
05-11 Bosch LSU4.2, Type PI (Intake)
05-12 CO, CO2

06 NOx and NH3 Sensors

06-01 NOx Original (use with NOxCAN)
06-02 NOx Type "G" (use with NOxCANg)
06-03 Calibrate NOx Sensor
06-04 Cal Sheet with NOx Sensor
06-05 NOx Type "T" (use with NOxCANt)
06-06 NOx/NH3 Sensor (use with NOx/NH3 5240)
06-07 NH3 Sensor

07 Sensors

07-01 Pressure, 0-75 psia, 1/4", (USA)
07-02 Pressure, 0-517 kPa, 6mm, (Metric)
07-03 Pressure, Type P, 0-75 psia, 1/4", (USA)
07-04 Pressure, Type P, 0-517 kPa, 6mm, (Metric)
07-05 Pressure, Type KP, 0-75 psia, 1/4", (USA)
07-06 Pressure, Type KP, 0-517 kPa, 6mm, (Metric)
07-07 RH (Humidity) Sensor, ¼" NPT
07-08 Pressure (LambdaCANp, COCO2CAN, baroCAN only), 0-75 psia, 1/4", (USA)
07-09 Pressure (LambdaCANp, COCO2CAN, baroCAN only), 0-517 kPa, 6mm, (Metric)
07-10 Pressure (LambdaCANp, COCO2CAN, baroCAN only), Type KP, 0-75 psia, 1/4", (USA)
07-11 Pressure (LambdaCANp, COCO2CAN, baroCAN only), Type KP, 0-517 kPa, 6mm, (Metric)
07-12 Pressure (baroCAN only), Type KP, 10-20 psia, ¼", (USA)
07-13 Pressure (baroCAN only), Type KP, 70-140 kPa, 6mm, (Metric)

08 Actuators

08-01 Ceramic Sensor Heater Mount for 05-01,05-04,05-07,05-10,05-12,06-01,06-05,06-06 Sensors

09 Eurofast Cables, Ts, Term. Resistors, Connectors

09-01 4m Eurofast 12mm Cable
09-02 2m Eurofast 12mm Cable
09-03/n "n"m, Eurofast 12mm Cable
09-03/10 10m, Eurofast 12mm Cable
09-03/20 20m, Eurofast 12mm Cable

09-04 Flexi-Eurofast Cable, 0.3m
09-05 Eurofast "T"
09-06 Eurofast Termination Resistor
09-07 Eurofast Male Connector
09-08 8 Channel Eurofast Hub Block
09-09 Termination Resistor for Hub Block
09-10 CSM-Type Lemo Terminating Resistor

10 Sensor Cables

10-01 Module Y Cable (not LambdaCANp, COCO2CAN, baroCAN, Superseded by -21)
10-02 1m Sensor Cable, (12 term.)
10-02/25' Sensor Cable, (12 term., teflon)
10-03 2m Sensor Cable, (12 term.)
10-04 1m Pressure Cable (not LambdaCANp, COCO2CAN, baroCAN), (4 term.)
10-05 2m Pressure Cable (not LambdaCANp, COCO2CAN, baroCAN), (4 term.)
append suffix SD to cable for Teflon (Severe Duty) Version

10-09 Adapter to use P/N 05-01 with AFM1000, M1200, etc

10-12 Adapter to Pressure Sensor Wires

10-14 Adapter to use P/N 2400E-1 sensor (CPC) with LCAN

10-16 Adapter to use P/N 2400E-1S sensor (Fischer) with LCAN
10-17 Adapter to use P/N 1001A-2 (Deutsch) with LCAN
10-21 Module Y Cable (not LambdaCANp, COCO2CAN, baroCAN)

10-26 1m Humidity Cable (baroCAN), (6 term.)
10-27 2m Humidity Cable (baroCAN), (6 term.)

10-30 Module Y Cable (for baroCAN only)
10-31 1m Extension Cable for 12 terminal Deutsch
10-32 2m Extension Cable for 12 terminal Deutsch

10-34 Module Y Cable (LambdaCANp, COCO2CAN only)
10-35 1m Pressure Cable (LambdaCANp, COCO2CAN, baroCAN only), (8 term.)
10-36 2m Pressure Cable (LambdaCANp, COCO2CAN, baroCAN only), (8 term.)
10-37 3m Sensor Cable, (12 term.)
10-38 3m Pressure Cable (LambdaCANp, COCO2CAN, baroCAN only), (8 term.)
10-39 1-to-4 Pressure Sensor Adapter (for /P kits only. Not for /PB kits)
10-40 3m Pressure Cable (not LambdaCANp, COCO2CAN, baroCAN), (4 term.)
10-41 3m Humidity Cable (baroCAN), (6 term.)

10-42A 1.5m LambdaCANp Cable, Lemos at Midpoint, Controller Side
10-42B 1.5m LambdaCANp Cable, Lemos at Midpoint, Sensor Side

11 Cables

11-01 DC Power Cable, DB9F, Spades
11-02 DC Power Cable, DB9F, Banana Plugs
11-03 DB9M to CSM Lemo F Adapter (CSM Upstream)
11-04 DB9M to ETAS Lemo Adapter
11-05 Female Eurofast to DB9F
11-06 Male Eurofast to CSM Lemo F Adapter (CSM Downstream)
11-07 In-Line Power Entry Cable
11-08 2m Key-on Cable
11-09 2m Heater Cable
11-10 2m Hub Power/Eurofast Harness
11-11 Simulator (SIM300, 400, 500, 600, 700, 800) Cable

11-14 BNC to Banana Cable
11-15 DC Power Cable, Spades
11-16 DC Power Cable, Banana Plugs
11-17 Deutsch DTM3M to DB9F
11-18 3m DB9 Cable, M-F
11-19 EIB Power Tap to Ceramic Sensor Heater Controller
11-20 25' DB9 M-F Cable
11-21 SIM-200 Calibration Kit
11-22 Left (gray) appsCAN Connector with 300mm Pigtail Wires
11-23 Right (blk) appsCAN Connector with 300mm Pigtail Wires
11-24 Connector Kit: 2 connectors, 24 terminals, 12 plugs
11-25 Male Eurofast to Braided Shield Ground
11-26 Boom Box Cable for CAN Products (80' CAN, 30' Power)
11-27 Boom Box to Hub Springy Cable (1m relaxed, 2m stretched)
11-28 Male Eurofast to DB9F
11-29 Simulator Power Cable
11-30 Simulator LSU4.9 Adapter Cable
11-31 Lemo to Eurofast Adapter Cable for LambdaCANc
11-32 M-F Eurofast Panelmount Connector
11-33 1m CSM F Lemo to DB9F
11-34 1m CSM Power Lemo to Male Eurofast
11-35 Termination Resistor for in F Lemo Package
11-36 1m DC Power Cable, DB9F, Banana Plugs

12 Mounting Panels, Bosses, Probes, and Hardware

12-01 19" Rackmount Panel. Holds up to 4 Displays
12-02 18mm x 1.5mm MS Boss and SS Plug
12-03 18mm x 1.5mm SS Boss and SS Plug
12-04 18mm x 1.5mm Tall Al Boss, Cu Gasket, Al Plug
12-05 1/4" NPT MS Boss and Brass Plug, (USA)
12-06 1/4" NPT SS Boss and Brass Plug, (USA)

12-07 1/4" NPT Al Boss and Brass Plug, (USA)

12-08 Pressure Line Assembly, 1/4" dia, 28" (USA)
12-09 Inconel Shield
12-10 18mm Cu Gasket

12-11 Pressure Line Assembly, 6mm dia, 711mm (Metric)
12-12 1/4" ISO tapered MS Boss and Brass Plug, (Metric)
12-13 1/4" ISO tapered SS Boss and Brass Plug, (Metric)
12-14 1/4" ISO tapered Al Boss and Brass Plug, (Metric)
12-15 15A Fuse
12-16 Bifurcated Intake Sample Probe, 8mm
12-17 Replacement Bifurcated Tube, 8mm
12-18 Aluminum Sensor Mounting Block, 18mm, (not for Type T NOx sensor)
12-19 Individual Cylinder Exhaust Probe, 18mm Sensor (USA)
12-20 Individual Cylinder Exhaust Probe, 18mm Sensor (Metric)
12-21PS Rolling Cart to Support 8 LCAN or NCANs
12-22 Sampling-Type Exhaust Probe (USA)
12-23 Sampling-Type Exhaust Probe (Metric)
12-24 Small Heated Aluminum Sensor Heater Block, 18mm, (not for Type T NOx sensor)
12-25 1/4" UNC Module Stacking Standoff
12-26 Small Aluminum Sensor Mounting Block, 18mm, (not for Type T NOx sensor)
12-27 Cu Gasket for 20mm x 1.5mm Boss and Plug
12-28 20mm x 1.5mm SS Boss and SS Plug for NGK NOx
12-29 18mm x 1.5mm (male) to 1/4" NPT (female)
12-30 Carrying Case, Medium
12-31 Aluminum Sensor Mounting Block, 20mm & 18mm, (not for Type T NOx sensor)
12-32 Small Aluminum Sensor Mounting Block, 20mm & 18mm, (not for Type T NOx sensor)
12-33 Pressure Line Assembly (for baroCAN), 1/4", (USA)
12-34 Pressure Line Assembly (for baroCAN), 6mm, (Metric)
12-35 Carrying Case for SIM300
12-36 Carrying Case for SIM400
12-37 Carrying Case for SIM500
12-38 Carrying Case for SIM600
12-39 Carrying Case for SIM700
12-40 Individual Cylinder Exhaust Probe, 20mm Sensor (USA)
12-41 Individual Cylinder Exhaust Probe, 20mm Sensor (Metric)
12-42 Aluminum Mounting Plate for 8-ch Block and Modules
12-43 Carrying Case for SIM800
12-44 Multi-Channel Cart
12-45 Sample Line Kit, ¼" dia, 1.3m
12-46 Sample Line Kit, 6mm dia, 1.3m
12-47 remoteSAMPLER, append suffix /P to Part Number for P-compensation Option
12-48 External Mounting Block, append suffix /P to Part Number for P-compensation Option
12-49 Aluminum Sensor Mounting Block for Type T NOx sensor
12-50 18mm Crush Gasket

13 Software, CAN Adapters, and Manuals

13-01 5200 Series Manuals and Config Software (CD)
13-02 Kvaser Leaf Light CAN Adapter
13-Product Name (Manual)

14 Tools

14-01 18mm x 1.5mm Tap
14-02 18mm x 1.5mm Die
14-03 ¼" NPT Tap
14-04 ¼" ISO Tapered Tap
14-05 Antiseize
14-06 Metal Brush to clean sensor threads
14-07 Lambda Sensor Calibration System
14-08 20mm x 1.5mm Bottoming Tap
14-09 Filler Bottle
14-10 Cupric Sulfate (3gm to add to 150cc of water)
14-11 NOx/NH3 5240 Calibration Kit

Appendix B: Module Stand-alone Mode and EIB Mode

LambdaCAN* modules can be used in conjunction with an analyzer (EIB mode) or on its own (Stand-alone mode). When used as part of an analyzer (ex. Lambda 5220, EGR 5230), the module is setup in EIB mode. When delivered to be used alone, the module is setup in Stand-alone mode.

In EIB mode, the module communicates to the display head of an analyzer via a special high-speed communication protocol. The module must be EIB mode when on the EIB with a display head. When in Stand-alone Mode, the module communicates via the common 500 kHz CAN broadcast protocol. This is the default rate and it is programmable.

The module must be properly configured in EIB mode or Stand-alone mode depending on how it will be used.

To convert from one mode to the other requires software reprogramming of the lambda module followed by the removal (set to EIB) or installation (set to Stand-alone) of a jumper inside the module.

◆ **To convert a module from Stand-alone to EIB Mode**

1. Connect the lambda module to a power supply and a PC via a supported USB-to-CAN communication adapter (Kvaser, ETAS, Peak VectorCAN CAN adapter card) using the cabling shown below. A sensor does not have to be connected to the module. Note that only one module is connected and the display head is not involved.

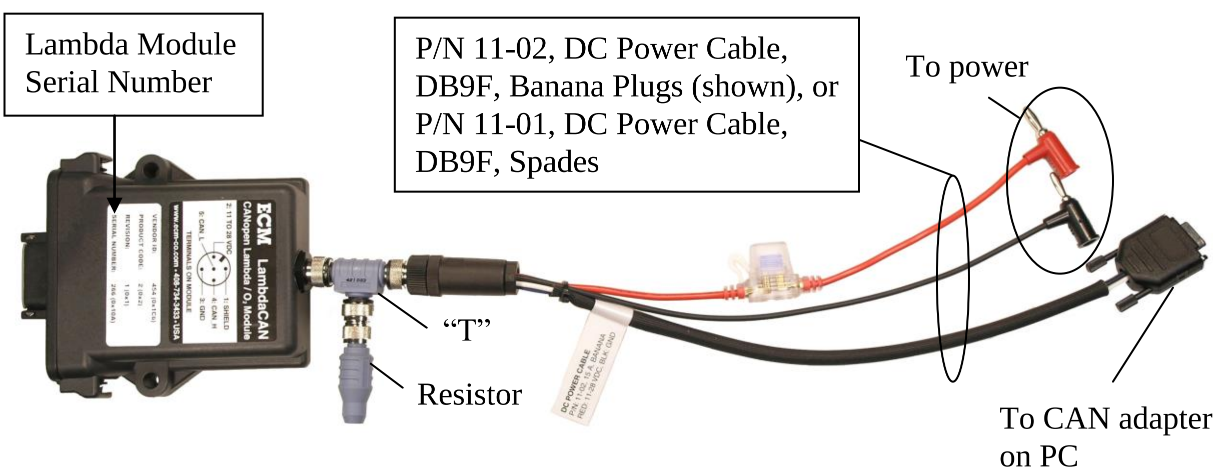
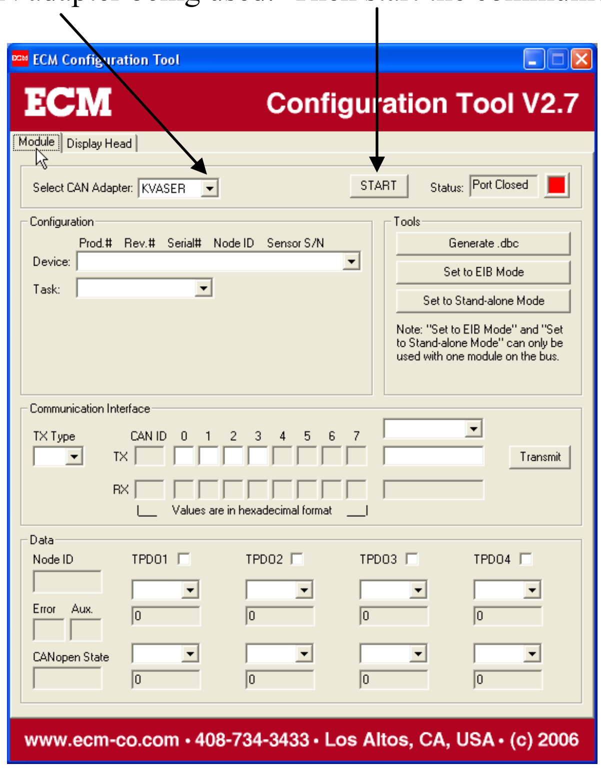
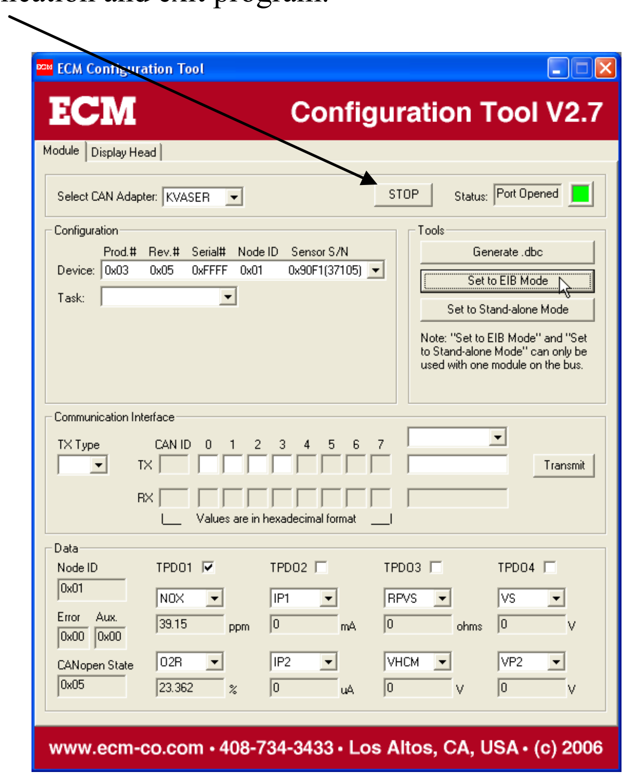


Figure B1: LambdaCAN Module prepared for Reprogramming

2. Start the Configuration Tool (software). Click on the "Module" tab. Select the CAN adapter being used. Then start the communication.



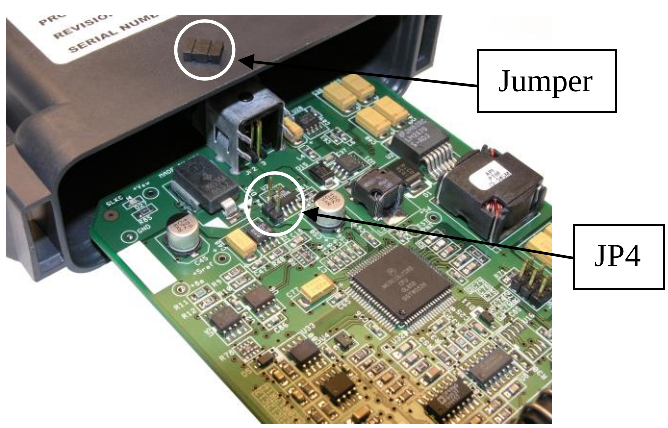
3. Click on the "Set to EIB Mode". Wait for "Done" Message. Stop communication and exit program.



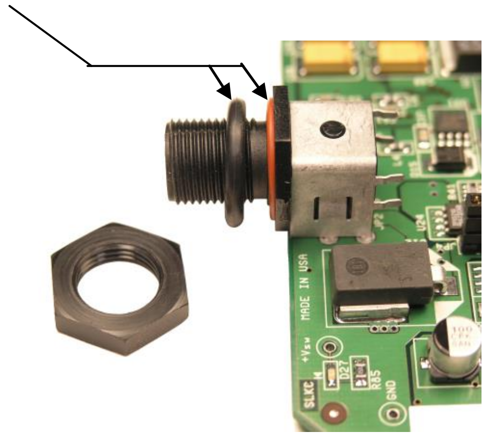
4. Take the nut off the end of the module. Use an 18mm socket without the wrench.

5. Release the two tangs at each side of the module.

6. Slide the PCB out. Remove the jumper from JP4. You can hang it on one pin of JP4 when "off".



7. Make sure both O-rings are on the threaded connector.



8. Slide the PCB into the enclosure until the two tangs "click".
9. Put the nut on and tighten ONLY ½ turn from where it is seated. If this nut is tightened too much, the connector will crack and the enclosure will not be sealed.
10. The lambda module is now in EIB mode and can be on the EIB with a display.

◆ To convert a module from EIB to Stand-alone Mode

The process is similar to the previously-described procedure. Note that in EIB mode, the module will not show up in the device list of the Configuration Tool.

1. Use the Configuration Tool (software) to "Set to Stand-alone Mode".
2. Install the jumper on JP4 in the lambda module.
3. In Stand-alone Mode, the module will continuously broadcast data via 500 kHz CAN (programmable). For more information, refer to the LambdaCAN Module Instruction Manual.

Appendix C: Error Codes and Troubleshooting

If one of the EGR 5230's displays flashes "ERR" followed by "####" (the Error Code), an error has been detected in that channel's module (or attached sensors). The below table lists the errors. The errors are also flashed on the module's LED.

Error Code	Module LED Action	Description of Error
0000	Green ON	All OK, (green LED constantly on)
0001	Flashing Green 10hz	Sensor warm-up period
0002	Green/Both/Red 2s	Power on reset / Init hardware
0011	Pulse Red 1x/2s	16 bit ADC failed to init. Internal module error. Contact ECM.
0012	Pulse Red 1x/2s	+Vsw shorted. Internal module error. Contact ECM.
0013	Red ON	O_2 sensor turned off (red LED constantly on)
0014	Pulse Red 1x/2s	O_2 sensor heater open. O_2 or Pressure sensor not connected.
0015	Pulse Red 1x/2s	O_2 sensor heater shorted. Bad O_2 cable or sensor.
0021	Pulse Red 2x/2s	Memory chip in O_2 sensor's bus shorted. Bad O_2 cable or sensor.
0022	Pulse Red 2x/2s	No memory chip in O_2 or P sensor detected. Bad cable or sensor.
0023	Pulse Red 2x/2s	CRC16 error. Bad O_2 cable or sensor.
0024	Pulse Red 2x/2s	Invalid O_2 sensor memory chip parameter. Wrong sensor.
0025	Pulse Red 2x/2s	Non-compatible O_2 sensor memory chip format (old Rev.)
0031	Pulse Red 3x/2s	Vsw < 5.6 for > 7 sec. Supply voltage too low.
0032	Pulse Red 3x/2s	Vsw > 30 V. Supply voltage too high.
0041	Pulse Red 4x/2s	VS too high. Bad O_2 cable or sensor.
0051	Pulse Red 5x/2s	RPVS too high. Sensor too cold, bad, or battery voltage too low.
0052	Pulse Red 5x/2s	(VH Commanded – VH Measured) > 0.5 V for > 10 sec. Battery voltage too low.
0061	Pulse Red 6x/2s	VP+ > 6 V. Bad O_2 cable or cracked sensor (common).
0062	Pulse Red 6x/2s	VP+ < 2 V. Bad O_2 cable or cracked sensor (common).
0064	Pulse Red 6x/2s	0.25 V > VS+ > 0.75 V. Bad O_2 sensor.
0065	Pulse Red 6x/2s	User data (span) in O_2 sensor memory chip corrupted. User must reperform O_2 sensor span.

The two most common problems are a damaged O_2 sensor and a low supply voltage (less than 11 V). When the O_2 sensor is damaged, it must be replaced. It cannot be repaired.

Three other displays of interest are:

1. "…." which means that a lambda module has not been assigned to that channel. See **MOd Setup Option**.
2. "----" which means that the display head has an internal problem.
3. "XXXX" which means that the display is not receiving any data. The lambda module is disconnected, dead, or the EIB cable is broken.

Appendix D: Calculating the %O_2 in Air

The Configuration Tool Software has a routine to calculate the %O_2 in air. If the software is not available, the below may be used.

The oxygen concentration in dry air (zero humidity) is 20.945 and decreases with increasing humidity. The %O_2 in air can be calculated from the barometric pressure (P_b, in mmHg), the relative humidity (Rh), and the saturated water vapor pressure (P_{ws}, in mmHg) by using the following formula:

$$\%O_2 = 20.945\% \text{ x } (P_b - P_{ws} \text{ x } (Rh/100)) / P_b$$

The saturated water vapor pressure (P_{ws}) is a function of the ambient temperature (T_a) and is given in the table below. For example, at 21 °C, P_{ws} = 18.65 mmHg.

T_a (°C)	0	1	2	3	4	5	6	7	8	9
	P_{ws} (mm Hg)									
0	4.579	4.926	5.294	5.685	6.101	6.543	7.013	7.513	8.045	8.609
10	9.209	9.844	10.518	11.231	11.987	12.788	13.634	14.530	15.477	16.477
20	17.535	18.650	19.827	21.068	22.377	23.756	25.209	26.739	28.349	30.043
30	31.824	33.695	35.663	37.729	39.898	42.175	44.563	47.067	49.692	52.442
40	55.324	58.34	61.50	64.8	68.26	71.88	75.65	79.60	83.71	88.02
50	92.51	97.2	102.09	107.2	112.51	118.04	123.80	129.82	136.08	142.60
60	149.38	156.43	163.77	171.38	179.31	187.54	196.09	204.96	214.17	223.73
70	233.7	243.9	254.6	265.7	277.2	289.1	301.4	314.1	327.3	341.0
80	355.1	369.7	384.9	400.6	416.8	433.6	450.9	468.7	487.1	506.1
90	525.76	546.05	566.99	588.60	610.90	633.9	657.62	682.07	707.27	733.24

1 mmHg = 0.01934 lbf/in2 = 1 torr = 133.32 N/m2

1 atm = 14.696 lbf/in2 = 760 torr = 101325 N/m2

Appendix E: LOCKing and unLOCKing Display Head

When the display head is locked, the parameters displayed and instrument setup cannot be modified. The display head can just be turned on and off.

◆ **To LOCK the display head**

1. Press SYS until “MOd” is displayed.
2. Press ↓ until “CONF” is displayed. Then press ENT.
3. Press ↓ until “LOCK” is displayed. Then press ENT.
4. “50” will be displayed. Press ↑ until “60” is displayed. Then press ENT.
   Display is now LOCKed.

◆ **To unLOCK the display head**

1. Press SYS until “LOCK” is displayed. Then press ENT.
2. “50” will be displayed. Press ↑ until “60” is displayed. Then press ENT.
   Display is now unLOCKed.

If an unauthorized person learns that 60 is the key number, contact ECM.

Appendix F: Using the Configuration Tool Software

ECM's Configuration Tool runs on a PC and is for use with ECM's analyzers and modules. The Configuration Tool is supplied on a CD with each analyzer and module and is available for download on www.ecm-co.com.

The Configuration Tool can be used for the following:

1. To produce a .dbc file for one or more analyzers on the same CAN bus.
2. Real-time display of data from analyzers. Only one analyzer's data is shown at a time.
3. Log data from one or more analyzers.

To connect a PC to the CAN connector on the back of an analyzer requires the supplied cables (see Figure 2) and a USB-to-CAN adapter. Make sure the CAN bus is properly terminated. The following adapters are supported: Kvaser, ETAS, Peak USB to CAN adapters, and the VectorCAN CAN adapter card. Driver software for one of these adapters must be installed prior to using the Configuration Tool. Driver software will be supplied with the adapter or be available on-line.

Once the analyzer(s) are connected to the CAN bus and turned on, leave "Exclusive" checked, start the Configuration Tool, select the "Analyzers" tab, select the CAN Adapter, leave "Exclusive" checked, and then press the start button. "Status:" should change to "Port Opened".

◆ Producing a .dbc File

Devices receiving CAN messages from one or more analyzers must understand the format of the messages. A .dbc file is used to describe the format. Using the Configuration Tool, a .dbc file describing the format of messages from one or more analyzers on the same CAN bus can be created.

Each analyzer communicates eight pieces of data, two error codes, and two auxiliary codes. The eight pieces of data are: what is being sent to the six analog outputs and what is sent to the upper and lower displays. Before producing a .dbc file for the analyzer(s), each analyzer on the CAN bus should have its displays and analog outputs programmed for the desired data. It is important to note that if a parameter that is being displayed is changed (by pressing the ↑ or ↓ key), the CAN data will also be changed to that newly displayed parameter. Similarly for an analog output. LOCKing the display head can be used to avoid this problem.

Once the analyzer(s) have been programmed, send (one analyzer at a time) each analyzer's message format to the Configuration Tool.

To do this:

1. For EGR 5230 v13.9 & below:
    a. In the Configuration Tool software, press "Manual Add Device". A "Waiting for Analyzer…" window will appear. Leave it open.

    b. On an analyzer, press SYS, arrow down to CONF, press ENT, arrow down to CAN, press ENT, and with "IdS" on the display, press ENT.

       Five CAN ids need to be entered (or left at defaults): one each for CID1, CID2, CID3, CID4, and ERCd. These are entered in decimal values. The allowable range is 1 to 2047. CID1 is the CAN id for the data going to analog outputs 1 and 2. CID2 is for analog outputs 3 and 4. CID3 is for analog outputs 5 and 6. CID4 is for the upper and lower displays. ERCd is for the error codes and auxiliary codes.

       After entering the CAN id for ERCd, ".dBC" will appear on the display. Press ENT here, and you'll see "spinning wheels" on the analyzer's display while the configuration of the analyzer's CAN output is being sent to the Configuration Tool.

       Note: If analyzers and modules are on the same CAN bus (not EIB bus), be careful to avoid choosing the CAN ids already used by the modules. The CAN ids used by the modules are: 0x00, 0x80 + Module NID, 0x180 + NID, 0x280 + NID, 0x380 + NID, 0x480 + NID, 0x580 + NID, 0x600 + NID, 0x700 + NID, 0x7E4, and 0x7E5. Note that these module CAN ids are given in hex.

2. For EGR 5230 v14.0 & above:
    a. Configure the CAN ids of the analyzer as in 1b above. But there will be no ".dbc" step.

    b. In the Configuration Tool software, press "Search for Devices". The software will automatically look for analyzers on the bus, retrieve their configurations, and add them to the device list.

3. Each analyzer's serial number will appear in the "Device:" window list (open window to see all present) after its message format has been received by the Configuration Tool. When an analyzer's serial number is in the "Device:" window, its data will appear at the bottom of the Configuration Tool's screen.

4. After the last analyzer on the CAN bus has sent its message format to the Configuration Tool, that list of analyzers can be saved using "Save List" and later recalled using "Load List". This saves having to resend message formats to the Configuration Tool next time the tool is used.

5. A .dbc file for all analyzers in the "Device:" window list is produced by pressing "Generate .dbc".

6. The analog parameters are called A#_sn where “#” is the analog output number and “sn” is the serial number of the display head (ex. A1_45405300). The serial number is the first thing that is displayed on startup on the display head. The display parameters are called TopDisp_sn, and BtmDisp_sn. The error codes are called TopErr_sn, TopAux_sn, BtmErr_sn, and BtmAux_sn. During O_2 sensor warm-up when the display is counting down, TopAux_sn or BtmAux_sn will contain the countdown number.

◆ Real-Time Display

When an analyzer’s serial number is in the “Device:” window, its data will appear at the bottom of the Configuration Tool’s screen.

◆ Logging Data

Analyzers whose serial numbers are in the “Device:” window list can be data logged. Press the “Log Data” button and follow the instructions. Data is saved in .csv format.

Appendix G: Setting Up ETAS INCA for ECM Modules

Hardware Setup: Using ETAS ES591.1

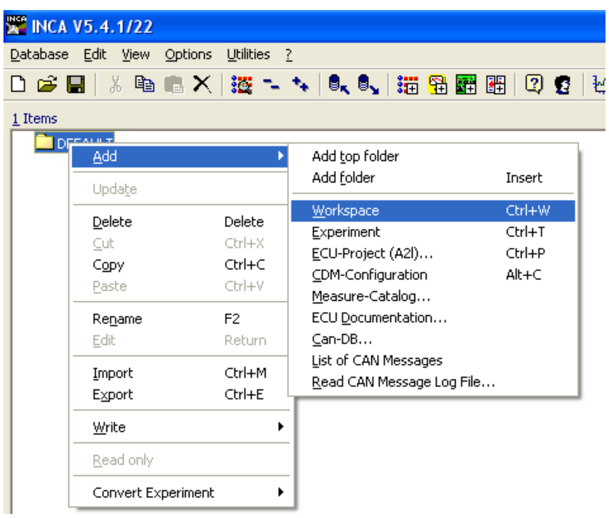
1. Connect the power port to a power source between 6V and 32V.
2. Connect the Ethernet port directly to the Ethernet port on your PC. This port does not use an internet/intranet connection like a router.
3. Connect either the CAN1 or CAN2 port to a CAN network (i.e. ECM analyzer(s) and/or module(s)).

Software Setup: Using ETAS INCA V5.4.1, Hotfix 22, GM Install

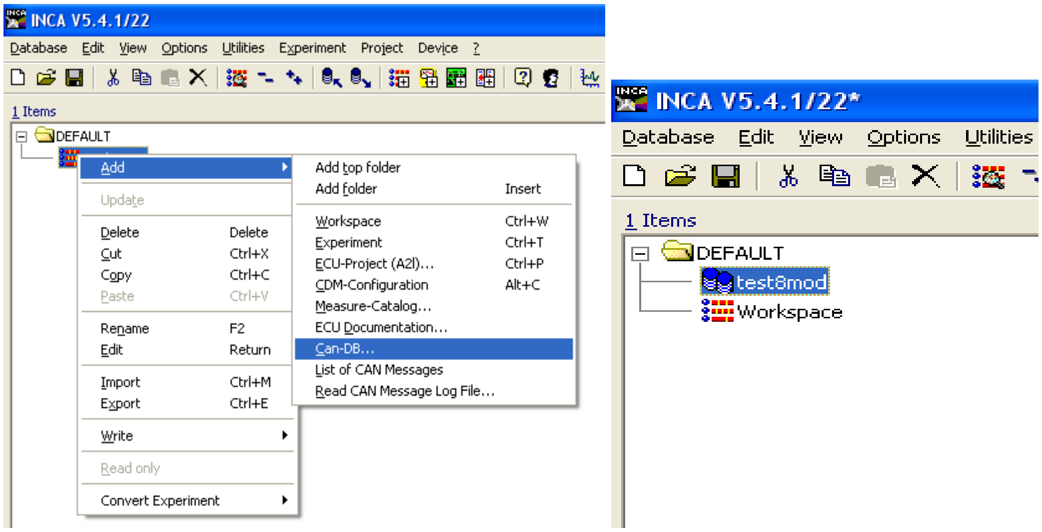
1. Double click the INCA V5.4 icon to open the software.

2. **Create a new Database**. In the Database menu, select New. Give your database a name (i.e. a folder name). In INCA, a Database means the current working directory. Each project is created in a unique directory. When INCA is opened, it will default to the last Database that was used.

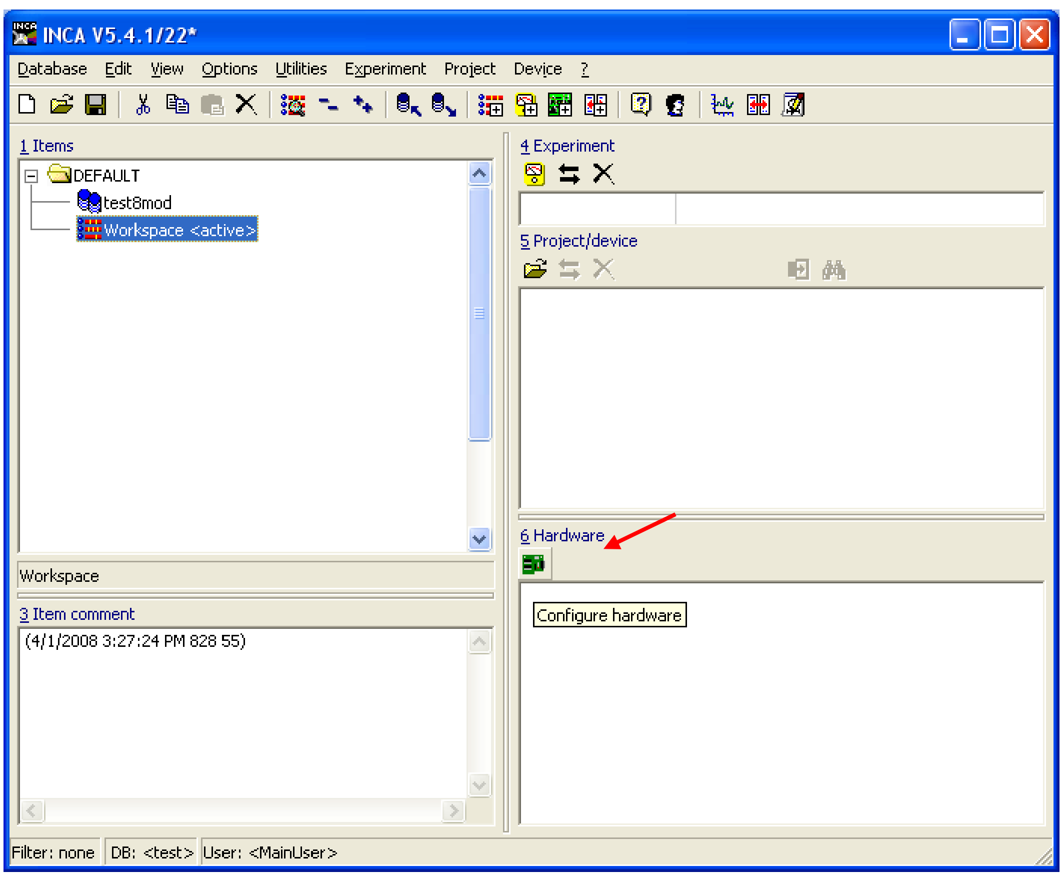
3. **Add a new Workspace**. Right click on the "DEFAULT" folder icon, select Add > Workspace. You can rename it to whatever you want.



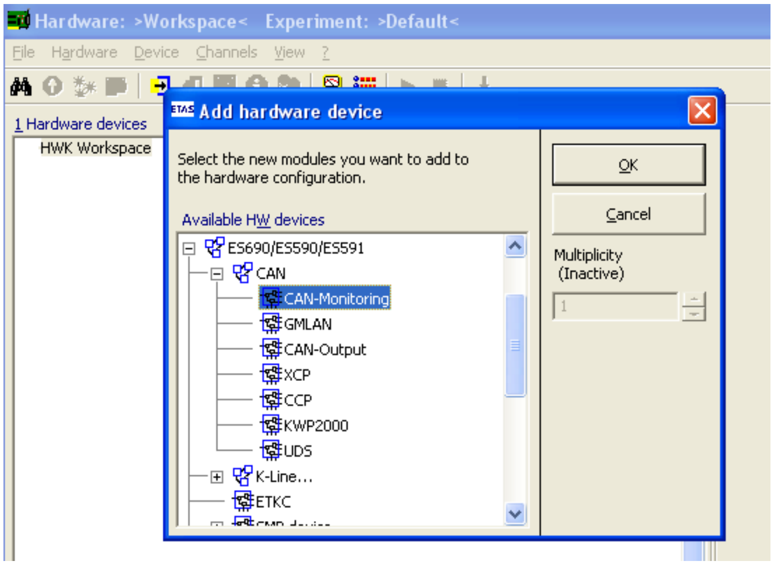
4. **Add a new dbc file for your project.** Right click on the workspace you created in step 3, select Add > Can-DB. Browse to your dbc file and click open. Appendix F describes how to produce this .dbc file. In this example, we are using a file named test8mod.dbc. An INCA log window will pop up. You can ignore this.



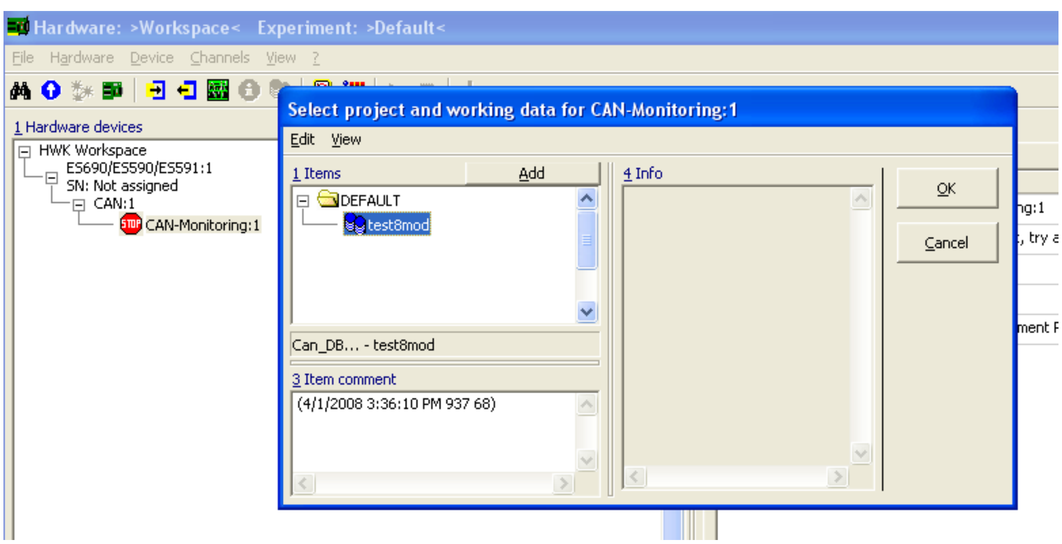
5. **Configure the hardware.** Click on the icon for the workspace you created in step 3. Open the Hardware Configuration icon under the section text "6. Hardware". A hardware configuration window will open.



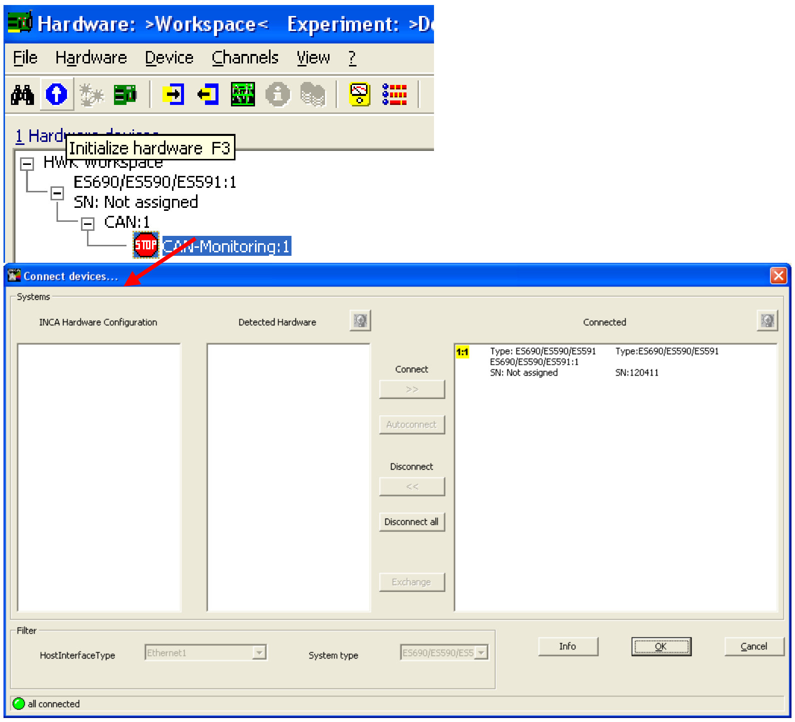
6. **Select the hardware.** In the hardware configuration window, right click the "HWK Workspace" listed under the section text "1. Hardware Devices", and select Insert. Select the ETAS device you wish to use. In this example, we are using an ETAS ES591.1. Expand the selection tree by clicking the "+" next to the hardware device model. Expand the CAN selection and select CAN-Monitoring. Click OK.



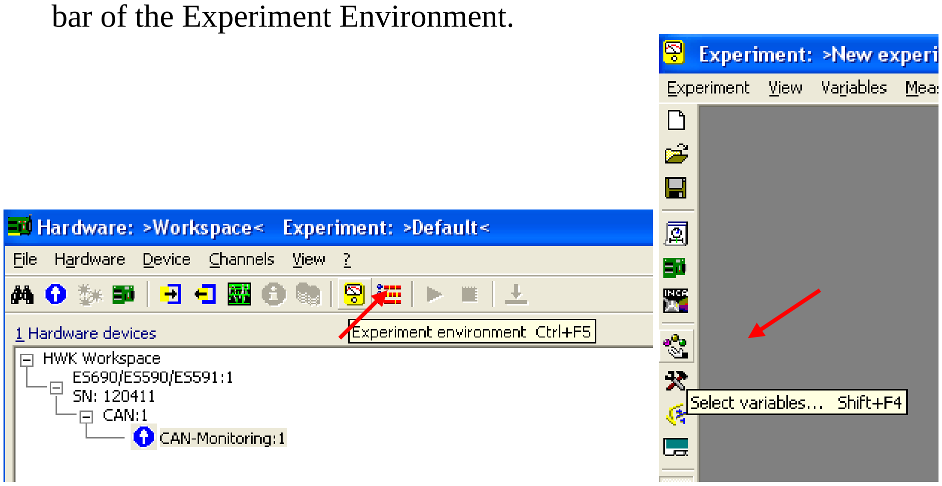
7. **Associate the dbc.** When you clicked OK in the last step, another window will pop up that will allow you to select a dbc that you have added to your workspace from step 4. Expand the selection tree, select your dbc file, and click OK.



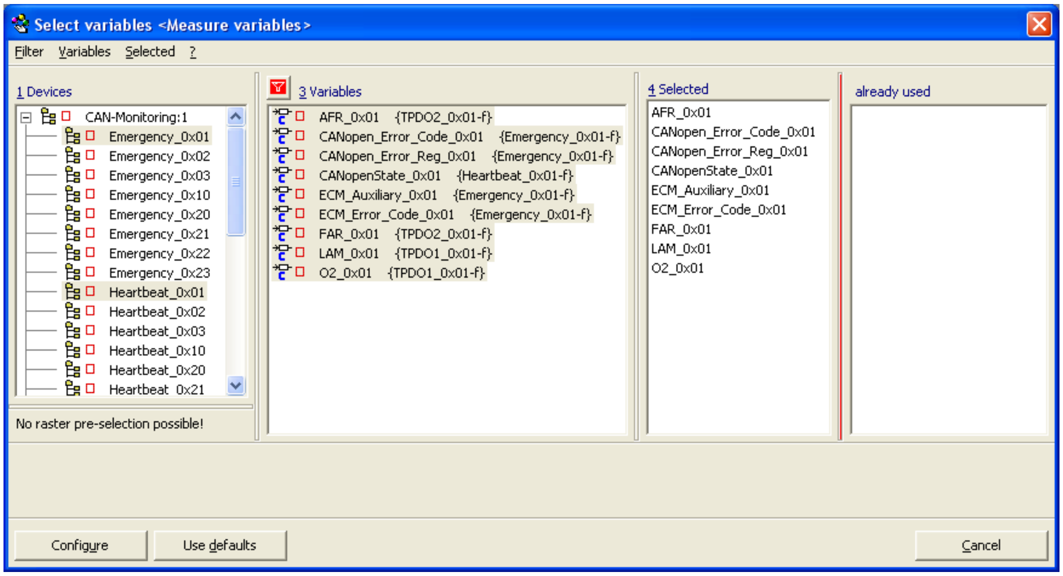
8. **Initialize hardware.** The hardware is currently stopped, as indicated by the red stop sign icon next to the selected hardware. You must initialize it before you can use it to collect data. Click on the Initialize Hardware button on the upper tool bar and wait for the hardware to complete its initialization. Another window will pop up to confirm the device to connect to. Click OK.



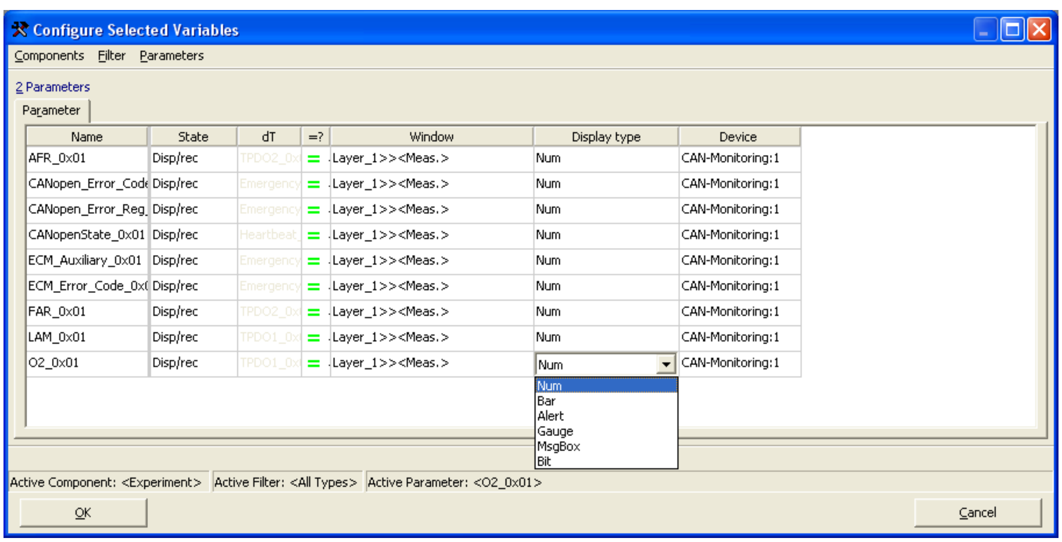
9. **Open an Experiment Environment.** Click on the Experiment Environment button on the upper tool bar to open an Experiment Environment. The Experiment Environment is where you can setup the monitoring of the CAN bus. By default, the Experiment Environment will be blank. You must select the variables from the dbc file that you wish to monitor. Click on the Select Variables icon in the left hand tool bar of the Experiment Environment.



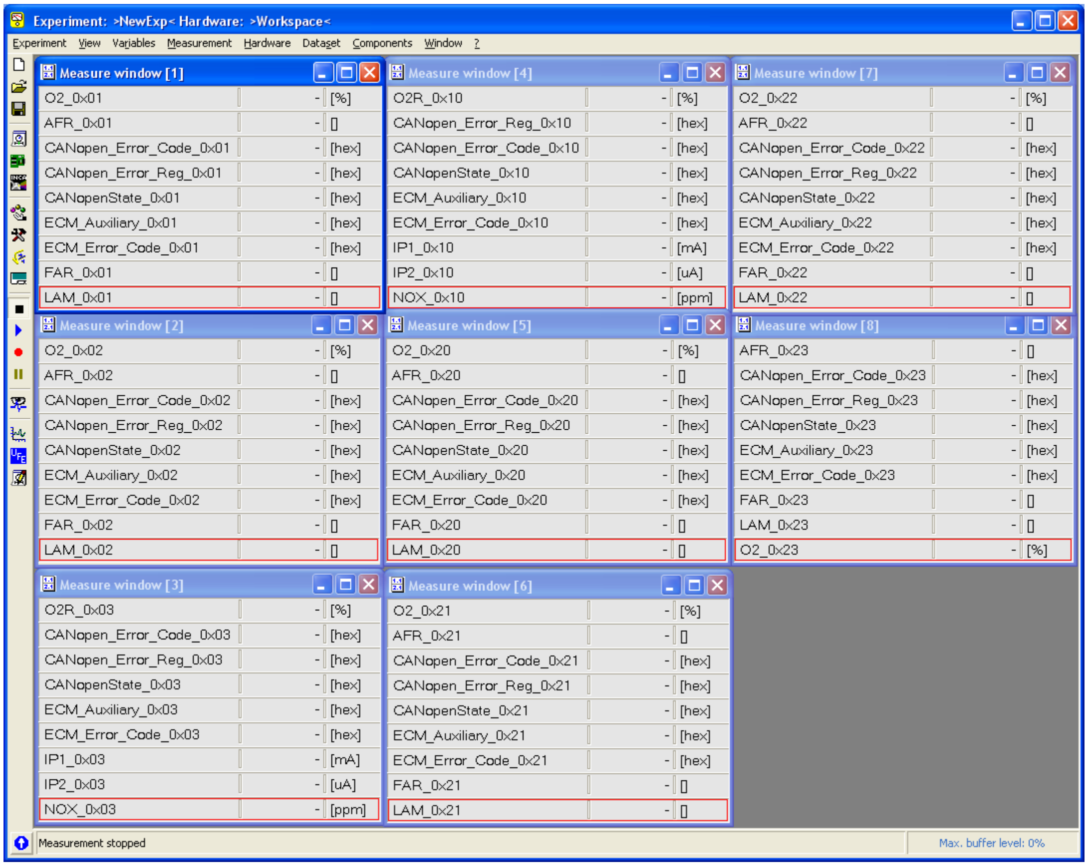
10. **Select and Configure Variables.** Select the variables that you wish to monitor in the Experiment Environment. These variables names are based on the data found in the dbc file. Click Configure.



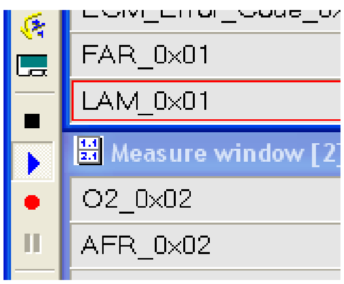
11. Another window will pop up to configure each selected variable. You can configure, for each variable, whether to record or simply display the data, how the data will be displayed (graphs, charts, gauges, numeric, etc.). When complete, click OK. We have left all configurations at default for this example.



12. A new sub-window will be added to the Experiment Environment. You do not need to select all the variables you want to monitor all at once. You can click on the Select Variables icon again at a later time to add more variables. Each set of variables you add will be placed in a new sub-window unless it is configured to join an existing sub-window. In this example, we have created a sub-window for each of the eight modules in the dbc file.



13. **Start CAN monitoring.** Right now there is no data displayed. That is because the CAN monitoring is stopped. To begin CAN monitoring, click on the Start Visualization icon (blue triangle) on the left hand tool bar. To stop CAN monitoring, click the Stop Measuring icon (black square) on the left hand tool bar. To begin recording the data, click on the Start Recording icon (red circle) on the left hand tool bar.



Appendix H: Setting Up ATI Vision for ECM Modules

NOTE: While shown here for a single LambdaCAN* module, the same procedure applies for any of ECM's CAN-based devices (i.e. Analyzers or Modules) as well as for multiple device simultaneously connected on the same bus.

Introduction

Connecting ECM LambdaCAN hardware to ATI VISION software is simple and does not require any third-party software interface. Using the ECM Configuration Tool software to produce a .dbc database file, and the ATI VISION CANMonitor interface, any available hardware CAN interface can be used to read LambdaCAN data.

Hardware Setup

A typical hardware configuration is shown in Figure 1. In this example, a Kvaser Leaf Light CAN-USB adapter is used. Other supported adapters have a similar procedure. Connect the DB9 CAN connector of the LambdaCAN to the PC to CAN adapter. Supply 11-28V DC (5A min. supply) to the LambdaCAN. For the case of an ECM analyzer (ex. Lambda 5220), connect to CAN port on display head. Do not directly connector to modules.

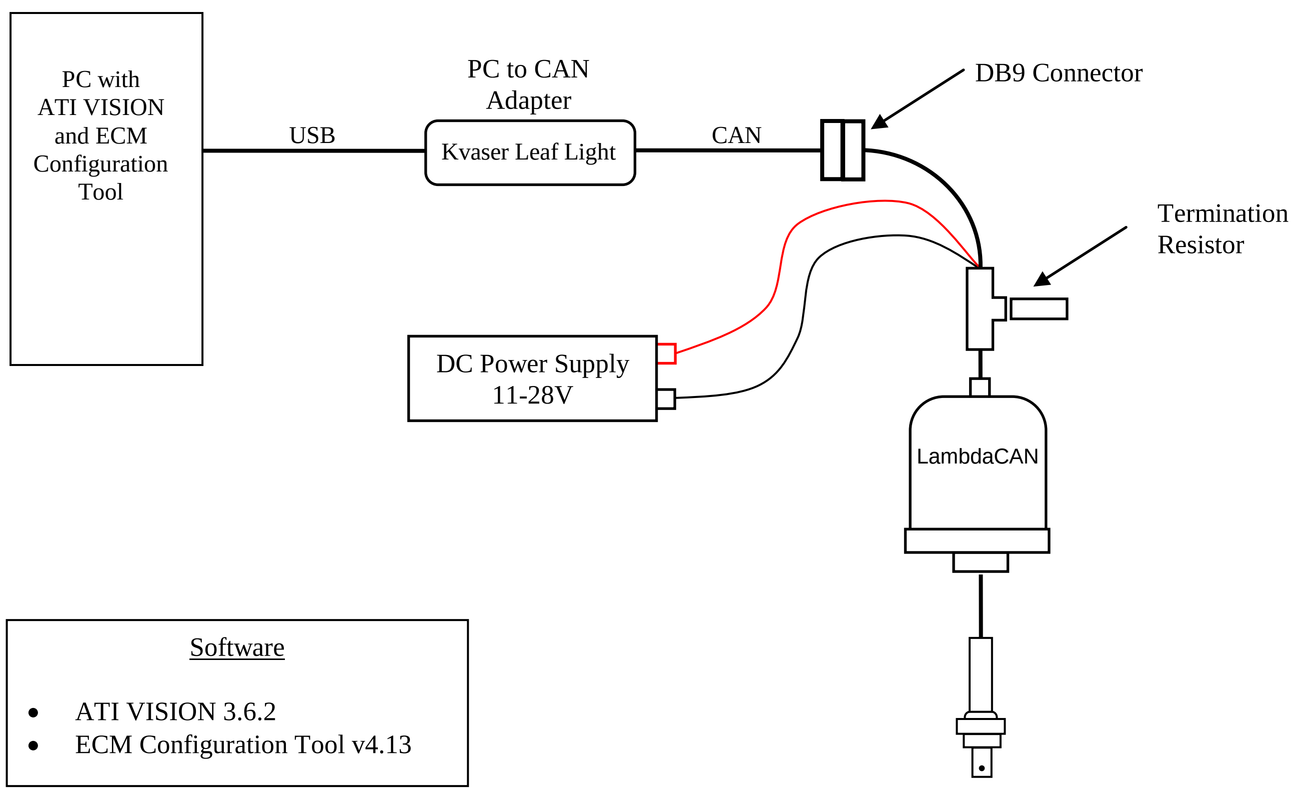


Figure 1: Equipment Schematic Layout

Creating a .dbc File

The ECM Configuration Tool is used to create a .dbc database file for describing the CAN messages broadcast from an analyzer or module. All ECM products with a CAN interface use the CANopen protocol at 500kHz by default. To generate a .dbc file from an analyzer, refer to Appendix F. To generate a .dbc file for a module (ex. LambdaCAN module):

1. Connect hardware as shown in Figure 1. Ensure LambdaCAN bi-color LED indicator near sensor connector is visible (green during normal operation, flashing red without sensor attached).
2. Run ECM Configuration Tool software, and select the Modules tab (or the Analyzers tab if connecting to 5200 series analyzers).
3. Select CAN adapter from drop down menus as shown in Figure 2, and click START.
4. After LambdaCAN module(s) have initialized, select desired parameters to transmit from the TPDO drop down menus for each module.
5. Click Generate .dbc, and save this file in a location such as the VISION Projects folder.
6. Click STOP to end CAN connection.

NOTE: Whenever TPDO's are modified, a new .dbc file must be created.

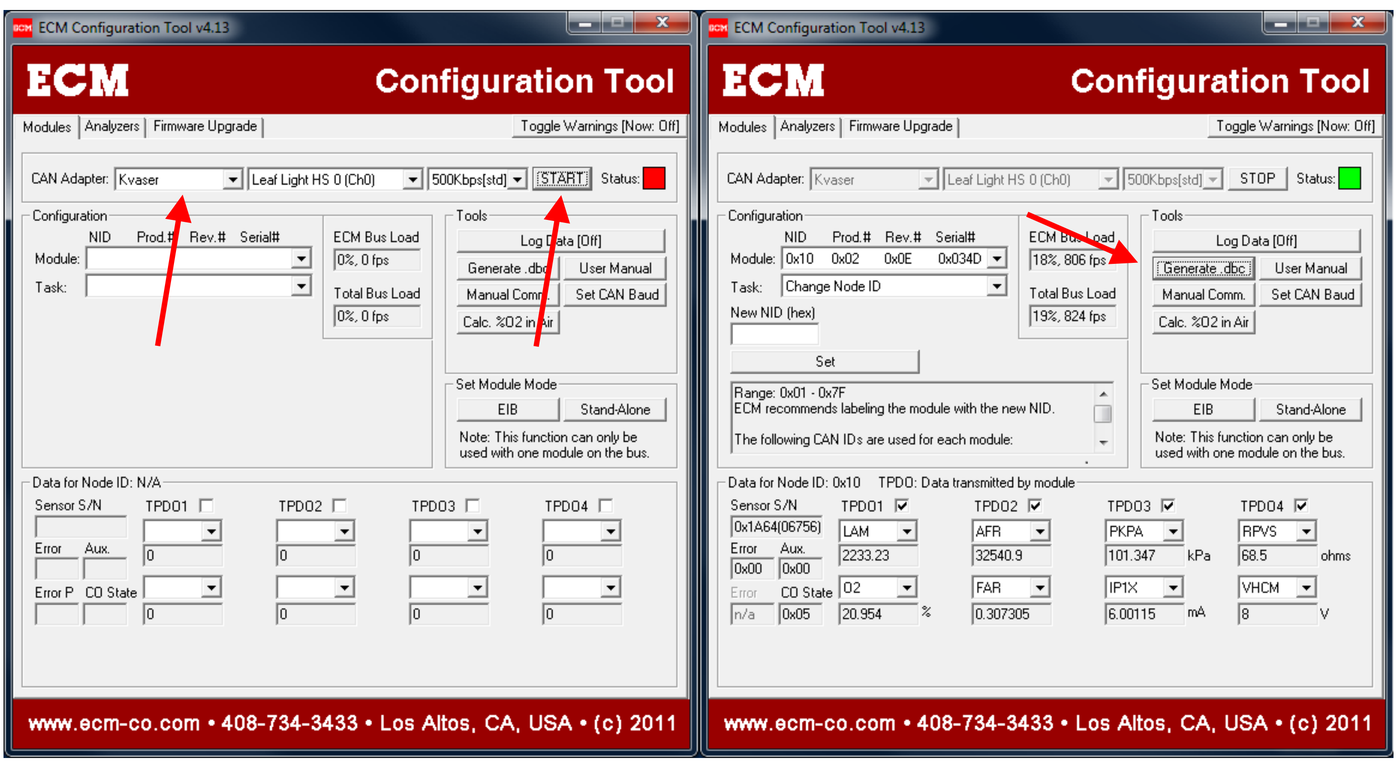
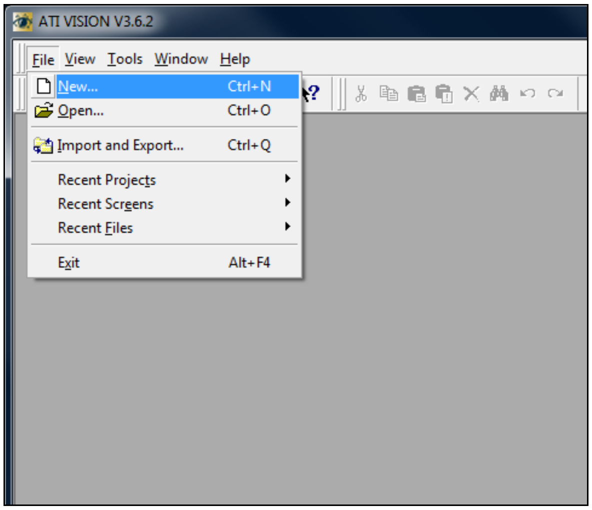


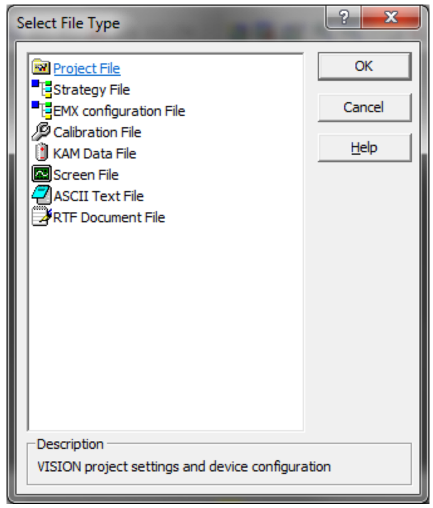
Figure 2: ECM Configuration Tool

Setup CANMonitor using ATI VISION

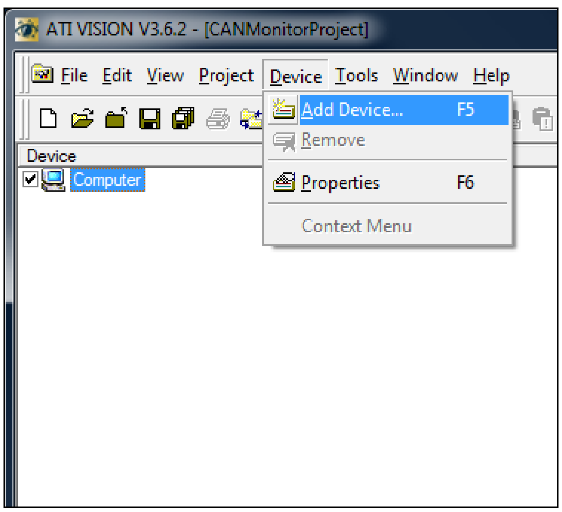
ATI VISION CANMonitor provides a method of reading general purpose information from any available CAN channel. The .dbc file generated by the ECM Configuration Tool is used to describe the format of the information available to VISION. To setup a CANMonitor in ATI VISION:

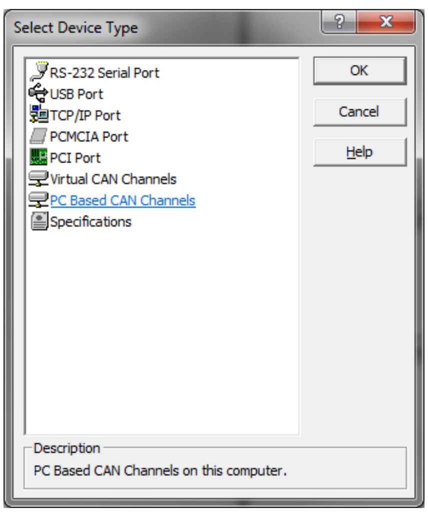
1. Run ATI VISION and open an existing Project File or create a new one by clicking File → New → Project File. In this example the Project has been named CANMonitorProject.



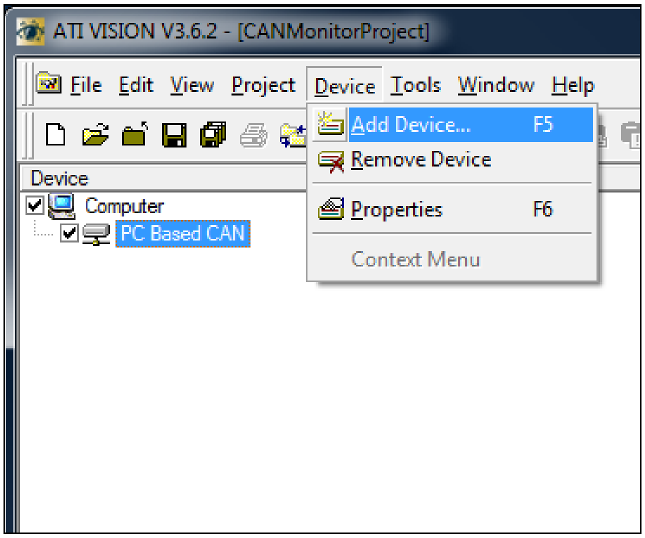


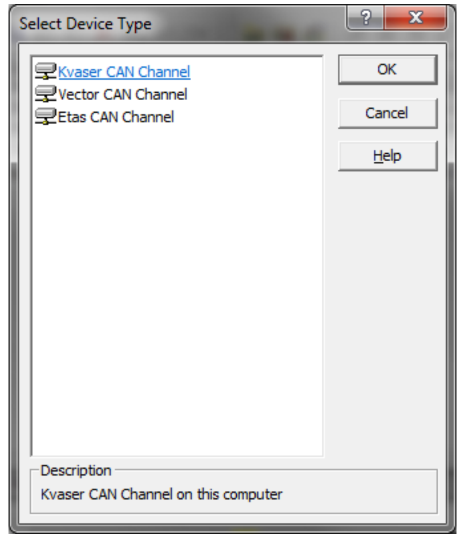
2. Add a Device by clicking Device → Add Device, select PC Based CAN Channels from the list.



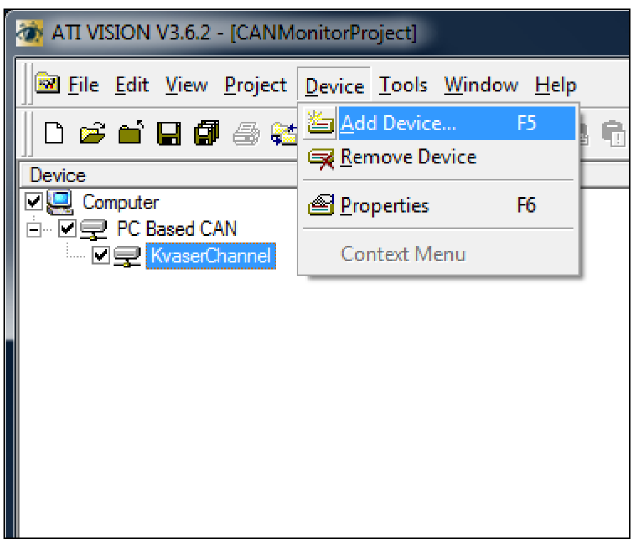


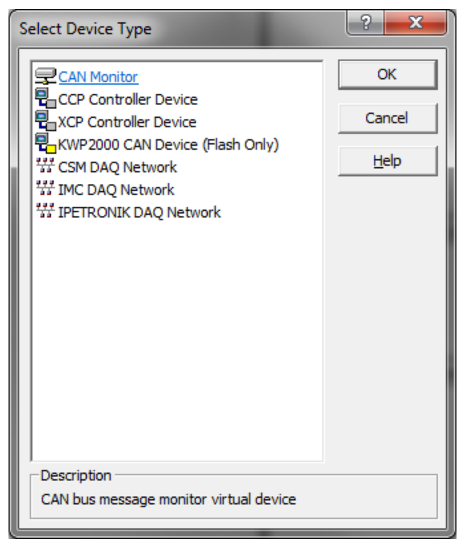
3. Add a physical hardware device by clicking Device → Add Device, and select Kvaser CAN Channel.



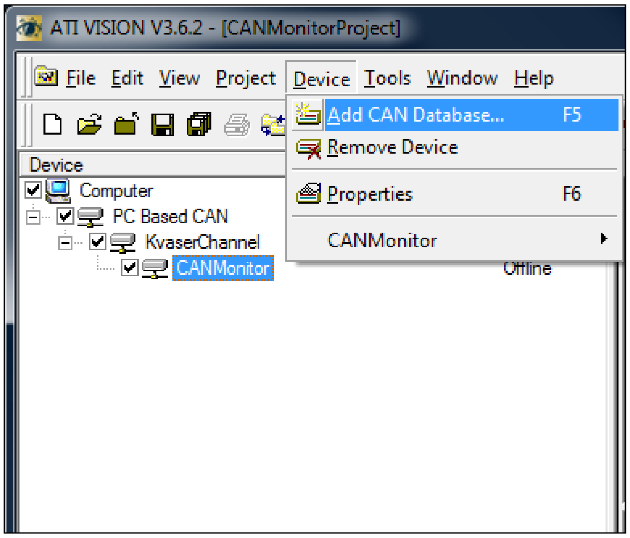


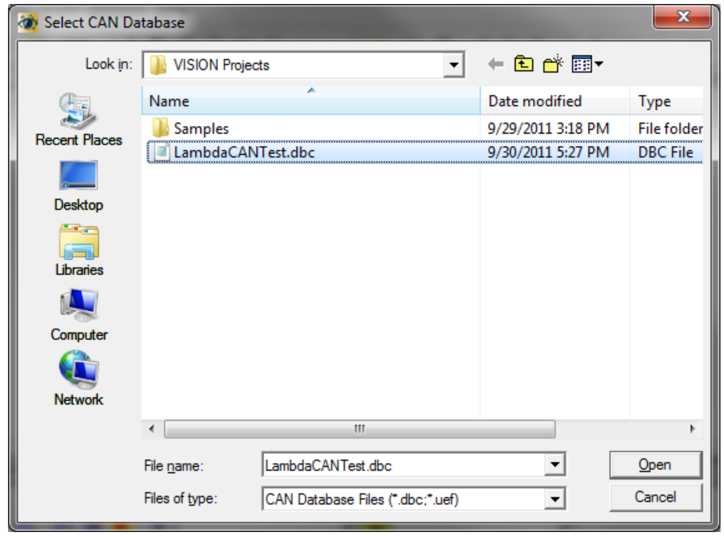
4. Select a CANMonitor device by again clicking Device → Add Device, and select CANMonitor.



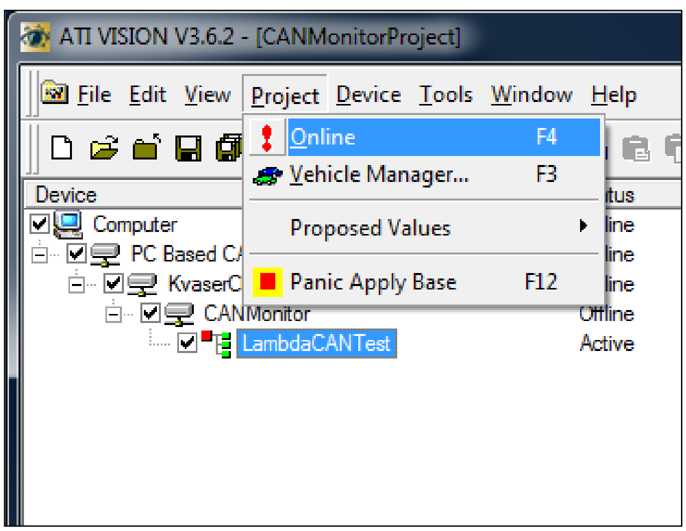


5. Add the .dbc file generated from the ECM Configuration Tool to CANMonitor by clicking Device → Add CAN Database and browsing to the previously created .dbc file.

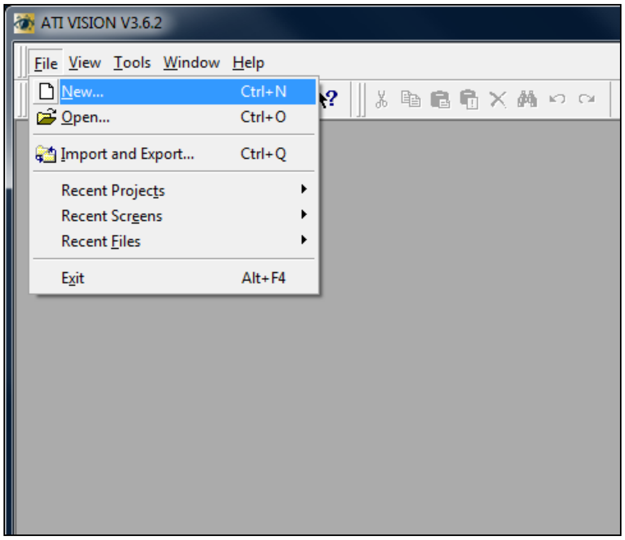


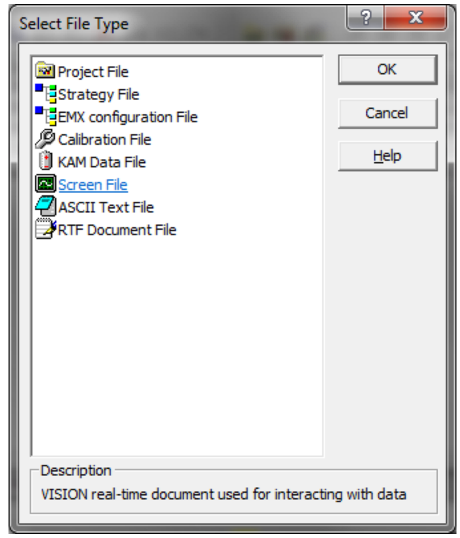


6. Enable the hardware by clicking Project → Online. The status of all of the devices should now show a Status of Online, and a value should appear in the Data Rate column of the Project window.

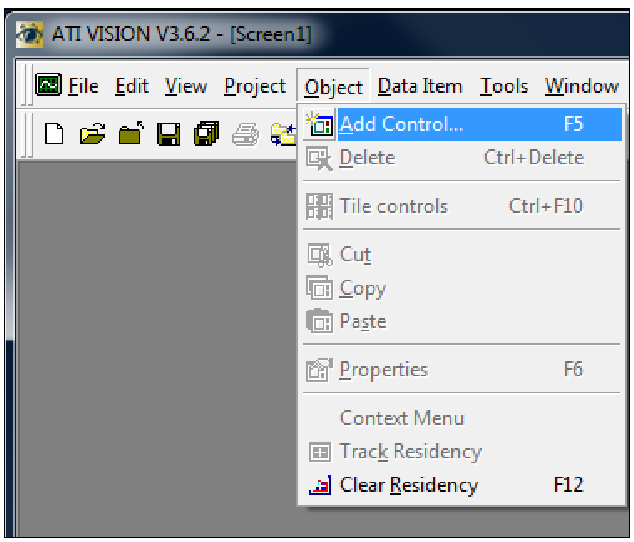


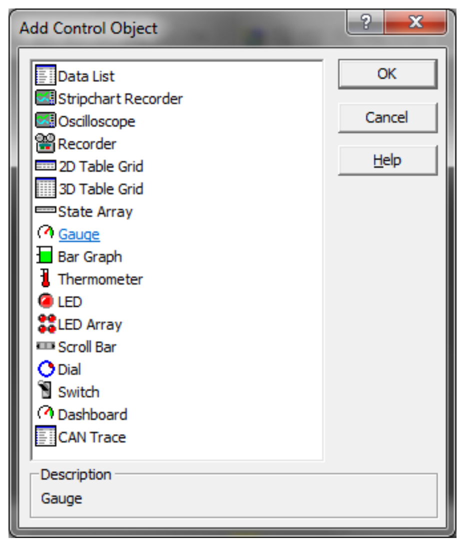
7. To view data, create a new Screen File and add a Control. Click File → New → Screen File



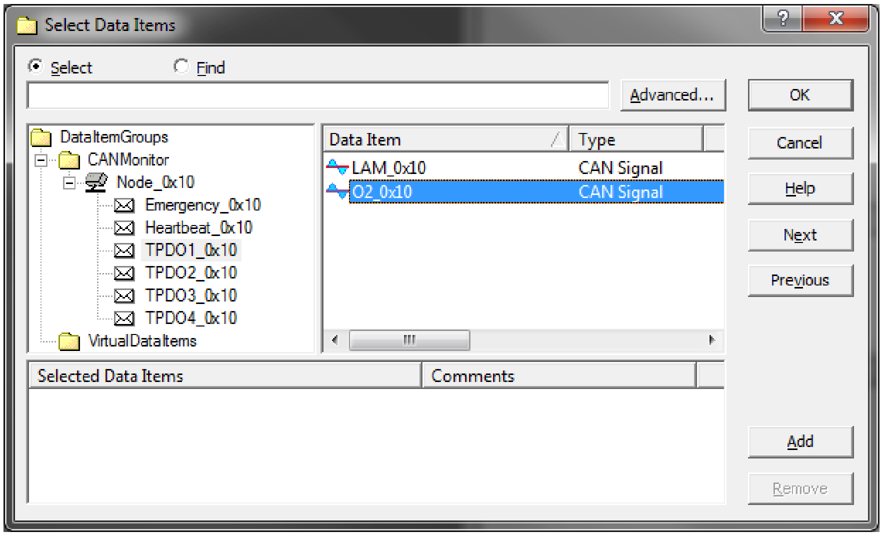


8. Select Object → Add Control → Gauge

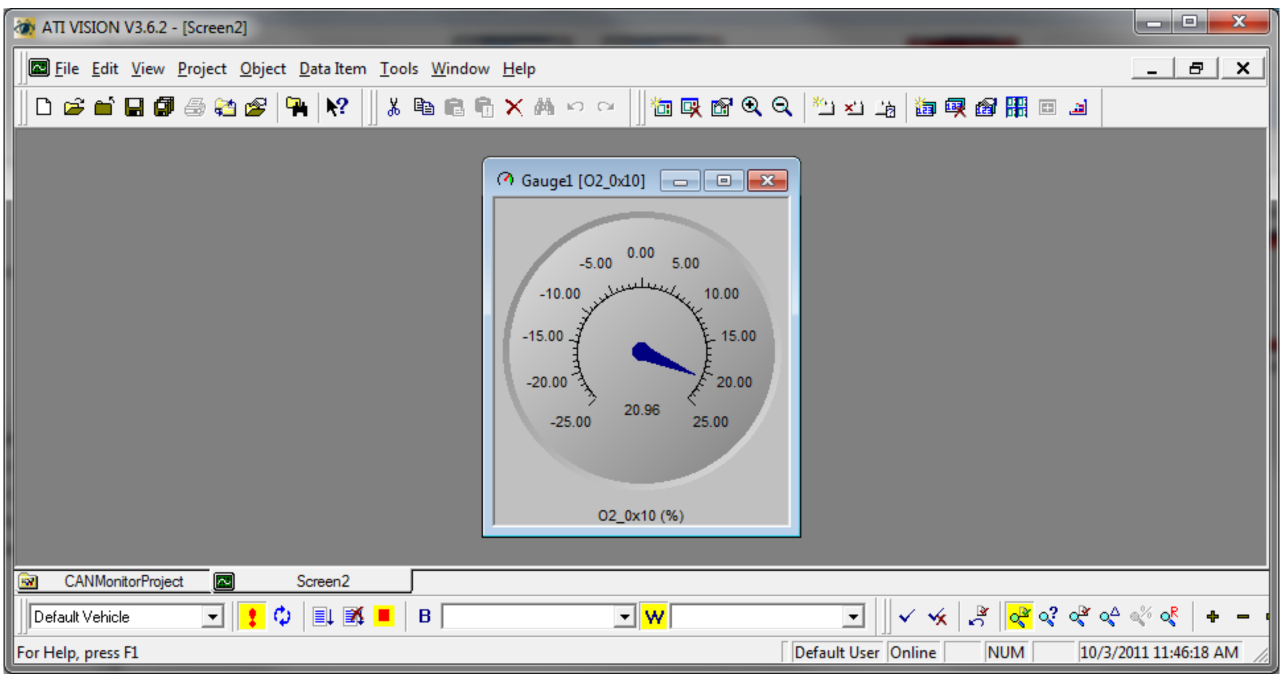




9. In the Select Data Items window open the CANMonitor file tree to view all of the available signals. Here the O2% from Node 0x10 has been selected. Click OK to add the Data Item to the Control.



10. Data should be visible on the gauge.



Appendix I. Using the Lambda (0_2) Sensor Simulator

The Lambda Sensor Simulator outputs currents to simulate a lambda (O_2) sensor and voltages to simulate a pressure sensor. It is plugged into a LambdaCAN* module instead of the lambda and pressure sensors. When plugged in, if the LambdaCAN* module is operating properly, it will report the correct currents (i.e. lambdas) and voltages (i.e. pressures) output by the simulator.

The simulator is a useful tool to check out a system where there is a problem and it is not known if the sensor, cable, module, or data acquisition system receiving the CAN data from the LambdaCAN* module is the cause of the problem. The simulator checks out everything but the sensors, however once everything else checks out okay, the focus can be put on the sensors. A properly operating LambdaCAN* module monitors lambda sensor condition and can calibrate the lambda sensor. An external pressure source is required to check out the pressure sensor.

Lambda Sensor Simulators can be returned to ECM on a schedule (1 year recommended) for recalibration.

Appendix J. Remote Control of the Analyzer over CAN

From version 14.0 and on, the analyzer can be controlled remotely via its CAN port. This section describes what functions can be performed via CAN and how to do it. You can connect multiple analyzers on the same CAN bus. This CAN communication protocol is capable of differentiating each analyzer. Do not confuse the CAN port with the EIB port, they are not interchangeable.

All CAN commands are in the following format:

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3-6	Byte 7
0x000	0x0C	Cmd	Sub-cmd	Data	Reserved

Where DLC = 8
Cmd = see table below for valid commands
Sub-cmd = where applicable, this byte further specifies how to apply the command.
Data = where applicable, this is command-specific data. See table. Data is formatted as little-endian (least significant byte first).
Reserved = not used at this time. Set to 0.

General Tasks Commands

Task	Cmd	Sub-cmd	Data	Notes
Request device info	0x0F	0	0 or target S/N	When data = 0, all analyzers on the bus will respond with their S/N. This is useful for determining how many are on the bus and each of their S/N. When data = S/N, the targeted analyzer will reply with a set of CAN messages identifying how its broadcast data is configured. See below section "Analyzer Info Response".
Enter config mode	0x0C	0	Target S/N	The targeted analyzer enters configuration mode.
Exit config mode	0x0D	0	0 or target S/N	When data = 0, all analyzers will exit configuration mode. When data = S/N, the targeted analyzer will exit configuration mode.

Configuration Tasks

These tasks can only be completed while the analyzer is in configuration mode. See "General Tasks" above on how to enter/exit configuration mode. Only one analyzer on the CAN bus should be in configuration mode at any given moment. It is recommended to apply "Exit config mode" task to all units (data = 0) first, then apply "Enter config mode" task to put the single targeted analyzer into configuration mode. These commands duplicate the functions available when navigating through the “SYS” menu via the front panel buttons. Many of these functions are explained in the “SYS” section of this manual. For more info on each task, please see the corresponding section of the manual.

Task	**Cmd**	**Sub-cmd**	**Data**	**Notes**
Set Module	0x20	1=top 2=bottom	Module S/N, or 0=none	
Set Display Item	0x21	1=top 2=bottom	0-7 display index	The 0-7 display index corresponds to the 8 parameters available for selection when you press the up & down key on the front panel.
Set Display Rate	0x22	1=top 2=bottom	0=slow 1=medium 2=fast	
Set Analog Output	0x23	Bit 4-7 (0xF0): 1-6 ch# Bit 0-3 (0x0F): 0=param name 1=Aout mode 2=min value 3=max value	4-byte param name 0=0-5V, 1=0-1V Floating pt value Floating pt value	When configuring analog outputs, you must configure the param name first. When a param name is changed, the min/max will also change to that param’s default min/max. Aout mode will not change, so the max value will apply to 1V or 5V respective of the mode. When changing mode, min/max stays the same and output gets rescaled up or down appropriately. See list of parameter names in table below.
Set P# parameter	0x24	1-4 P#	4-byte param name	The parameters P1-P4 are configurable. These are available to be displayed on the front display panel. After setting the param associated with P1-P4, you have to select it in the front panel to see the value. See list of parameter names in table below.
Set Fuel Ratios	0x25	Bit 4-7 (0xF0): 1=top 2=bottom Bit 0-3 (0x0F): 0=H:C 1=O:C 2=N:C 3=H2 mode	For fuel ratios, floating pt value. For H2 mode, 0=off, 1=on.	
Span O2	0x26	1=top 2=bottom	Floating pt O2 span value.	This task takes ~10secs to collect data & apply the span. You will not receive reply from the analyzer until the task is complete. Please wait for the reply. Do not start a new task until then.
Regenerate Sensor	0x27	1=top 2=bottom	Byte 0-1 = Volt*10 Byte 2-3 = seconds	See info in section Cal > O2 >Rgen on pg 21 for details on how to use this task. The analyzer will respond when the specified time has expired. Please wait for the reply. Do not start a new task until then.
Fact. Rst Sensor	0x28	1=top 2=bottom	n/a. Set to 0	

Set Constants	0x2A	Bit 4-7 (0xF0): 1=top 2=bottom Bit 0-3 (0x0F): 0=ILAM 2=PLAM 3=Punits 4=N 5=C 6=AEGV 7=AEGM 8=AO2I 9=AO2E 10=APIN 11=APEX 12=O2IZ	For Punits, 0=psia, 1=mmHg, 2=kpaa, 3=bar, 4=kgcm. All others, use floating pt value.	Indexes 0-5 are applicable to both top & bottom modules independently. Indexes 6-12 are only applicable to "top" module. Indexes 4-5 are only applicable when using the 4-pin pressure sensors. 8-pin pressure sensors do not use N & C constants.
Configure CAN	0x2B	0-4=CAN ID Index 5=broadcast rate 6=baud rate	0x001-0x7FF 5-9999ms 0=50kbps 1=125 kbps 2=250kbps 3=500 kbps 4=1Mbps	See info in section Conf > CAN on pg 24 for details on what data in transmitted on each of the 5 CAN messages. When changing the baudrate, the change will apply immediately. The success reply will be transmitted using the new baudrate. Change the baudrate on your CAN system to continue communications.
Fact. Rst Analyzer	0x2C	n/a. Set to 0.	n/a. Set to 0.	When performing a factory reset via the CAN port, all settings except for the baud rate of the CAN port will be reset. This prevent losing communication during the process.
Read Age Factor	0x42	1=top 2=bottom	n/a. Set to 0.	The reply data is in floating pt format.

Analyzer Replies

Unless otherwise specified, the above commands will reply with one of the following messages. Byte 1 & 2 in these messages will match the Cmd & Sub-cmd in the original command message for which these messages are responding to. Replies are transmitted on CAN ID 0x000.

	Byte 0	Byte 1	Byte 2	Byte 3-6	Byte 7
Success	0x1C	Cmd	Sub-cmd	S/N	Reserved
Data Response	0x9C	Cmd	Sub-cmd	Data Requested	Reserved
Error	0xEC	Cmd	Sub-cmd	Error code	Reserved

Error codes:
0 no error
1 generic error
2 invalid subcmd: invalid module
3 invalid subcmd: invalid param index
4 invalid data

5 module not ready, or no module selected
6 processing error
7 busy processing last request

Analyzer Info Response

The following block of 38 CAN messages are sent in response to a request for device info (command 0x0F). The messages are in a format similar to the Data Response reply outlined above, with the exception of the Sub-cmd used to identify the info in the block, i.e. CAN ID = 0x000, byte 0 = 0x9C, and byte 1 = 0x0F.

	Byte 0	Byte 1	Byte 2	Byte 3-6	Byte 7
Data Response	0x9C	Cmd=0x0F	Sub-cmd	Data Requested	Reserved

Byte 2	Byte 3-6, Data
0x0F	4-byte analyzer S/N
0x10	2-byte CAN ID for Aout1&2 data
0x11	2-byte CAN ID for Aout3&4 data
0x12	2-byte CAN ID for Aout5&6 data
0x13	2-byte CAN ID for top & bottom display data
0x14	2-byte CAN ID for error codes.
0x20-27*	4-byte ascii parameter name
0x28-2F*	4-byte ascii parameter units
0x30-37*	Min value in floating pt.
0x38-3F*	Max value in floating pt.

* These 8 sub-cmds are used to describe each of the 8 pieces of data transmitted over CAN. They are indexed in the following order: Aout1, Aout2, Aout3, Aout4, Aout5, Aout6, top display, bottom display.

List of Parameters

O2R	0x4F325220
IP1	0x49503120
RPVS	0x52505653
VHCM	0x5648434D
VS	0x56532020
VP1P	0x56503150
VSW	0x56535720
VH	0x56482020
TEMP	0x54454D50
IP1R	0x49503152
PR16	0x50523136
UERF	0x55455246
UERC	0x55455243
PR10	0x50523130
PCF	0x50434620
PCFE	0x50434645
O2E	0x4F324520
IP1E	0x49503145
PE	0x50452020
P	0x50202020
LAMR	0x4C414D52
AFR	0x41465220
PHI	0x50484920
FAR	0x46415220
LAM	0x4C414D20
O2	0x4F322020
IP1X	0x49503158
PVLT	0x50564C54
PKPA	0x504B5041
PBAR	0x50424152
PPSI	0x50505349
PERF	0x50455246
PERC	0x50455243
NLO	0x4E4C4F20
NLOE	0x4E4C4F45
EGRV	0x45475256
EGRM	0x4547524D
PIN	0x50494E20

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.

The O_2 sensor is heated, gets hot, and can burn you.

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 the EGR 5230's cabling and sensor(s) 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, or high voltage (spark) 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 EGR 5230 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 O_2 and pressure sensors, 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 O_2 and pressure sensors are 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 a module or the display head 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.

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EC DECLARATION OF CONFORMITY

We declare under our sole responsibility that the products:

AFM1540 Lambda Module
AFM1600 Lambda and O_2 Analyzer
DIS1000 Display Head
EGR 4830 Analyzer
Lambda 5220 Lambda Analyzer
NOx 5210 NOx Analyzer
EGR 5230 EGR Analyzer
LambdaCAN, LambdaCANc, LambdaCANd, LambdaCANp Lambda Modules
NOxCAN, NOxCANg, NOxCANt NOx Modules
NOx1000 NOx Module
baroCAN Module
dashCAN, dashCANc, dashCAN+, dashCAN2
appsCAN
SIM300, SIM400, SIM500, SIM600, SIM700, SIM800
BTU200
NOx/NH3 5240 Analyzer

To which this declaration relates are in conformity with the essential requirements of the following standards:
EN61326: 1997/A2: 2001 (Class A & Annex A)
EN61010-1: 2001 (Electrical Safety)

And therefore conform to the requirements of the following directives:
89/336/EEC Electromagnetic Compatibility (EMC)
72/23/EEC Low Voltage Directive (LVD)

RSPatrick

Ronald S. Patrick
Vice President Sales
August 22, 2014

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