ECM ENGINE CONTROL AND MONITORING

# NOx/NH3 5240

## $NO_x$, $NH_3$, and $O_2$ Analyzer

# Instruction Manual

10/18/13

Information and specifications subject to change without notice.

Printed in the United States of America.

# Table of Contents

# Introduction

## The NOx 5240

The NOx/NH3 5240 is a ceramic sensor-based NOx, $NH_3$, and $O_2$ analyzer for the development of engines and their aftertreatment systems. Its features include:

- Wide range of operation: NOx : 0 to 5000 ppm
  $NH_3$ : 0 to 1000 ppm
  $\lambda$ : 0.4 to 25.0
  AFR : 6.0 to 364.0
  $\Phi$ : 0.04 to 2.5
  $\%O_2$ : 0.0 to 25.0
  FAR[1] : 27 to 1667
- Determines wet and dry NOx ppm, $NH_3$ ppm, and $\%O_2$
- No cross-interference between NOx and $NH_3$
- Can specify any fuel type by H:C, O:C, and N:C ratios, including $H_2$
- Optional pressure compensation for NOx, $NH_3$, $\lambda$, AFR, $\Phi$, $\%O_2$, and FAR
- All sensor parameters available for display and output
- Calibration data for sensors stored in sensors' connectors
- Six programmable 0 to 5V or 0 to 1V analog outputs
- Simulated EGO (exhaust gas oxygen) sensor output
- CAN output and .dbc generation software
- Up to 100m 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[2] operation

The analyzer uses two ceramic sensors placed in series. The first ceramic sensor (Sensor A) measures NOx + $NH_3$, and $O_2$ (AFR, $\lambda$**,** **$\Phi$**, FAR). The second ceramic sensor (Sensor B) measures just NOx. $NH_3$ is determined by subtracting the signals of the two sensors. Sensor B is the same as Sensor A except that a liquid $NH_3$ scrubber is located upstream of it so it only sees NOx. The analyzer has an internal sample pump with no moving parts. The pump is driven by externally-supplied compressed air.

[1] 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.

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

## NOx/NH3 5240 Kit Contents

The following items are included with a NOx/NH3 5240 kit:

| Item No. | Description | Part Number |
|---|---|---|
| 1. | NOx/NH3 5240 Display Head | 01-07 |
| 2. | NOx/NH3 Sensor (2 included)<br>(called Sensors A and B but they are interchangeable) | 06-06 |
| 3. | Eurofast 12 mm Cable, 10 m, (2 included) | 09-03/10 |
| 4. | Flexi-Eurofast 12mm Cable, 0.3m, (2 included) | 09-04 |
| 5. | Eurofast "T", (2 included) | 09-05 |
| 6. | Eurofast Termination Resistor, (2 included) | 09-06 |
| 7. | Sensor Cable, 1 m | 10-02 |
| 8. | DC Power Cable, Banana Plugs | 11-16 |
| 9. | Female Eurofast to DB9F | 11-05 |
| 10. | Key-on Cable, 2 m | 11-08 |
| 11. | External Mounting Block (w/o Sensor A) | 12-48 |
| 12. | remoteSAMPLER 1000 (w/o Sensor B) | 12-47 |
| 13. | Sample Line Kit, 1.3m, ¼", (USA), (2 incl.) or<br>Sample Line, Kit, 1.3m, 6mm, (Metric), (2 incl.) | 12-45<br>12-46 |
| 14. | ¼" NPT (female) Fitting (2 included) | 12-05 |
| 15. | Filler Bottle | 14-09 |
| 16. | Cupric Sulfate, 3 gm (2 packages included) | 14-10 |
| 17. | 5200 Series Analyzer and Module Manuals<br>and Configuration Software, CD | 13-01 |

Optional Items:

| | | |
|---|---|---|
| 1. | Sensor Cable, 2m | P/N 10-03 |
| 2. | Sensor Cable, 3m | P/N 10-37 |
| 3. | AC/DC Power Supply, Universal 24VDC @ 4.2A | P/N 04-01 |
| 4. | Vboost Supply, 10-14VDC to 24VDC @ 14.5A<br>(helps to avoid battery drop-out issues during cold starts) | P/N 04-02 |
| 5. | Pressure Compensation Kit for remoteSAMPLER | P/N 47/P |
| 6. | Pressure Compensation Kit for External Mounting Block | P/N /P |
| 7. | NOx/NH3 5240 Calibration Kit (hoses and flowmeter) | P/N 14-11 |

# 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 sensors are heated, get 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 NOx/NH3 5240 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 NOx/NH3 5240 in a moving vehicle, the operator should keep his or her eyes on the road.

Cupric Sulfate is supplied to make the NH3 scrubber fluid. **CUPRIC SULFATE IS HARMFUL IF SWALLOWED. IT AFFECTS THE LIVER AND KIDNEYS. IT CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT.** Refer to MSDS information on web for more information.

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.

# How to Use

## Hooking up the NOx/NH3 5240

Figure 1 shows the NOx/NH3 5240 Analyzer kit. The kit consists of 3 parts:

1. The display head and cabling

2. The sampling system; composed of:

   i. The external mounting block (with Sensor A mounted on it)
   ii. The remoteSAMPLER 1000 (with Sensor B mounted in it)
   iii. Sample tube from i. to ii.
   iv. Sample tube from ii. to exhaust
   v. Cable from Sensor A to ii.

3. Compressed air supply: 50–150 psig (3.5-10 bar) @ 1 cfm (28 lpm). User-supplied.

Power (11~28V, 3A) for the analyzer is attached to the remoteSAMPLER. If the battery voltage can dip below 11V, the optional Vboost power supply (P/N 04-02) is recommended. An optional AC/DC power supply is available (P/N 04-01). The power does not have to be switched since the analyzer can be turned on via the "PWR" button on the display head or a 2.7 to 32V signal to the "Key" connector on the back of the display head. The current requirements of this signal are very low (100 μA).

The length between the remoteSAMPLER and the display head can be extended up to 100m using additional P/N 09-03/10 cables. To avoid voltage dropout issues, the cable supplying power to the remoteSAMPLER should not be longer than the supplied 10m (P/N 09-03/10) cable. Shorter cables are available from ECM.

After being turned on, the display head will test both displays, the 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 of the NOX/NH3 module powering Sensor A (on the top display) and the serial number of the module powering Sensor B (on the bottom display).
5. "Rotating wheels" and sensor countdowns as they warm up.
6. Parameter data

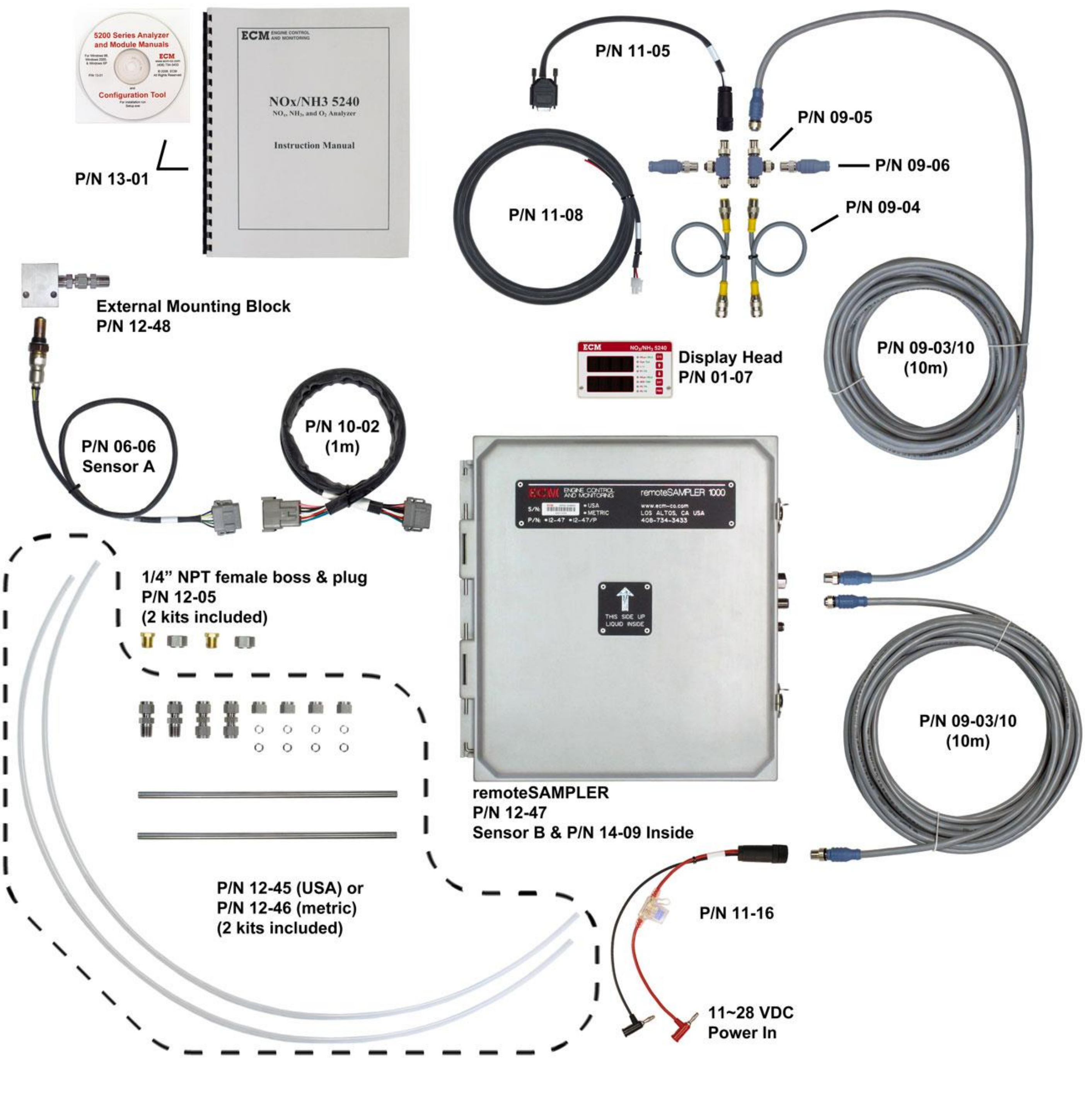



Figure 1: NOx/NH3 5240 Analyzer

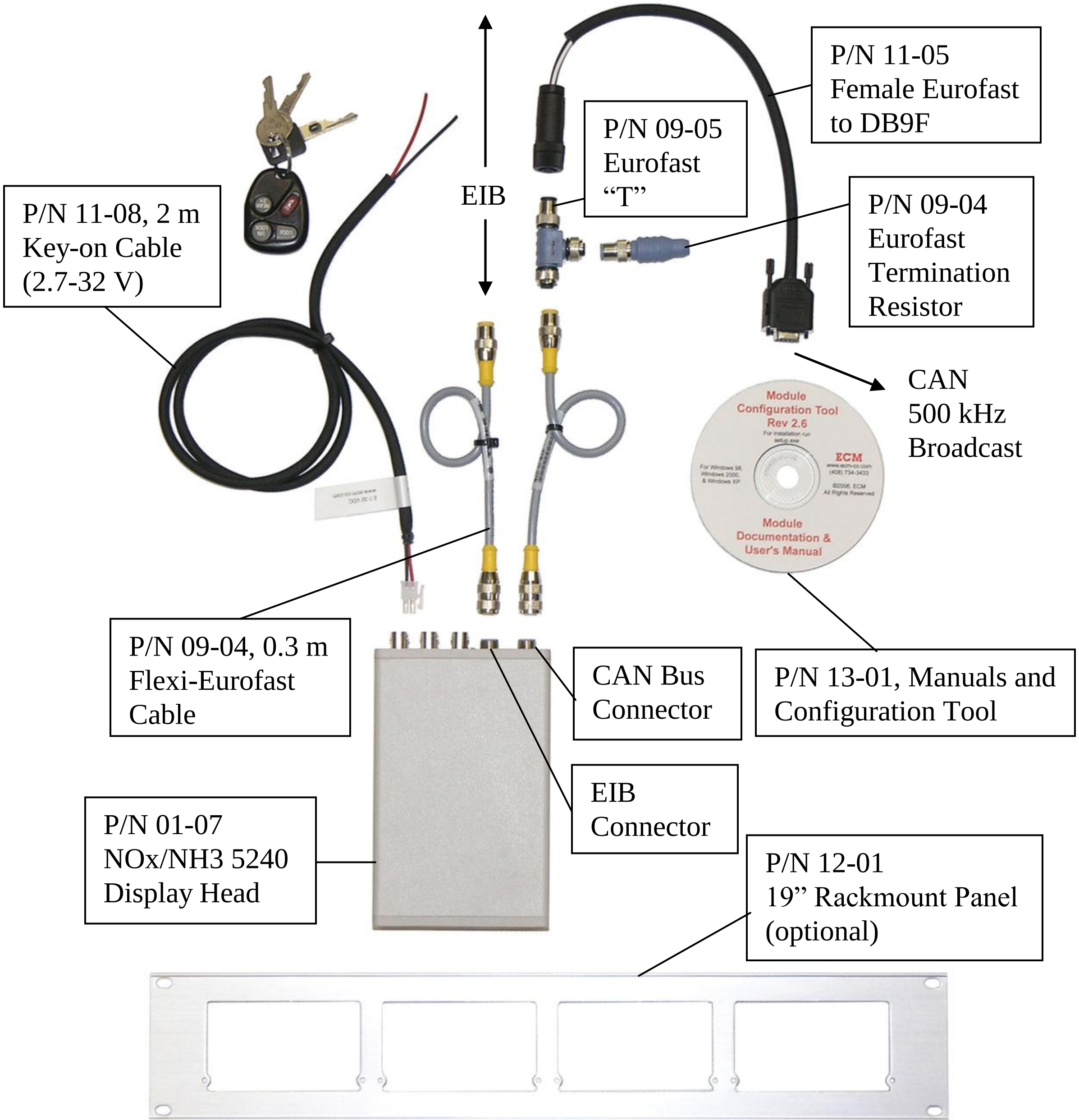




Figure 2: Front and Back of Display Head

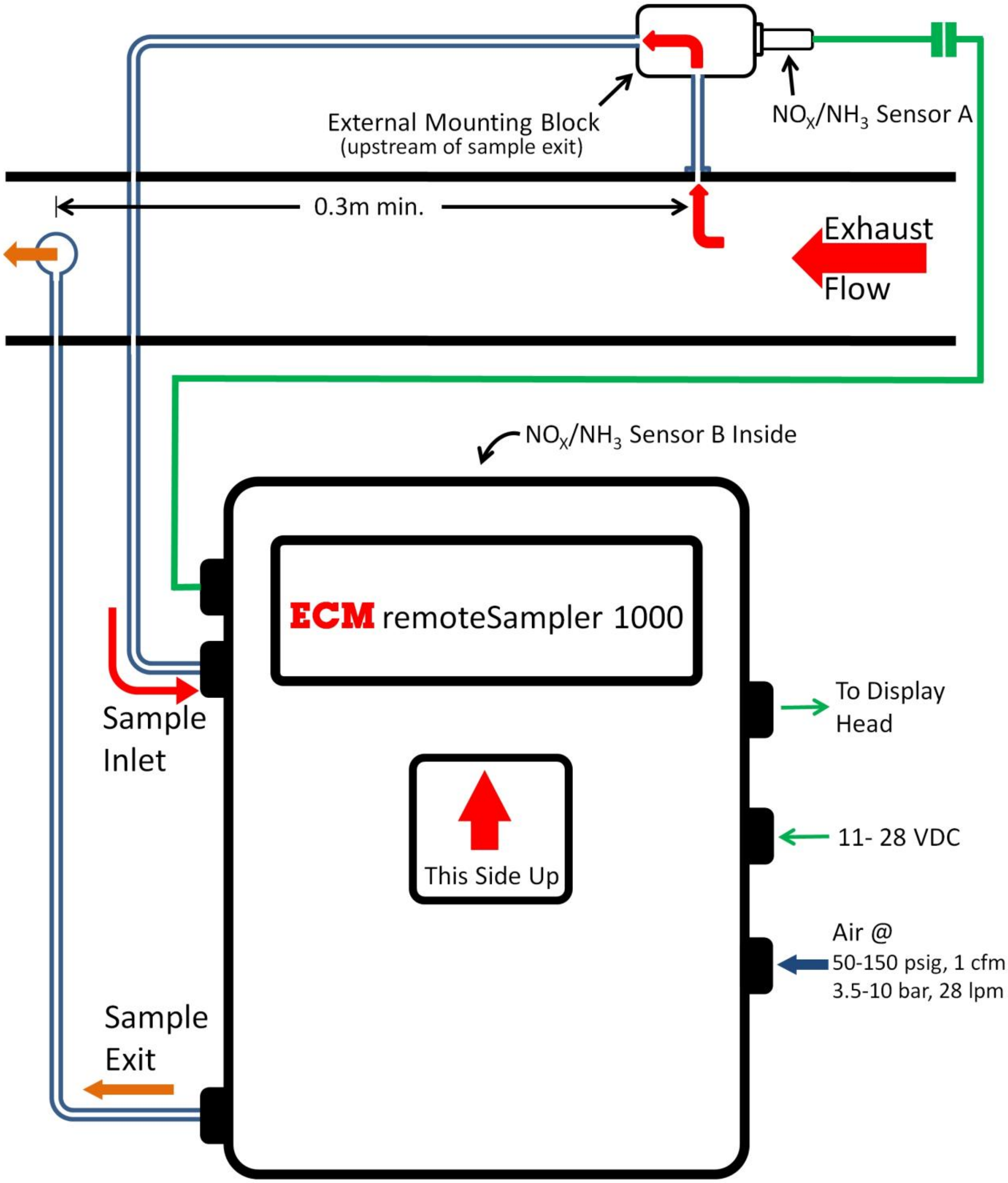



Figure 3: Sampling System

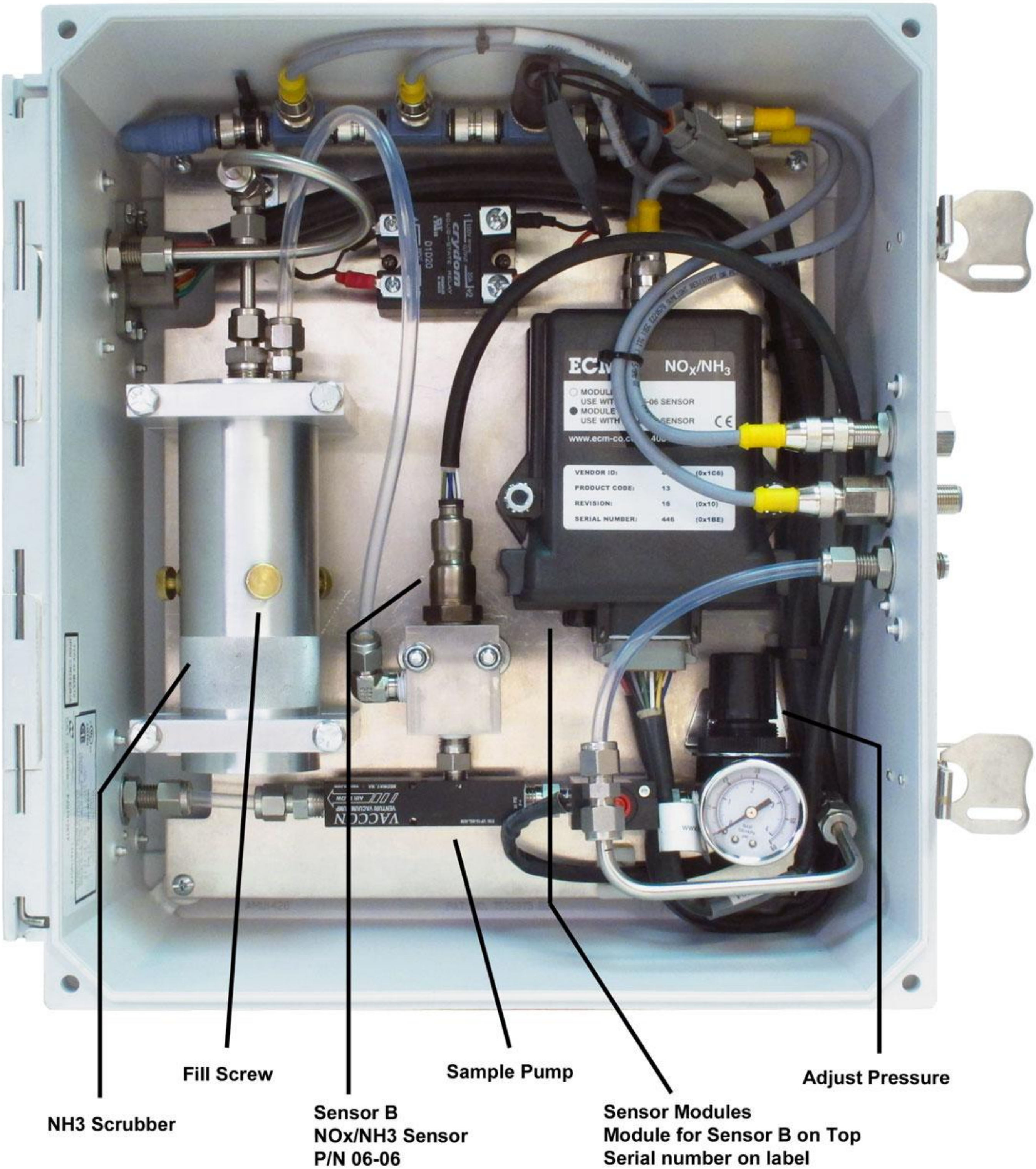



Figure 4: Inside the remoteSAMPLER 1000
(early model without drain solenoid shown)

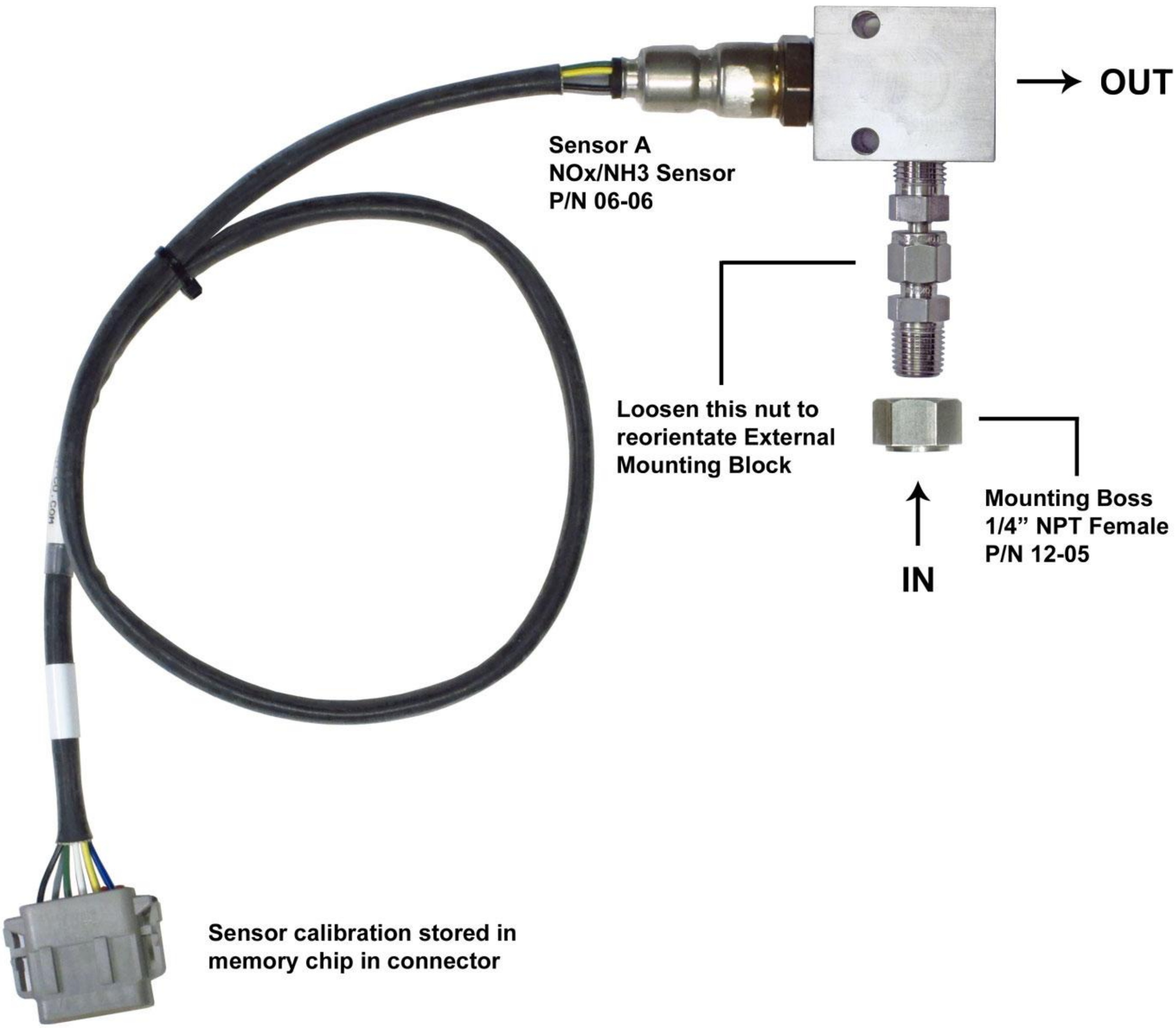



Figure 5: External Mounting Block

(Sensor and Mounting Boss Also Shown)

## Mounting the Sampling System

The NOx/NH3 5240's sampling system (see Figure 3) is closed (i.e. sample returned to the exhaust). This reduces the system's sensitivity to exhaust pressure. The sample intake and exhaust locations must be located at least 0.3m from each-other. Otherwise, air added to the sample exhaust will dilute the sample intake. A ¼" NPT (female) boss will need to be welded at each location. To avoid condensed matter from entering the sampling system, locate the bosses on the upper half of the exhaust pipe.

The remoteSAMPLER must be mounted vertically and within 1m of the bosses. If it isn't mounted vertically, the analyzer will not work properly. In tight installations, the cover can be removed by sliding out the hinge pin. The external mounting block mounts on the sample inlet boss. Note the direction of flow and position of Sensor A on the block (see Figure 5). Do not modify the block. Cable P/N 10-02 connects Sensor A to the remoteSAMPLER.

Using a P/N 12-44 (or P/N 12-45) sample line kit, plumb from the external mounting block to the remoteSAMPLER's "Sample Inlet" port. Use the 0.3m of stainless steel line at the external mounting block (i.e. hot) end of the line, then transition to PFA for the rest of the line to the remoteSAMPLER. You may trim the PFA to a suitable length.

Measure the length of this line (L in meters), calculate Td (remoteSAMPLER delay in msec), and enter the value for Td into the display head. Td units are msec.

$$Td = 274 \times (L + 2.715) \quad \text{[Equation 1]}$$

Plumb from the "Sample Outlet" port on the remoteSAMPLER to the sample exhaust boss on the exhaust pipe. Use the 0.3m of stainless steel line at the exhaust pipe end of the line. Again, you may trim the PFA to a suitable length.

An $NH_3$ scrubber is inside the remoteSAMPLER (see Figure 4). With the analyzer off, remove a fill screw on its side and using the supplied P/N 14-09 filler bottle, fill the scrubber with a cupric sulfate/water solution (3 gm cupric sulfate/150 cc water) to the level of the screw. Reinstall the screw (with gasket) and tighten.

It is important to maintain the fluid level in the $NH_3$ scrubber. The level will slowly go up with use due to exhaust water condensing in the scrubber. Conversely, it will slowly go down if the analyzer is on while the engine is off (not recommended). This is because when the engine is off, relatively dry air will be drawn through the scrubber evaporating the fluid. Generally though, it is the increase in fluid level that has to be monitored. To do this:

- For early remoteSAMPLERS, it is recommended that after every 5 hours of use, the analyzer be turned off (Important!), the fill screw be removed, and the fluid be allowed to drain down to the level of the screw. If the analyzer is not turned off before removing the screw, the fluid will not properly drain.

- For later remoteSAMPLERs, a drain solenoid was added to the side of the scrubber. When analyzer power is off, or if the button is pressed, the solenoid will be open and drain the scrubber. If the analyzer has operated continuously for 5 hours, press the button for 10 seconds. For operating periods less than 5 hours, the turning off of the analyzer will automatically drain excess fluid.

For both early and later remoteSAMPLERs, always turn the analyzer off before removing a fill screw. Otherwise pump action will cause you to overfill or underfill the scrubber.

It is recommended the scrubber be removed, cleaned, and the fluid replaced every 100 hours of use.

Inside the remoteSAMPLER, there is a compressed air-powered sampling pump. Supply the remoteSAMPLER with 50 to 150 psig (3.5 to 10 bar) of compressed air @ 1 cfm (28 lpm). Set sample flowrate to 5 lpm (see Appendix F). With the pressure regulator adjusted to 15 psig, ~5 lpm of exhaust will be drawn. An air solenoid inside the remoteSAMPLER is activated when the analyzer is on allowing sample to be drawn from the exhaust. This sample and the compressed air used to power the pump are returned to the exhaust.

For vehicle installations, ECM has used a Viair 450C-IG air compressor (Viair P/N 45050), 2 gallon air tank (Viair P/N 91022), 110/150 psi pressure relay switch (Viair P/N 90111), and a tank port fitting kit (Viair P/N 90005). The compressor is powered by the vehicle's battery and is activated by KEY ON power from the vehicle's fuse box. To avoid pump noise from reaching the cabin, mount the pump as far away from the cabin as possible and to the frame (not to the floor of the vehicle) using rubber isolators.

See Appendix F for pictures of an installation on a Ford F-250 pickup truck.

## Front Panel and the "SYS" Key

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. Ten parameters: NOxw (wet NOx), NOxd (dry NOx), %$O_2$w (wet O2), %$O_2$d (dry O2), λ, Φ, $NH_3$w (wet $NH_3$), $NH_3$d (dry $NH_3$) AFR, and FAR are fixed and six: P1~P6 are programmable from the list of parameters in Table 2. The ↑ and ↓ keys select which of the eight parameters are displayed (unless the display is LOCKed, see below).

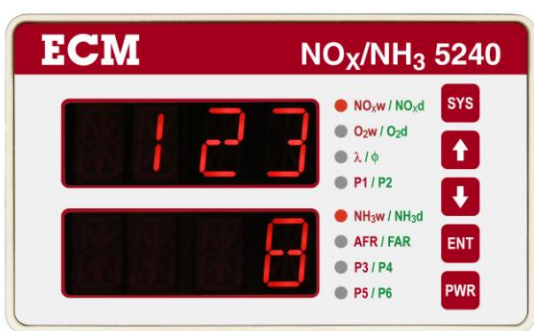
While in RUN mode, pressing the ENT key will toggle between the ↑ and ↓ keys changing parameters on one display to changing parameters on the other display.

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

1. "ERR" and "####" where "####" is an error code. See **Appendix B**.
2. "…." which means that a module has not been assigned to that display. 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 as they warm up.

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 on the upper display are shown, followed by options 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 D describes how to LOCK and unLOCK the display head.



| Setup Option | Level 1 | Level 2 | Level 3 | Function |
|---|---|---|---|---|
| MOd | | | | Select module s/n [NONE] |
| RATE | | | | Set display update rate [FAST] |
| FUEL | | | | Program fuel H:C,O:C,N:C and if $H_2$ [1.85,0,0,NO] |
| AOUT | A1 | | | Program analog output 1 [NOxd,0,2000] |
| | A2 | | | Program analog output 2 [O2d,0,25.00] |
| | A3 | | | Program analog output 3 [LAM,0.400,25.00] |
| | A4 | | | Program analog output 4 [NH3d,0,1000] |
| | A5 | | | Program analog output 5 [AFR,-25.00,25.00] |
| | A6 | | | Program analog output 6 [FAR,27,1667.00] |
| dISP | P1 | | | Program upper display parameter P1 [AFR] |
| | P2 | | | Program upper display parameter P2 [FAR] |
| | P3 | | | Program lower display parameter P3 [LAM] |
| | P4 | | | Program lower display parameter P4 [PHI] |
| | P5 | | | Program lower display parameter P5 [NOxd] |
| | P6 | | | Program lower display parameter P6 [O2d] |
| CAL | O2 | SPAN | | SPAN O2 measurement function |
| | | FACT | | Reset O2 SPAN to factory calibration |
| | | AGEF | | Show sensor age factors |
| | | EXIT | | |
| | NOX | ZERO | | ZERO NOx measurement function |
| | | SPAN | | SPAN NOx measurement function |
| | | FACT | | Reset NOx ZERO and SPAN to factory calibration |
| | | EXIT | | |
| | SAMP | Td | | remoteSAMPLER delay: Td = 274 x (L+ 2.715), L = length of line (m) from external mounting block to remoteSAMPLER, Td is time in msec [800] |
| | | ASAM | | remoteSAMPLER averaging [0.1] |
| | | CNH3 | | Cal check NH3 using model gases |
| | | EXIT | | |
| | P | UNIT | | Choose pressure units [KPA] |
| | | N, C | | Enter pressure sensor calibration numbers |
| | AVG | ANH3 | | Program NH3 averaging [0.02] |
| | | ANOX | | Program NOx averaging [1] |
| | | AO2 | | Program O2 averaging [1] |
| | | EXIT | | |
| | SKEW | *** | | Program gain and offset modifier [1,0] of parameter "***" where " ***": NH3w, NH3d, NOxw, NOxd, O2w, O2d, P, PHI (Φ), FAR, LAM (λ) |
| CONF | LEdS | | | Set display intensity [3333] |
| | 1V4V | | | Check analog outputs at 1V and 4V |
| | CAN | IdS | | Program CAN addresses and produce .dbc file [1~5] |
| | | RATE | | Program CAN transmit rate [5 ms] |
| | | BAUd | | Program CAN baud rate [500k] |
| | NEG | | | Show negative O2, NOx, NH3 [no] |
| | LOCK | | | |
| | FACT | RST | | Reset all but FUEL, N, C, Td, ASAM, ILAM, I2NX, PLAM, ANH3, ANOX, AO2, and NOx/NH3 sensor user calibration to factory defaults |
| | | EXIT | | |

MOd, RATE, AOUT, dISP, and CAL (just CAL(P) for lower display) appear on the upper and lower displays. FUEL appears on upper display only. CONF appears on lower display only. All entries must be followed by pressing the ENT key. Default values shown in square parentheses.

Table 1: Menu Tree for NOx/NH3 5240

## MOd (Module) Setup Option

In MOd setup, the serial number of the NOX/NH3 module assigned to the upper or lower display is entered. The serial number is written on a label on the module (see Figure 4). The module connected to Sensor A (in external mounting block) must be assigned to the upper display. The module connected to Sensor B (in remoteSAMPLER) must be assigned to the lower display. Both modules are located in the remoteSAMPLER. The module for Sensor B is on top of the module for Sensor A.

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 (H:C, O:C, N:C, H2)

Fuel H:C, O:C, and N:C ratios and whether or not the fuel is $H_2$ can be programmed. 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 modules.

## AOUT (Analog Output) Setup Option (A1 to A6)

The display head has six programmable analog outputs. Analog outputs 1, 2, and 3 are programmable on the upper display. Analog outputs 4, 5, and 6 are programmable on the lower display. Each output can be programmed as 0 to 5V, 0 to 1V, or as an EGO (exhaust gas oxygen) sensor simulated output.

The analog outputs are updated every 100 ms based on information sent to it by the NOX/NH3 modules. Three programmable averaging filters are used: ANH3 (for NH3w, NH3d), ANOx (for NOxw, NOxd), and AO2 (for O2w, O2d). See **CAL Setup Option** (AVG Suboption) for more information.

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

Here is an example of setting the 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 ↓ keys until the parameter (see Table 2) that will drive A2 is displayed. Then press the ENT key.
5. Press the ↑ and ↓ keys to select 0V to 5V, 0V to 1V, or EGO sensor simulated output. Then press the ENT key. EGO sensor simulation is only available on %O2, λ, AFR, Φ, and FAR parameters. If EGO selected, go to step 8.

6. 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.
7. When 5V (or 1V) 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 (or 1V) on analog output 2.
8. If you want the EGO sensor simulated output, when EGO is displayed, press ENT. Using the ↑, ↓, and ENT keys, set the parameter value that you want the lean-to-rich (0V-to-1V) transition to occur at. 0V will be output when lean of the programmed value and 1V will be output when rich of the programmed value.
9. When “AOUT” is displayed, press SYS to return to RUN mode.

For analog outputs 4, 5, and 6, your entries will be shown on the bottom display.

## dISP (Display) Setup Option (P1 to P6)

Parameters from Table 2 can be selected as programmable display parameters. P1 and P2 are selected on the upper display. P3, P4, P5, and P6 are selected on the bottom display.

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 ↑ or ↓ 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.

| Name | Full Parameter Name | Parameter Description |
|---|---|---|
| NOx | NOx (ppm) | NOx |
| O2R | %O2real (%) | %O2 before addition of Delta O2 curve |
| IP1 | Ip1 (μA) | Pressure-compensated Ip1 sensor pumping current |
| IP2 | Ip2 (μA) | Pressure-compensated Ip2 sensor pumping current |
| RPVS | RPVS (ohms) | NOx sensor internal VS cell resistance |
| VHCM | VH Commanded (V) | Desired heater voltage commanded by the module |
| VS | VS (V) | NOx sensor internal VS cell voltage |
| VP1P | VP1P (V) | NOx sensor Ip1 pumping voltage |
| VP2 | VP2 (V) | NOx sensor Ip2 pumping voltage |
| VSW | Vsw (V) | Supply Voltage 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) | NOx sensor Ip1 pumping current (unsigned integer format) |
| IP2R | Ip2raw (bits) | NOx sensor Ip2 pumping current (unsigned integer format) |
| ERFL | Error bit flags (bits) | Module error flags (unsigned long format) |
| ERCd | ECM CANOpen Error Code | ECM CANOpen Error Code |
| PR10 | Praw10 (bits) | 10 bit Pressure sensor output voltage (unsigned integer format) |
| PCF | Pressure Correction Factor | NOx sensor Ip1 Pcomp correction factor (x 10000) |
| PCFE, O2E | | ECM diagnostic parameters |
| IP1E, PE | | ECM diagnostic parameters |
| 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 (see below) |
| 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 O2 Table |
| IPX | Ip1 non Pcomp (mA) | Non-pressure compensated NOx sensor Ip1 pumping current |
| PVLT | P (V) | Raw volts from pressure sensor |
| PKPA | P (kPa) | Pressure sensor measured pressure (abs.) in kPa |
| PBAR | P (bar) | Pressure sensor measured pressure (abs.) in bar |
| PPSI | P (psi) | Pressure sensor measured pressure (abs.) in psi |
| IP2X | Ip2 non Pcomp (μA) | Non-pressure compensated NOx sensor IP2 pumping current |
| NCF | NOx Pressure Correction | NOx sensor Ip2 pressure comp. correction factor x 10000 |
| NH3W | Ammonia Wet (ppm) | NH3wet |
| NH3d | Ammonia Dry (ppm) | NH3dry |
| NOXW | NOx Wet (ppm) | NOxwet |
| NOXd | NOx Dry (ppm) | NOxdry |
| O2W | O2 Wet (%) | O2wet |
| O2d | O2 Dry (%) | O2dry |
| O2RB | %O2real (%), Sensor B | %O2 before addition of Delta O2 curve (Sensor B) |
| NOxB | NOx (ppm), Sensor B | NOx (Sensor B) |
| PPSB | P (psi), Sensor B | Pressure sensor measured pressure (abs.) in psi (Sensor B) |
| PKAB | P (kPa), Sensor B | Pressure sensor measured pressure (abs.) in kPa (Sensor B) |
| I1XB | Ip1 non Pcomp, Sensor B | Non-pressure compensated NOx sensor B Ip1 pumping current |
| I2XB | Ip2 non Pcomp, Sensor B | Non-pressure compensated NOx sensor B IP2 pumping current |

Table 2: Parameter List for the NOx/NH3 5240

## CAL (Calibrate) Setup Option (O2, NOx, SAMP)

Calibration consists of one ZERO and two SPANs. During the calibration process, both sensors are simultaneously calibrated with the calibration stored in memory chips located in the sensors' connectors. The sensors are factory calibrated and can be sent back to ECM for recalibration. The frequency of recalibration is application-dependent and can only be determined by experience.

The ZERO and SPANs are as follows and should be performed in sequence:

1. SPAN the $O_2$ measurement (see **CAL, O2, SPAN Option**)
   The recommended SPAN gas is ambient air bubbled through water.

2. ZERO the NOx measurement (see **CAL, NOX, ZERO Option**)
   The recommended ZERO gas is ambient air bubbled through water.

3. SPAN the NOx measurement (see **CAL, NOX, SPAN Option**)
   The recommend SPAN gas is: NO + N2 (balance) bubbled through water.
   Choose NO ppm close to maximum expected measurement level.

There is no need to ZERO or SPAN the $NH_3$ measurement. Due to the nature of operation of the instrument, ZEROing and SPANing NOx is equivalent to ZEROing and SPANing $NH_3$. The instrument's $NH_3$ calibration can be checked using the CHN3 feature (see below).

Calibration gases need to be bubbled through water to add water vapor. There are two ways to do this: the first is to add a bubbler at the Sample Inlet. The second is to use the NH3 Scrubber as a bubbler by temporarily re-plumbing the system. Water or the cupric sulfate/water solution (3 gm cupric sulfate/150 cc water) can be used. Figure 6 shows how using two temporary lines, the system can be re-plumbed for calibration. ECM P/N 14-11 (NOx/NH3 5240 Calibration Kit) contains these two lines and a flowmeter.

When dry gases are bubbled though water, they exit containing water vapor. It is assumed that the exiting gas is 100% saturated with water (i.e. Rh = 100). The resultant %O2 and NOx has to be calculated and those numbers will be entered during the calibrations.

To calculate the %O2 for the O2 SPAN, use Rh = 100 and the formula in Appendix C.

The NOx ZERO doesn't need a calculation. Bubbled air has 0 ppm NOx.

To calculate the ppm NOx for the NOx SPAN, use Rh = 100 and the formula in Appendix C but with 20.945 replaced with the span gas tank ppm NOx. The number you will calculate will be less than the span gas tank ppm NOx.

**Prior to calibration, remove the NOx/NH3 sensors, allow to cool, and strike them against your forearm to remove any liquid water that may be inside them. This water will ruin the calibration. Shaking them in air doesn't seem to be as effective in removing the water. Note that your forearm is soft and covered by your shirt.**

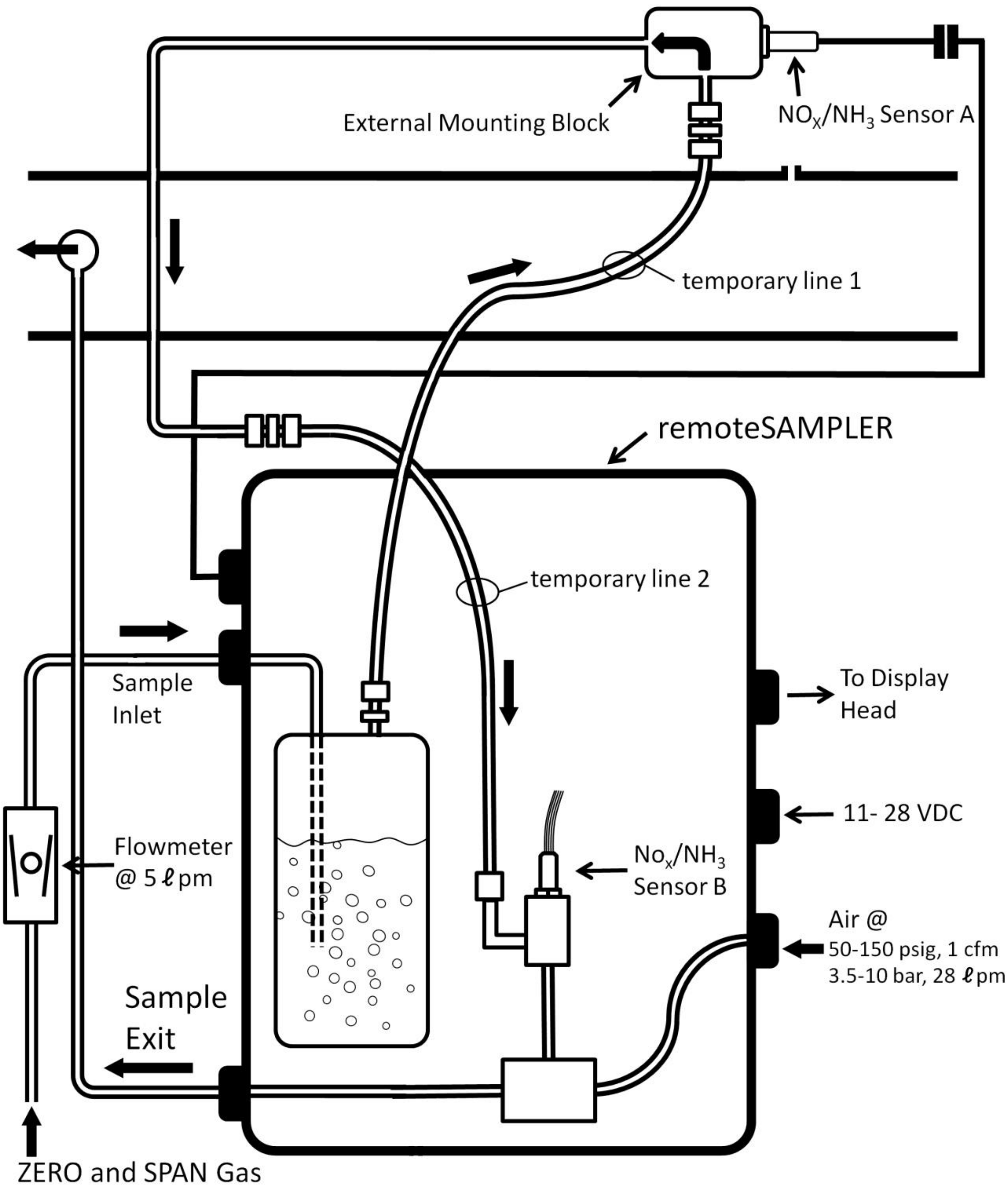



Figure 6: System Re-Plumbed for Calibration

◆ **O2**

The O2 SPAN function is for the recalibration of the analyzer's %$O_2$, λ, AFR, Φ, and FAR measurements. This recalibration is stored in the sensors' memory chips and is used instead of the factory calibration. The FACT function (under "O2") cancels the user calibration resulting in the factory calibration being used.

SPAN (for %$O_2$, λ, AFR, Φ, and FAR measurements)

To perform an O2 SPAN:

1. A span should be performed after the analyzer has been on for at least 20 minutes with 5 lpm of ambient air being drawn through the system. Adjust the pressure regulator inside the remoteSAMPLER to obtain 5 lpm. It will be approximately 15 psig.
2. Calculate the %$O_2$ that the sensors will see assuming 100% Rh (relative humidity). To calculate the %$O_2$, use Rh = 100 and the Configuration Tool Software or refer to Appendix C.
3. Press the SYS key until "MOd" appears.
4. Press the ↓ key until "CAL" is on the upper display. Then press the ENT key.
5. With "O2" on the display, press the ENT key.
6. With "SPAN" on the display, press the ENT key.
7. Using the ↑ and ↓ keys, change the display to show the %$O_2$ in air calculated in 2 (above). Press the ENT key.
8. When "CAL" is displayed, press SYS to return to RUN model. See **AGEF** (below).
9. The user calibration is written into the memory chip in the sensors' connectors and will be used to calculate %$O_2$, λ, AFR, Φ, FAR, and the wet-to-dry conversions. If the sensors is removed and installed on another analyzer, this user calibration will be carried over with the sensors.

FACT (return to factory %$O_2$, λ, AFR, Φ, and FAR calibration)

To return to the factory calibration of %$O_2$, λ, AFR, Φ, and FAR for the sensors:

1. Press the SYS key until "MOd" appears.
2. Press the ↓ key until "CAL" is on the upper display. Then press the ENT key.
3. With "O2" on the display, press the ENT key.
4. Press the ↓ key until "FACT" is on the display. Press the ENT key. The user O2 SPAN calibration of the sensors is erased and the factory calibration will be used to calculate %$O_2$, λ, AFR, Φ, and FAR. Sensors' age factor (AGEF) will be reset to "1.00".

AGEF (sensor age factors)

After Sensor A and Sensor B have had their $O_2$ measurement spanned, data from this span is compared to data from the sensors when they were new. From this, sensor age factor parameters are calculated that indicates the relative $O_2$ sensitivity of the sensors compared to when they were new. The age factor for Sensor A (in external mounting block) is displayed on the upper display. The age factor for Sensor B (in remoteSAMPLER) is displayed on the lower display. The age factor goes down with use. When the age factor is 0.75 or below, it is recommended that the sensor be replaced. The age factors are reset to "1.00" after the FACT option (see above) has been executed.

### ◆ NOx

The NOx ZERO is similar to the O2 SPAN except for the menu selections. This recalibration is stored in the sensors' memory chips and is used instead of the factory calibration. The FACT function (under "NOx") cancels the user calibration resulting in the factory calibration being used.

<u>ZERO (for NOx and NH3 measurement)</u>

To perform a NOx zero:

1. A zero should be performed after the analyzer has been on for at least 20 minutes with 5 lpm of ambient air being drawn through the system. Adjust the pressure regulator inside the remoteSAMPLER to obtain 5 lpm. It will be approximately 15 psig.
2. Press the SYS key until "MOd" appears.
3. Press the ↓ key until "CAL" is on the top display. Then press the ENT key.
4. Press the ↓ key until "NOx" appears. Then press the ENT key.
5. With "ZERO" on the display, press the ENT key.
6. Using the ↑ and ↓ keys, change the display to read 0 ppm. Press the ENT key.
7. When "CAL" is displayed, press SYS to return to RUN mode.
8. The user calibration is written into the memory in the sensors' connectors and will be used to calculate NOx and NH3. If the sensors are removed and installed on another analyzer, this user calibration will be carried over with the sensors.

<u>SPAN (for NOx and NH3 measurement)</u>

To perform a NOx SPAN:

1. A span should be performed after the analyzer has been on for at least 20 minutes with 5 lpm of ambient air being drawn through the system. Adjust the pressure regulator inside the remoteSAMPLER to obtain 5 lpm. It will be approximately 15 psig.
2. <u>Turn the pump off by disconnecting the compressed air.</u>
3. Attach a span gas tank containing a NO + N2 (balance) mixture. Starting at zero pressure on the tank's regulator, slowly increase the pressure until 5 lpm is obtained. To obtain 5 lpm, the pressure will be just above 0 psig.
4. <u>Turn the pump on by attaching the compressed air.</u> Readjust the tank pressure until 5 lpm is obtained.
5. Calculate the NO ppm that the sensors will see assuming 100% Rh (relative humidity). To calculate the NO ppm, use Rh = 100 and the formula in Appendix C replacing 20.945 by the NO ppm in the span gas tank.
6. Wait 10 minutes with SPAN gas flowing.
7. Press the SYS key until "MOd" appears.
8. Press the ↓ key until "CAL" is on the top display. Then press the ENT key.
9. Press the ↓ key until "NOx" appears. Then press the ENT key.
10. Press the ↓ key until "SPAN" appears. Then press the ENT key.

11. Using the ↑ and ↓ keys, change the display to read the NO ppm calculated in 5 (above). Press the ENT key.
12. When "CAL" is displayed, press SYS to return to RUN mode.
13. <u>Turn the pump off by disconnecting the compressed air.</u>
14. Shut off the span gas tank and disconnect the line from the remoteSAMPLER.
15. <u>Turn the pump on by reconnecting the compressed air.</u>
16. The user calibration is written into the memory chip in the sensors' connectors and will be used to calculate NOx and NH3. If the sensors are removed and installed on another analyzer, this user calibration will be carried over with the sensors.

<u>FACT (return to factory NOx and NH3 calibration)</u>

To return to the factory calibration of NOx and NH3 for the sensors:

1. Press the SYS key until "MOd" appears.
2. Press the ↓ key until "CAL" is on the top display. Then press the ENT key.
3. Press the ↓ key until "NOx" appears. Then press the ENT key.
4. Press the ↓ key until "FACT" is on the display. Press the ENT key. The user NOx and NH3) ZERO and SPAN calibration of the sensors is erased and the factory calibration will be used to calculate NOx and NH3.

### ◆ SAMP

SAMP contains features related to the remoteSAMPLER.

<u>Td</u>

Td is the pure transport delay (units: msec) of the gases from Sensor A (in the external mounting block) to Sensor B in the remoteSAMPLER. The user must enter this number based on the actual external mounting block-to-remoteSAMPLER sample line length L (unit: meters).

$$Td = 274 \times (L + 2.715)$$

<u>ASAM</u>

ASAM is the filter coefficient for the flowrate of the gases from Sensor A (in the external mounting block) to Sensor B in the remoteSAMPLER. Contact ECM for assistance before changing ASAM from the default value.

<u>CNH3</u>

CNH3 allows the user to check the calibration of the NH3 measurement using a NH3 + NO (0~5000 ppm) + N2 (balance) dry model gas mixture. To check the calibration:

1. Configure the analyzer as shown in Figure 3.
2. Remove the external mounting block from the exhaust.
3. <u>Turn the pump off by disconnecting the compressed air.</u>
4. Attach the model gas tank to the inlet of the external mounting block. Starting at zero pressure on the tank's regulator, slowly increase the pressure until 5 lpm is obtained. To obtain 5 lpm, the pressure will be just above 0 psig. Do not externally bubble the

gases though water because the water will absorb NH3. Feed dry gases directly from the tank to the external mounting block.

5. Turn the pump on by attaching the compressed air. Readjust the tank pressure until 5 lpm is obtained.
6. NOx will be displayed on the upper display and NH3 will be displayed on the bottom display. Press the ENT key to exit.
7. Turn the pump off by disconnecting the compressed air.
8. Shut off the model gas tank and disconnect the line to the external mounting block.
9. Turn the pump on by reconnecting the compressed air.
10. Adjust the pressure regulator inside the remoteSAMPLER to obtain 5 lpm into the external mounting block with the block drawing in ambient air.

Note that the analyzer will not read correctly in normal operation mode (versus CNH3 mode) when dry NH3 + NO (0~5000ppm) + N2 (balance) is fed into the external mounting block. The reason why is that the analyzer calculates a %H2O based on the Lambda of the sampled gases in order to perform the wet-to-dry calculation. With no oxygen, the analyzer will assume Lambda = 1 and a significant %H2O, when actually the %H2O in the dry gases is zero. The wet-to-dry calculation is an integral part of the NH3 calculation.

## CAL (Calibrate) Setup Option (P, AVG, SKEW)

◆ **P (only relevant if optional pressure compensation kits installed)**

Pressure sensor calibration numbers (N and C) and displayed pressure units can be programmed. The "N" and "C" values must match those written on a label on the pressure sensor. The pressure sensor cannot be user calibrated.


The programmable pressure units are PSIA, KPAA, MMHG (mmHg), BAR, and KGCM ($kg/cm^2$). All pressures shown are absolute (i.e. not gauge).

◆ **AVG**

NH3, NOx, and O2 data sent from the NOx/NH3 modules is averaged in the display head via averaging filters ANH3, ANOX, and AO2. Do not change their default values without contacting ECM.

How the averaging filters are used is shown by Equation 2. The averaging filters are user-programmable and can be assigned values from 0.001 (heavy averaging) to 1.000 (no averaging).

$$ParameterAverage_{t+5ms} = \alpha \text{ x } Parameter_{t+5ms} + (1 - \alpha) \text{ x } ParameterAverage_{t} \quad \text{[Equation 2]}$$

where:

$ParameterAverage_{t+5ms}$ = the parameter average at time "t+5ms"

α = ANH3 for $NH_3$w and $NH_3$d, or
ANOx for NOxw and NOxd, or
AO2 for $\%O_2$w and $\%O_2$d .

These user-programmable filters range from 0.001 (heavy averaging) to 1.000 (no averaging).

$Parameter_{t+5ms}$ = the parameter value at time "t + 5ms"

$ParameterAverage_{t}$ = the parameter average at time "t"

The default averaging filter values are given within square parentheses in Table 1. These values should not be modified without first consulting ECM.

### ◆ SKEW

SKEW allows the parameters $NH_3w$, $NH_3d$, NOxw, NOxd, P, AFR, Φ, FAR, λ, $\%O_2w$, and $\%O_2d$ each to be modified by a programmable transform of the form:

$$\text{ParameterSkewed} = M \times \text{Parameter} + B \quad \text{[Equation 3]}$$

where:

ParameterSkewed = $NH_3w$, $NH_3d$, NOxw, NOxd, P, AFR, Φ, FAR, λ, $\%O_2w$, and $\%O_2d$ value after being skewed.

Parameter = $NH_3w$, $NH_3d$, NOxw, NOxd, P, AFR, Φ, FAR, λ, $\%O_2w$, and $\%O_2d$ measurement 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.

The skewed parameters are displayed and output (i.e. analog outputs, CAN).

## CONF (Configure) Setup Option (LEdS, 1V4V, CAN, MOdE, FACT)

CONF setup appears at the end of the setup list on the lower display. 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 NOx 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 2 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 rule is that they should be at the ends of the CAN bus.

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 display (sensor B and module B). See **Appendix B**.
10. An error code for the lower display (sensor A and module A). See **Appendix B**.
11. An auxiliary code for the upper display (sensor B and module B).
12. An auxiliary code for the lower display (sensor A and module A).

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 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 |
|---|---|---|---|---|---|---|---|---|
| CANid1 | What is being sent to analog output 1 | | | | What is being sent to analog output 2 | | | |
| CANid2 | What is being sent to analog output 3 | | | | What is being sent to analog output 4 | | | |
| CANid3 | What is being sent to analog output 5 | | | | What is being sent to analog output 6 | | | |
| CANid4 | What is being sent to upper display | | | | What is being sent to the lower display | | | |
| ERCd | Error code for upper display (sensor B, module B) | | | | Error code for lower display (sensor A, module A) | | | |
| | Error Code Low | Error Code High | Aux. Code | N/A | Error Code Low | Error Code High | Aux. Code | N/A |

Each of the eight parameters in CANid1 to CANid4 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 B. 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 display. If there is no error or active countdown, an error message is not broadcast.

Addresses CANid1 through CANid4 and ERCd are user programmable. To program them: enter SYS mode, ↓ down to "CONF", press the ENT key, ↓ down to "CAN", press the ENT key once (while displaying "CAN"), press the ENT key again (while displaying "IdS"), and enter them (CId1, CId2, CId3, CId4) one by one (enter number then press the ENT key). After entering ERCd, ".dBC" will appear on the display. If the CAN port of the NOx/NH3 5240 is connected directly to a PC via a CAN adapter, pressing the ENT key will result in data for the .dbc file for the current NOx/NH3 5240 setup being sent to the PC. This .dbc file can be used with programs accepting the VectorCAN .dbc format. How to get this .dbc file is explained in more detail below:

1. Configure the analog outputs and displays as desired. The parameters assigned to the analog outputs and displays are what will be broadcast on the CAN bus.

2. Connect the NOx/NH3 5240 display head directly to the CAN adapter connected to the PC. There should be nothing else on the CAN bus. Just the display head and the PC.

3. Start the Configuration Program and click on the "Display Head" tab. Select the CAN adapter being used. Then start the communication.

   The rate at which CAN data is sent can also be programmed via the "RATE" parameter under "CAN". To program how often the CAN data is to be sent: enter SYS mode, ↓ down to "CONF", press the ENT key, ↓ down to "CAN", press the ENT key, ↓ down to "RATE", press the ENT key, then enter the rate in ms. The allowable range is 5ms to 9999ms with 5ms being the default.

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

4. Click on the "Generate .dbc" button on the PC's screen. Enter the filename and directory for the .dbc file.

5. Get to the CAN setup in the display head and enter the desired CAN addresses for CANid1 to CANid4 (CId1, CId2, CId3, CId4), and ERCd. Then when ".dBC" is shown on the display, press the ENT key. Within a second, the .dbc file for that particular NOx/NH3 5240 analyzer setup will be sent to the PC. It is a good idea to LOCK the display head after this (see "LOCK" below) since changing a new displayed parameter or new analog out parameter will change the data transmitted via CAN to that of the new parameter.

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 NOx sensor warm-up when the display is counting down, TopAux_sn or BtmAux_sn will contain the countdown number.

7. See Appendix E for additional information.

### ◆ NEG

Parameters $NH_3$w, $NH_3$d, NOxw, NOxd, %$O_2$w, and %$O_2$d are normally limited to a lower value of 0 (zero). However, the calibration of the analyzer can drift and if it drifts down, it is useful to know that. Thus, some users may wish to allow negative $NH_3$, NOx, and %$O_2$ values. These values will affect what is displayed and output via analog outputs or CAN. A programmed value of "yes" will enable negative values.

### ◆ 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 D 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, pressure sensor calibration numbers N and C, averaging filters ILAM, I2NX, PLAM, ANH3, ANOX, AO2, Td, ASAM nor does it cancel a user calibration of the NOx/NH3 sensors. To cancel a user calibration of a NOx/NH3 sensor use "FACT" (Twice: once for $O_2$ and once for NOx) in the CAL Setup Option.

# Specifications and Limits

## Measurements and Accuracies

| Parameter | Range | Response Time | Accuracy |
|---|---|---|---|
| $NH_3$ | 0 to 1000 ppm | < 1 s[1] | ±5 ppm (0 to 1000 ppm)<br>±1% of reading (elsewhere) |
| NOx | 0 to 5000 ppm | < 1 s[2] | ±5 ppm (0 to 1000 ppm)<br>±1% of reading (elsewhere) |
| Lambda (λ) | 0.4 to 25 | < 150 ms | ±0.8% (at λ=1)<br>±1.8% (elsewhere) |
| AFR | 6 to 364[4] | < 150 ms | ±0.8% (at 14.56 AFR)<br>±1.8% (elsewhere) |
| Equivalence Ratio (Φ) | 0.04 to 2.5 | < 150 ms | ±0.8% (at Φ=1)<br>±1.8% (elsewhere) |
| FAR | 27 to 1667[4,5] | < 150 ms | ±0.8% (at 687 FAR)<br>±1.8% (555<FAR<833) |
| $\%O_2$ | 0 to 25% | < 150 ms[3] | ±0.2 (absolute) |
| Pressure | 0 to 517 kPa, 75 Psia | < 150ms | ±5.2 kPa<br>±0.75 Psia |

[1] The response time is for default settings of averaging filter ANH3.
See **CAL Setup** for more information.
[2] The response time is for default settings of averaging filter ANOX.
See **CAL Setup** for more information.
[3] The response time is for default settings of averaging filter AO2.
See **CAL Setup** for more information.
[4] AFR and FAR range given above for a fuel with an H:C ratio of 1.85, however all fuel types supported by analyzer and programmable by H:C, O:C, and N:C ratios.
[5] 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.

## Sensor Limits and Specifications

### ◆ NOx/NH3 Sensors

Exhaust Gas Temperature Range: 0 - 850 °C, 32 - 1562 °F
Maximum Exhaust 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 NOx/NH3 sensor in a heavily-sooting or crankcase-oil-burning engine because these conditions will shorten the life of the sensor.

Thread Size: 18mm x 1.5mm
Lightly coat with non-lead containing antiseize compound.

Hex Size: 22 mm

Tightening Torque: 40 ±4 Nm, 30 ±3 ft-lbf

### ◆ Sample Line Kit (P/N 12-45 (USA), P/N 12-46 (Metric))

Notes: 1. Two kits included.
2. Stainless steel end of tubing towards exhaust. PFA end towards remote remoteSAMPLER.
3. Program parameter Td = 274 x (L + 2.715) where L is length (in meters) of external mounting block-to-remoteSAMPLER sample line length and Td is in msec.

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

Tubing Lengths: 0.3m stainless steel, 1m PFA (Perfluoroalkoxy)

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

Nut, Front Ferrule, Back Ferrule at remoteSAMPLER 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 PFA Tubing:
Swagelok SS-400-6 (USA), or
Swagelok SS-6MO-6 (Metric)

Fitting on Exhaust 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)

◆ **Pressure Sensors (only included with optional pressure-compensation kits)**

Note: Do not directly attach pressure sensor to the exhaust or pressure sensor damage will result. Use pressure line assembly (below).

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 Line Assemblies (only included with optional pressure compensation kit for external mounting block, P/N 12-08A (USA), 12-11A (Metric))**

Notes: 1. Must be 28” (711mm) long. Do not modify by more than 25% without contacting ECM.
2. Stainless steel end of tubing towards external mounting block. Teflon end towards pressure sensor.

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

Tubing Assembled Length: 28” (USA), (19” stainless steel, 9” teflon), or
711mm (Metric), (483mm stainless steel, 229mm teflon)

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 External Mounting Block 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 5V, 0 to 1V, 20 mA max.

Output Impedance: 2.66 kΩ

Bits Resolution: 12 bits

Update Rate: 100 ms

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

◆ **CAN**

Protocol: Broadcast.

Broadcast Rate: Programmable 5 to 9999ms. 5ms 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), 2.4 A steady-state (NOx/NH3 sensors and modules), on start-up, NOx/NH3 sensors and modules may draw as much as 8 A for 30 s.

Case Ground: The NOx/NH3 5240 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 µA

◆ **Environment**

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

remoteSAMPLER: -55 to 125 °C, 100% humidity, IP66 (modules inside are IP67)

◆ **Dimensions and Weight**

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

remoteSAMPLER: 406 mm x 366 mm x 191 mm, 16" x 14" x 7 ½", (W x H x D)
7.82 kg, 17.25 lbm

◆ **Vibration Isolators used on remoteSAMPLER**

Four of McMaster Carr P/N 4403K39 (USA)

Four of McMaster Carr P/N 4403K84 (Metric)

# 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+
01-06 dashCANc
01-07 NOx/NH3 (just head)

**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
04-02 Vboost Supply, 10~14VDC to 24VDC @ 14.5A
04-03 30A AC/DC Power Supply, 15V, 120VAC
04-04 15A AC/DC Power Supply, 15V, 120VAC
04-05 60A AC/DC Power Supply, PWR 60, 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)

**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, 0-100 psia, 1/4", (USA)
07-06 Pressure, Type KP, 0-689 kPa, 6mm, (Metric)
07-07 RH (Humidity) Sensor, ¼" NPT
07-08 Pressure (Lp,C,bCAN only), 0-75 psia, 1/4", (USA)
07-09 Pressure (Lp,C,bCAN only), 0-517 kPa, 6mm, (Metric)
07-10 Pressure (Lp,C,bCAN only), Type KP, 0-75 psia, 1/4", (USA)
07-11 Pressure (Lp,C,bCAN only), Type KP, 0-517 kPa, 6mm, (Metric)

**08 Actuators**

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

**10 Sensor Cables**

10-01 Module Y Cable (Superseded by -21)
10-02 1m L/N/C/bCAN Cable, (12 term.)
10-02/25' L/N/C/bCAN Cable, (12 term., teflon)
10-03 2m L/N/C/bCAN Cable, (12 term.)
10-04 1m Pressure Cable (LCAN, NCAN, not Lp,C,bCAN), (4 term.)
10-05 2m Pressure Cable (LCAN, NCAN, not Lp,C,bCAN), (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 (for all except Lp, C, and bCAN)

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

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

10-34 Module Y Cable (for Lp and CCAN only)
10-35 1m Pressure Cable (Lp,C,bCAN only), (8 term.)
10-36 2m Pressure Cable (Lp,C,bCAN only), (8 term.)
10-37 3m L/N/C/bCAN Cable, (12 term.)
10-38 3m Pressure Cable (Lp,C,bCAN only), (8 term.)
10-39 1-to-4 Pressure Sensor Adapter (for /P kits only. Not for /PB kits)
10-40 3m Pressure Cable (LCAN, NCAN, not Lp,C,bCAN), (4 term.)
10-41 3m Humidity Cable (bCANm), (6 term.)

**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 LCANc
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

**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, 19", (USA)
12-08A Pressure Line Assembly, 1/4" dia, 28" (USA)
12-09 Inconel Shield

12-10 18mm Cu Gasket
12-11 Pressure Line Assembly, 6mm dia, 483mm, (Metric)
12-11A 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
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 (Pwr & Suc)
12-22 Sampling-Type Exhaust Probe (USA)
12-23 Sampling-Type Exhaust Probe (Metric)
12-24 Small Heated Aluminum Sensor Heater Block, 18mm
12-25 1/4" UNC Module Stacking Standoff
12-26 Small Aluminum Sensor Mounting Block, 18mm
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
12-32 Small Aluminum Sensor Mounting Block, 20mm & 18mm
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

**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 1/4" NPT Tap
14-04 1/4" ISO Tapered Tap
14-05 Antiseize
14-06 Metal Brush
14-07 Lambda Sensor Calibration System
14-08 20mm x 1.5mm Bottoming Tap
14-09 Filler Bottle
14-10 Cupric Sulfate (3 gm)
14-11 NOx/NH3 5240 Calibration Kit

# Appendix B: Error Codes and Troubleshooting

If one of the NOx/NH3 5240's displays flashes "ERR" followed by "####" (the Error Code), an error has been detected in that display'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 |
|---|---|---|
| NONE | Green ON | All OK (green light constantly on) |
| 0001 | Flash Green, 10 hz | Sensor warm-up period (not really an error) |
| 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 | Sensor turned off (red led constantly on) |
| 0014 | Pulse Red 1x/2s | NOx/NH3 sensor heater open / NOx/NH3 sensor not connected. |
| 0015 | Pulse Red 1x/2s | NOx/NH3 sensor heater shorted. Bad NOx/NH3 cable or sensor. |
| 0021 | Pulse Red 2x/2s | Memory chip in NOx/NH3 sensor's bus shorted. Bad cable or sensor. |
| 0022 | Pulse Red 2x/2s | No memory chip in NOx/NH3 sensor detected. Bad cable or sensor. |
| 0023 | Pulse Red 2x/2s | CRC16 error. Bad cable or sensor. |
| 0024 | Pulse Red 2x/2s | Invalid NOx/NH3 sensor memory chip parameter. Wrong sensor. |
| 0025 | Pulse Red 2x/2s | Non-compatible NOx/NH3 sensor memory chip format (old Rev.) |
| 0031 | Pulse Red 3x/2s | Vsw < 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 NOx/NH3 sensor or cable. |
| 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 NOx/NH3 cable or cracked sensor (common). |
| 0062 | Pulse Red 6x/2s | VP+ < 2 V. Bad NOx/NH3 cable or cracked sensor (common). |
| 0063 | Pulse Red 6x/2s | VP2 out of range |
| 0064 | Pulse Red 6x/2s | 0.25 V > VS+ > 0.75 V for 7.5s. Bad NOx sensor. |
| 0065 | Pulse Red 6x/2s | User data (span) in NOx/NH3 sensor memory chip corrupted. User must reperform NOx/NH3 sensor span. |

The two most common problems are a damaged NOx/NH3 sensor and a low supply voltage (less than 11 V). When the NOx/NH3 sensor is damaged, it must be replaced. It cannot be repaired. The NOx/NH3 sensor should be considered an expendable component and a spare kept.

Three other displays of interest are:

1. "…." which means that a NOx module has not been assigned to that display. 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 NOx module is disconnected, dead, or the EIB cable is broken.

# Appendix C: 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:

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

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

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

# Appendix D: 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 "MOdE" is displayed. Then press ENT.
4. Press ↓ until "LOCK" is displayed. Then press ENT.
5. "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 E: Using the Configuration Tool Software

The ECM Configuration Tool with be used with analyzers (i.e. NOx 5210, Lambda 5220, EGR 5230, NOx/NH3 5240). One or more analyzers can be connected to the same CAN bus using the CAN connector on the back of the analyzers. Make sure that the CAN bus is properly terminated.

The Configuration Tool can be used for the following:

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

Once the analyzers are connected to the CAN bus and turned on, start the Configuration Tool, select the "Analyzers" tab, select the CAN Adapter, 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.

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:

In the software, press "Add Device"

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: one each for CID1, CID2, CID3, CID4, and ERCd. These are entered in decimals. The allowable range is 1 to 2047. If analyzers and modules are on the same CAN bus (not EIB bus), be careful to avoid using the CAN ids 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. 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 and the format of the messages for that analyzer will be sent to the Configuration Tool.

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.

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.

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

◆ 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 F: Installation on Ford F-250 Pick-up Truck

This installation example is for a 2012 Ford F-250 Extended Cab pickup truck with the 6.7L Power Stroke® Engine. The remoteSAMPLER is mounted on a ¼" thick aluminum plate. The aluminum plate is mounted on the outside of the frame, on the right side of the truck, using two existing holes in the frame. The plate is held off of the frame using two 1" diameter x 1" tall aluminum dowels that are drilled through for a 5/16" bolt. Two 5/16" x 2" bolts, two nylock nuts, and four washers is the required hardware. The plate, dowels, and hardware are user-supplied.

Here are the plate dimensions.  Only six holes have to be drilled.  All units in inches.

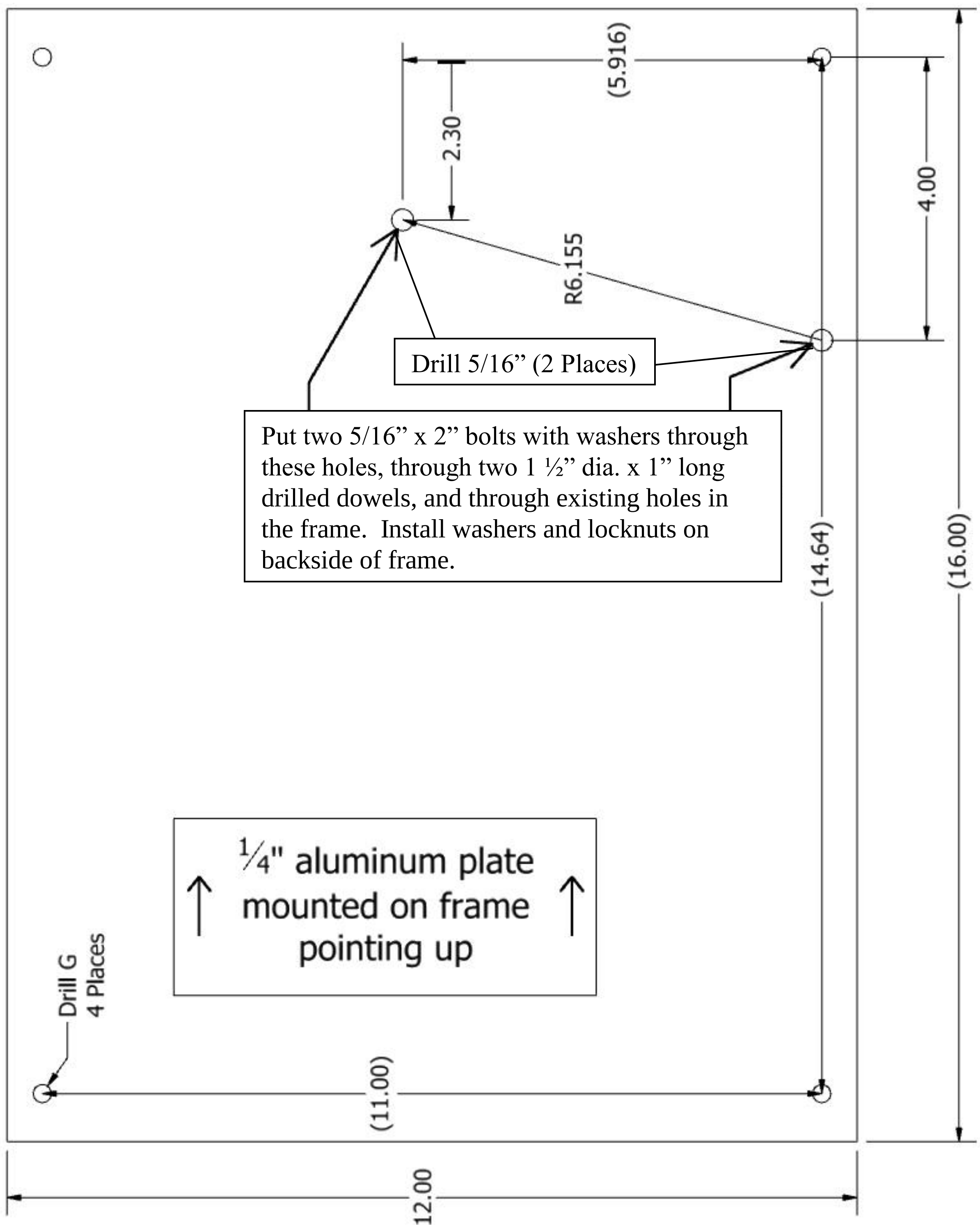


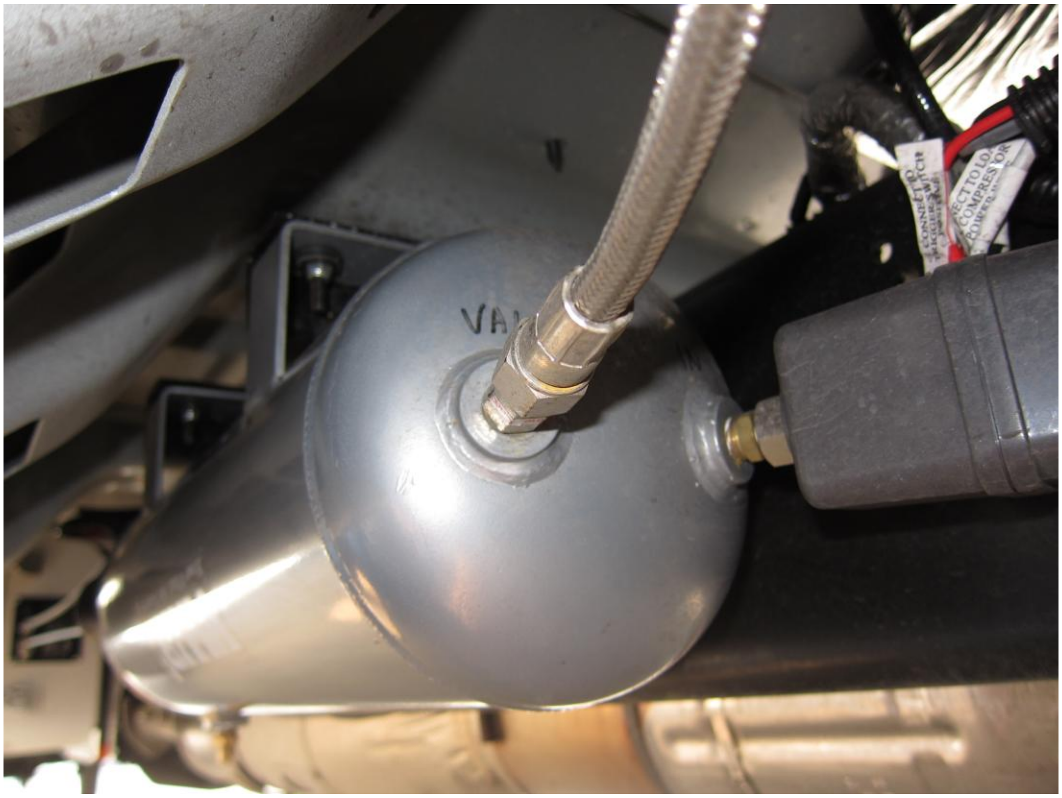
Plate is mounted on two existing holes in the frame.

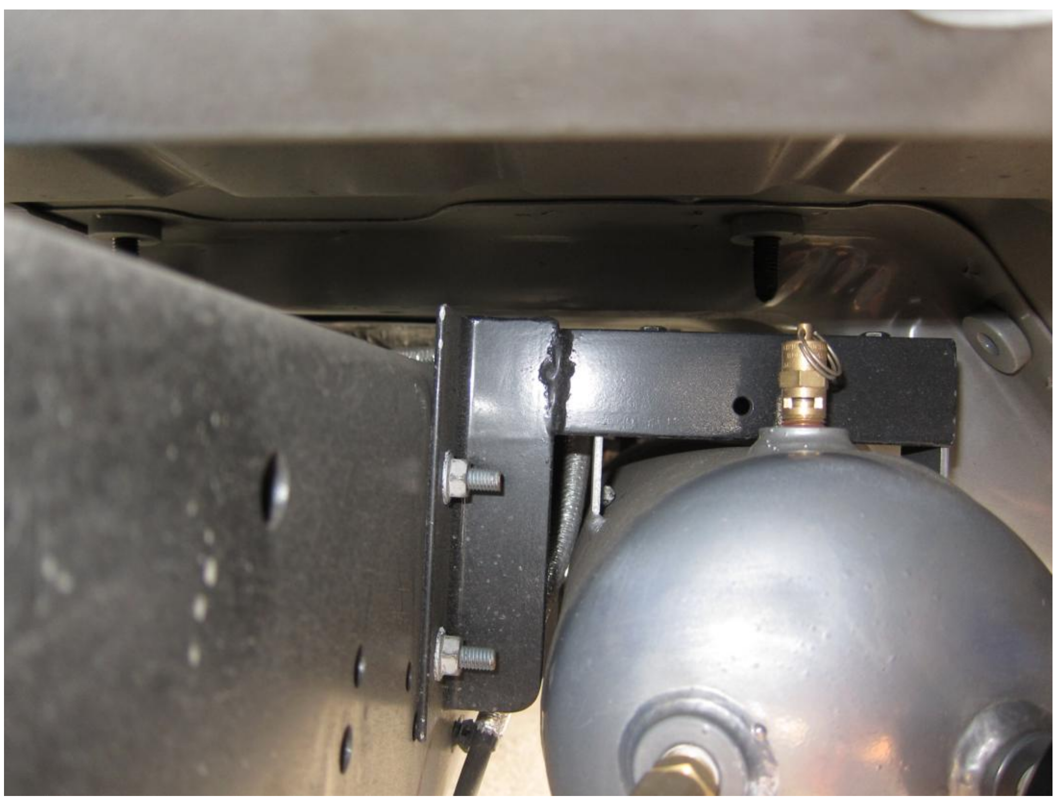

Here's the plate mounted.

Mount the remoteSAMPLER on the plate and attach the Eurofast cable for the EIB (to display head), the Eurofast cable for power (to battery), and the line to the pressurized air source. Note the orange silicone isolators (McMaster Carr P/N 4403K39 (USA), P/N 4403K84 (Metric)).

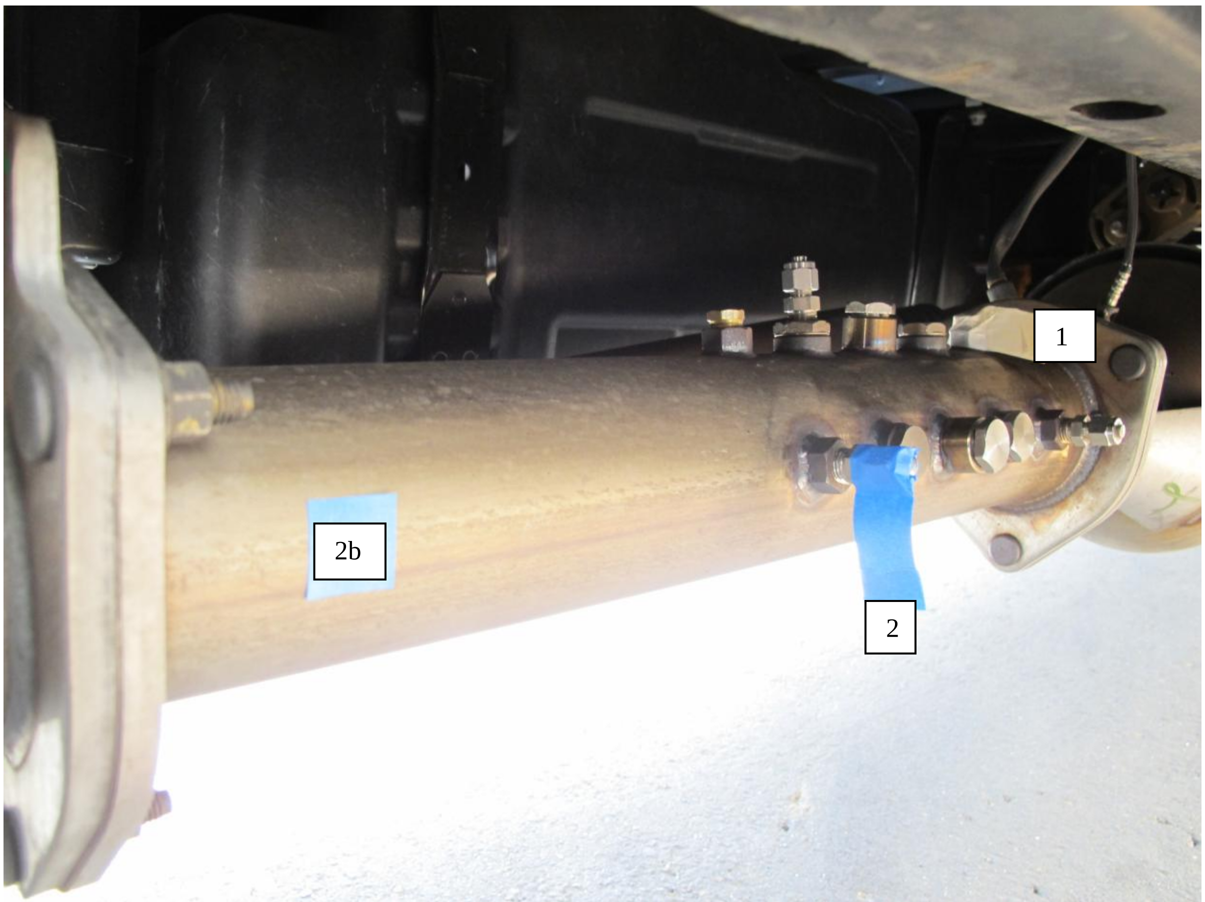
The 2 gallon air tank (Viair P/N 91022) was mounted on the frame just forward of the remoteSAMPLER using custom-made brackets. Again, existing holes on the frame were used. Ahead of the tank you can see the compressor (Viair 450C-IG). The compressor is attached to an aluminum plate which is attached to the cab body via rubber isolators (McMaster-Carr P/N 5822K9). The rubber isolators significantly reduce the transfer of pump noise to the cab; however, the pump can still be heard at idle. If we were to do it again, we would mount the pump as far away from the cab as possible and to the frame via rubber isolators. The tank location is fine, however.

Here are some pictures of the front of the tank showing the pressure relay switch (Viair P/N 90111), the feed from the pump, the blow-off valve, and the tank mounts.





The truck has a short section of exhaust pipe after the SCR that can be removed so that the ¼" NPT female fittings can be welded on. This picture shows many bosses welded to the pipe but only two will be used. A piece of tape labeled "1" is on the fitting that the external mounting block will be mounted on. This is where the sample is sucked out of the exhaust. A piece of tape labeled "2" is on the fitting that the sample will be returned to after going through the remoteSAMPLER. The sample that is returned to the exhaust has air from the compressor added. To avoid this air from being recycled back to the inlet, it is recommended that the sample return be at least 0.3m downstream of where the sample is sucked out of the exhaust. In the photograph, the bosses are a little closer than 0.3m however no problems were detected in this application. If we were to do it again, we would put the sample return at the most downstream point "2b" on the pipe.

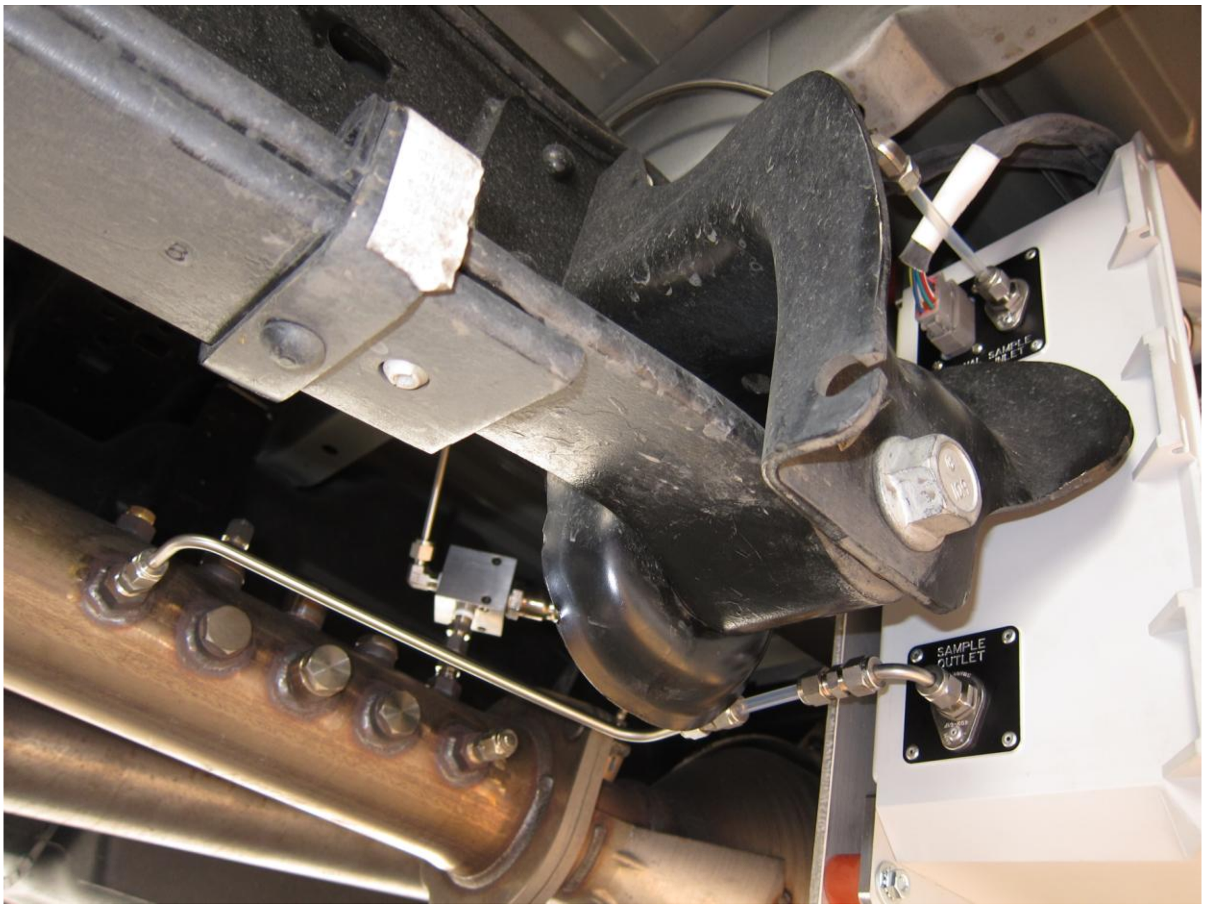


Here is the external mounting block mounted on the forward boss that was welded to the exhaust. Sensor A is installed in the block. Note that the sample line coming from the block uses a 90 degree hard right Swagelok fitting (not supplied) instead of the straight-on tube fitting supplied with the analyzer. For this application, the 90 degree hard right made it a little easier to plumb from the block to the remoteSAMPLER. Once the block is screwed into the exhaust, the Swagelok nut can be loosened to reorientate the block in a manner that makes the plumbing most direct. Use stainless steel tubing coming off the external mounting block.

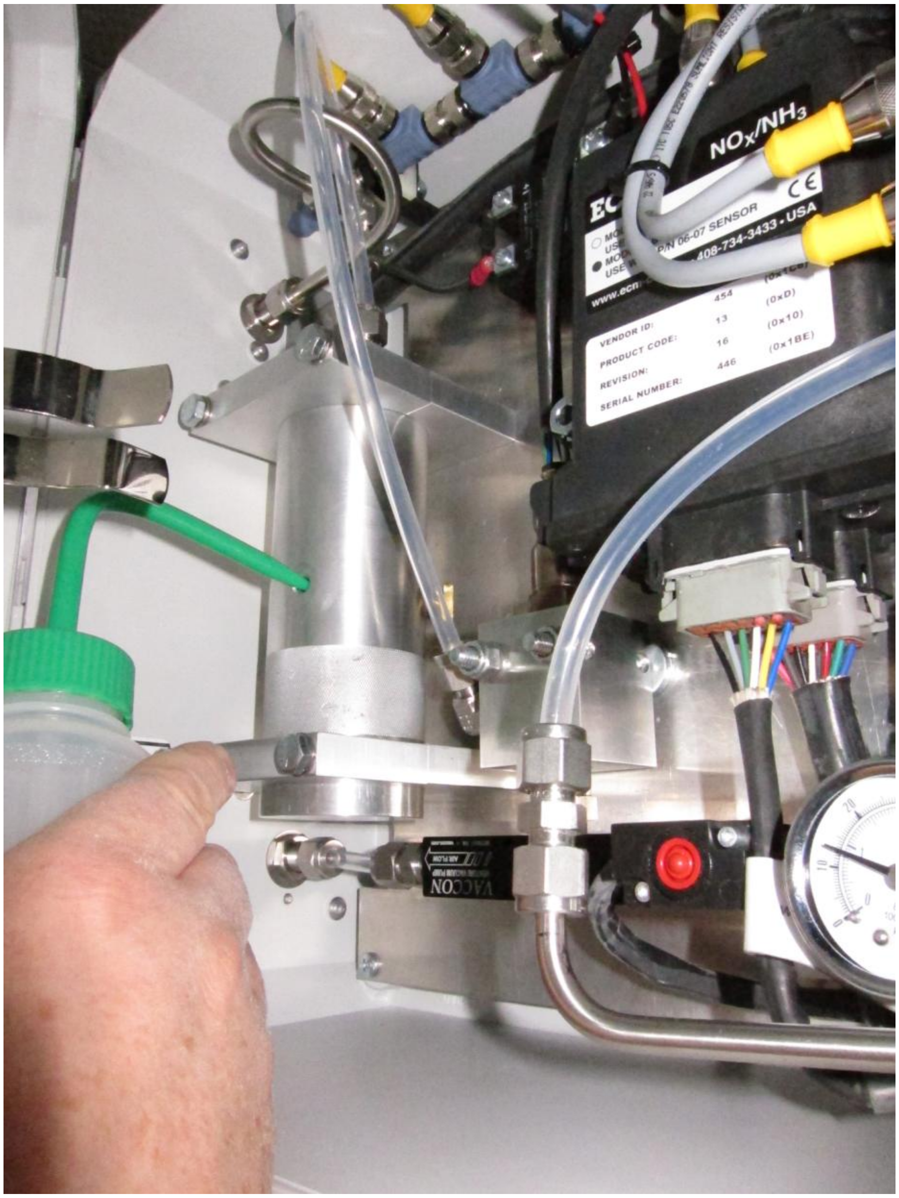
To SPAN the O2, and ZERO the NOx and NH3, remove the external sampling block from the exhaust and hang it in air. To SPAN the NOx and NH3, attach a PFA (Perfluoroalkoxy) hose to the entrance of the block from SPAN gas tanks.

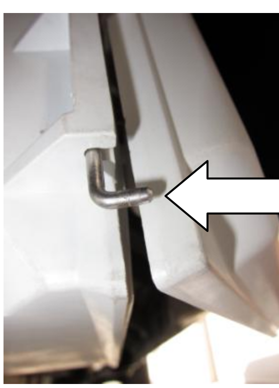
The line from the external mounting block goes to the “Sample Inlet” port on the remoteSAMPLER. Use a length of PFA tubing near the remoteSAMPLER to give the sample line some “give”. Measure the length of the sample line (L). This value will be used to calculate a Td value that must be entered into the analyzer.

Connect sensor A to the remoteSAMPLER using the supplied cable and build the remoteSAMPLER-to-exhaust line.



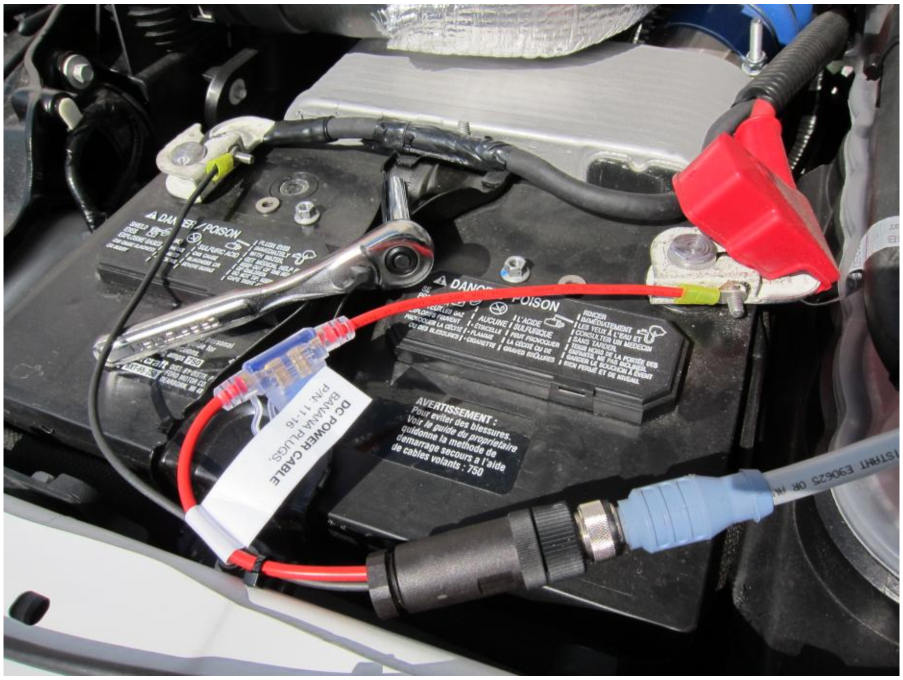
With the system off (i.e. pump off), fill the scrubber with a cupric sulfate/water solution (3 gm cupric sulfate/150 cc water) until it starts leaking out of the screw hole. Reinstall the screw (with gasket) and tighten. Turn the system on and check that the pressure is 15 psig. Adjust the pressure using the regulator in the remoteSAMPLER if necessary.

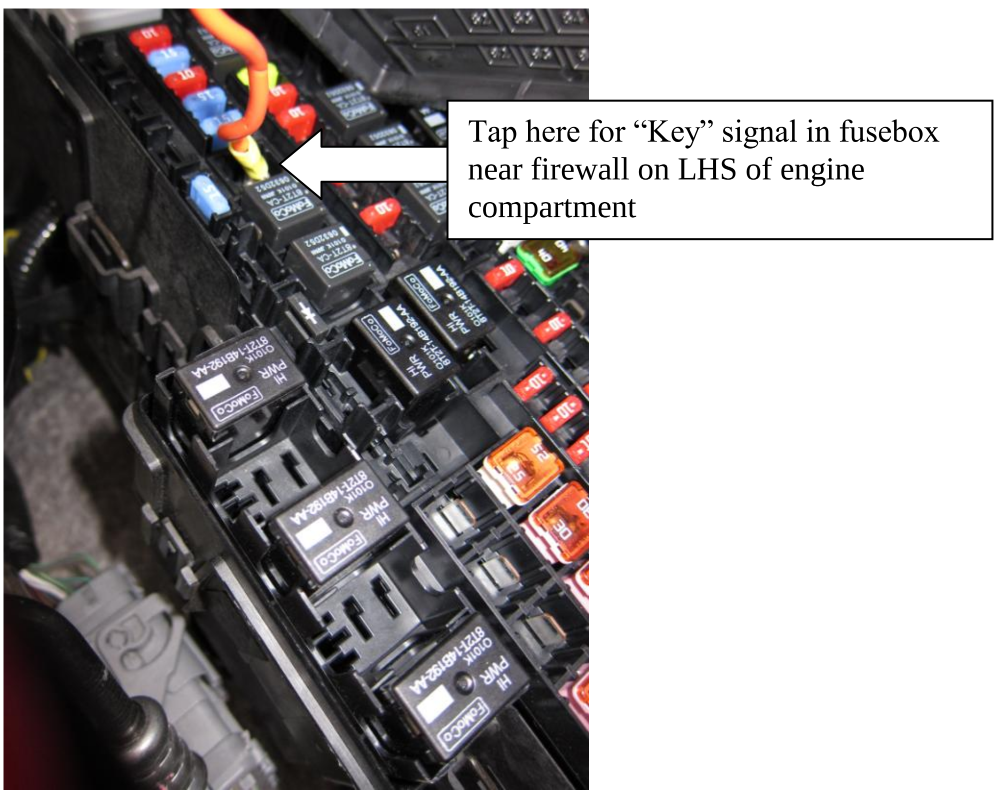


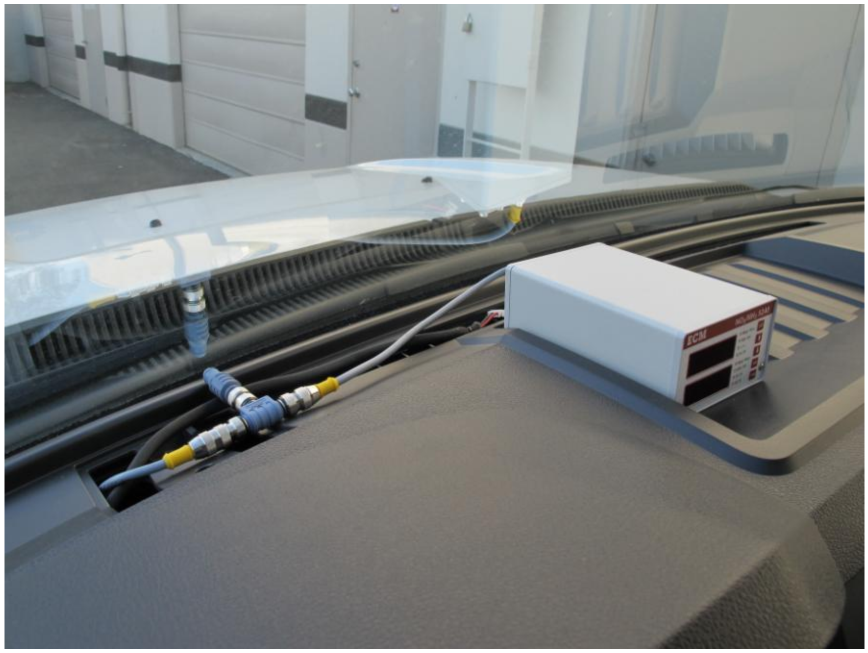
remoteSAMPLER door can be removed by rotating bent portion of hinge out of pocket and sliding hinge out

Tap power from battery on LHS of engine compartment.  Use battery on RHS of engine compartment to power air pump.



The display head fits nicely in the dash tray. There is a removable panel on the dash through which the EIB cable and the “Key” wire can be routed. Turn the display on and enter the value for Td (msec) that is calculated via Td = 274 x (L + 2.715) where “L” is the measured length (in meters) of the external mounting block-to-remoteSAMPLER sample line. See Table 1.




Check sample flowrate by removing external mounting block from exhaust and attaching to top of flowmeter (Dwyer VFB-66-SS shown here). Adjust pressure regulator in remoteSAMPLER until flowrate is 5 lpm. Pressure will be approximately 15 psig.

# Warranty and Disclaimers

**WARRANTY**

The products described in this manual, with the exception of the NOx/NH3 sensors 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 NOx/NH3 sensors and pressure sensors are considered expendable parts 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 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.

ECM ENGINE CONTROL AND MONITORING

586 Weddell Drive, Suite 2
Sunnyvale, CA 94089-2134
USA
Phone: (408) 734-3433
FAX: (408) 734-3432
Email: sales@ecm-co.com
Web: www.ecm-co.com

# 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+**
**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
February 21, 2013

ECM ENGINE CONTROL AND MONITORING
Los Altos, CA  94023-0040 • USA • (408) 734-3433 • Fax: (408) 734-3432 • www.ecm-co.com