

**ECM** ENGINE CONTROL  
AND MONITORING

# pmCAN Module

## Engine Particulate Matter (PM) Measurement



# Instruction Manual

### Important Note

Due to the nature of CAN instrumentation, you cannot just physically connect a measurement module to a bus and expect data from that module to be available. The pmCAN measurement module has to be set up to send the data required and the receiving device (ex. data acquisition software) has to know what is being sent. The setting up of modules and the production of a .dbc file used by the receiving device to interpret the data sent is performed using the supplied Configuration Tool (software) which runs on a PC.

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## Quickstart Manual

The PM sensor has three conditions of operation: seeding, normal operation, and fouled. Seeding is necessary before normal operation begins and this will typically take a clean and dry sensor 4 minutes at 1.5 mg/m<sup>3</sup>. When the PM level is doubled, the seeding time is halved. When the PM level is halved, the seeding time is doubled. There will be a slight to moderate reseeding time required each time the sensor (or engine) is stopped and restarted. Fouled sensors can be identified by pinned or “-1” PM and PN outputs and a VHV of less than 900V. This requires that the sensor be blown out with air or cleaned (see Appendix G).

Mount the sensor vertical so that water can drain out of it and just finger-tighten it. The material it is made out of is a little sticky so the sensor won't unwind on its own. Make sure the mounting boss's threads are clean and straight before screwing the sensor in. Sometimes you'll need a wrench to take it out, so go easy. Wait until the sensor cools because it swells a little with heat. The sensor is made out of plastic so be gentle with it.

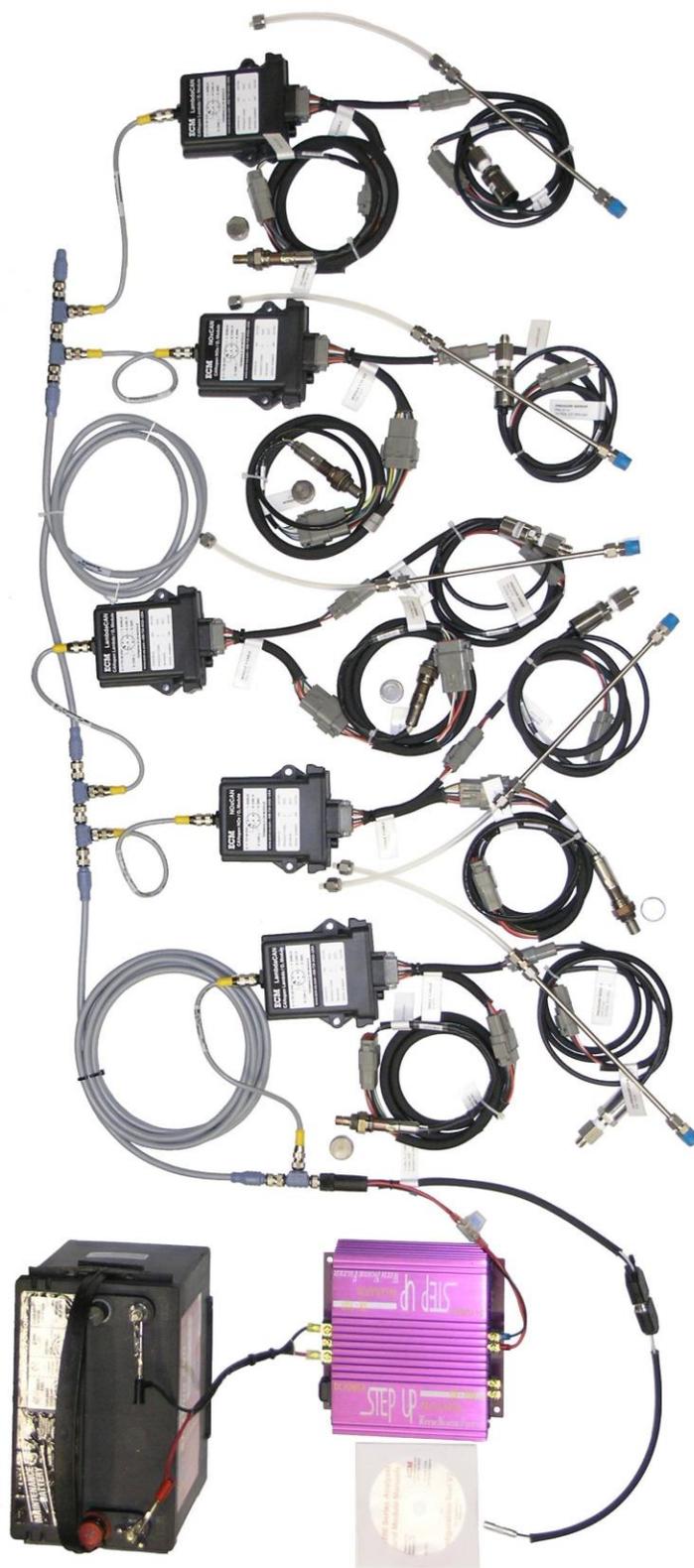
For best results, each time before you install the sensor, first blow it out with compressed air for about 10 seconds.





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Complex measurement systems can be easily built with pmCAN, LambdaCAN\*, NOxCAN\*, NH3CAN, and baroCAN modules. Here is a five-channel lambda, O<sub>2</sub>, and NO<sub>x</sub> pressure-compensated, in-vehicle system.

# Introduction

The pmCAN module kit is a compact PM (particulate matter) measurement device for use on internal-combustion engines. The PM sensor looks like a spark plug, is screwed into the engine's exhaust pipe, and operates on a charge-transfer mechanism explained in the section "How the PM Sensor Works". The specifications for the kit are as follows:

**Ranges:** PM (Mass): 0.05 to 100 (Units: mg/m<sup>3</sup>)  
PN (Number): 0.24 to 480 (Units: millions/cc (M/cc), ex. 0.24 M/cc is 240,000 #/cc)

**Accuracy:** ±10%. Increased accuracy via user-entered delta tables.

**PM Sensor Mounting:** 18mm x 1.5mm thread, 22mm hex,  
Sensor must be mounted pointing down and finger tight.

**Maximum Exhaust Temperature for Sensor:** 500 °C, 932 °F

**Temperature Range for Electronic Module:** -55 to 100 °C

**Temperature Range for Cables:** -55 to 220 °C

**Minimum Bending Radii for Sensor Cable and Extension Cables:** 100 mm

**Module:** 114 mm x 120 mm x 35 mm, 540 gm, Sealing Class IP27

**Communication:** CANopen, Programmable Baud Rate, Programmable Node ID

**Power:** 6 to 32 VDC, 0.14 A @ 12 V

**pmCAN Kit Contents:** See Appendix A

pmCAN kits are normally supplied with a PM sensor P/N 06-10T which has been designed for tailpipe applications. A PM sensor P/N 06-10E can be optionally supplied which has been designed for diesel engine-out applications. P/N 06-10E is less likely to foul but has a longer seeding time which may not matter for diesel engine-out applications where the PM levels are higher.

Setup of the pmCAN kit is performed using the supplied PC software program called the "Configuration Tool". The Configuration Tool requires a CAN communication device to communicate with one or more ECM CAN modules (ex. pmCAN, LambdaCAN\*, NOxCAN\*, NH<sub>3</sub>CAN, baroCAN, appsCAN) or analyzers (ex. NOx 5210, Lambda 5220, EGR 5230, NH<sub>3</sub> 5250, miniSOOT 5260). While the tool is being used with modules, just ECM modules set to stand-alone mode (see Appendix B) should be connected to the CAN bus. While the tool is being used with analyzers, just analyzers should be connected to the CAN bus. With analyzers, the Configuration Tool is just used to produce .dbc files. However with modules, the Configuration Tool replaces the analyzer's display head as the user interface so it must do much more. This document focuses on using the Configuration Tool with ECM's pmCAN module.

The Configuration Tool supports four CAN communication devices: Kvaser, ETAS, Peak USB-to-CAN adapters, and the VectorCAN CAN adapter card. The latest driver software for one of these adapters must be installed prior to using the Configuration Tool. This software

will be supplied with the adapter or be available on-line. ECM's Configuration Tool is delivered on a CD or memory stick and is available for download from [www.ecm-co.com](http://www.ecm-co.com)

Once the adapter's driver and the Configuration Tool software are installed, and with the module(s) powered and connected to the CAN adapter, start the Configuration Tool software. Click on the "Modules" tab, select the CAN adapter, select the baud rate (all modules shipped from ECM are set at 500kbaud except if they are to be used in a miniPEMS where they are set at 250kbaud), and click on the "START" button.

The software will identify the modules on the bus and display them in the "Module" field. If this does not happen, make sure that the CAN bus is properly terminated (i.e. termination resistors), that all modules on the bus are set to the same baudrate, and that baudrate is selected in the Configuration Tool. Open the Module field to see all the modules on the bus. If a module is not listed, one reason could be that its Node ID is the same as another module. To resolve this, remove all modules except the "missing" one from the CAN bus, STOP then START the software, and change that module's Node ID. Another reason that a module is not listed could be that the module is in EIB mode instead of stand-alone mode. All modules must be in stand-alone mode.

To configure one of the modules (ex. change its Node ID) or to look at that module's data, you have to select that module in the "Module" field.

There are three things you can do with modules using the Configuration Tool:

1. Configure a module.
2. Look at data coming from that module in real-time and optionally log it.
3. Produce a .dbc file to be used by a device receiving module data.

Alternatively, 1. and 2. (above) can be performed by direct CAN communication with the pmCAN module using user-written software. For information on how to do this and detailed information about the modules, refer to the pmCAN Programmer's Manual.

## How the PM Sensor Works

Figure 1 shows the structure of the PM (particulate matter) sensor. There are three concentric metallic bodies: the outer shell, the high voltage (1000V) electrode, and the ground electrode. When mounted perpendicular to the flow in an exhaust pipe, exhaust (with PM) enters the sensor through an annulus in its bottom, passes up between the outer shell and the ground electrode, then through holes and down between the high voltage electrode and the ground electrode, and then out of the sensor through holes in the bottom of the sensor.

The simple explanation of how the sensor works is that PM flowing between the electrodes strikes either the high voltage electrode or the ground electrode, is charged, and then is drawn to the opposite polarity electrode where it gives up its charge, creating a current that is measured by external electronics. This current is proportional to the density of the PM flowing between the electrodes which is proportional to the density of PM in the exhaust. More current means more PM (ie. mg/m<sup>3</sup>, #/cc).

The above is true with the necessary addition that the sensor has to have its electrodes “seeded” with soot for the sensor to work. When a new (i.e. clean) sensor is put in the exhaust, soot flowing through the sensor will attach to the electrodes and then to each-other growing structures that look like little trees (i.e. dendrites). The dendrites on the two electrodes will grow towards each other until the gap between the tops of the dendrites reaches a threshold distance. This is called “seeding the sensor”. At this threshold distance, any additional PM that strikes the dendrites on either electrode will break off pieces of the dendrites which will be attracted and carry charge to the opposite electrode. The carrying of charge across the electrodes via broken dendrites is measured by the pmCAN’s electronics. The greater the concentration of PM flowing between the electrodes, the greater the collisions with the dendrites, the greater the charge that will be carried across the electrodes, and the greater the current that will be measured. This current is then correlated to the PM concentration (i.e. mg/m<sup>3</sup> and #/cc) in the exhaust and this calibration is stored in a memory chip in the sensor’s connector.

Like trees in the wind, the dendrites in the sensor bend with flow. This causes interesting flow-driven dynamics that have to be taken into consideration when interpreting the pmCAN’s reported PM:

1. When transitioning from a low flowrate to a high flowrate, the dendrites on the 1000V electrode and ground electrode will bend over more. This will increase the gap between the tops of the dendrites causing a momentary drop in PM signal until the dendrites grow back up to the threshold distance again. The period of the momentary drop is a function of the density of the PM in the exhaust. The lower the PM level, the longer the drop.
2. Similarly, when transitioning from a high flowrate to a low flowrate, the dendrites on the electrodes will bend over less. This will decrease the gap between the tops of the dendrites and cause a momentary increase in PM signal as the dendrites are quickly “trimmed” to the threshold distance.

3. When the engine (and hence exhaust flow) stops, the dendrites on the electrodes will point directly at each other. This will substantially reduce the effective gap between the electrodes and the high voltage across the electrodes will cause a slow “tree-trimming” effect.

A sensor will be deseeded if it is blown out with compressed air, if it is left “on” in stationary exhaust or air, or if it is struck by liquid water. How long it takes for the sensor to be reseeded is a function of the density of PM in the exhaust and the exhaust flowrate. The higher the density of PM and the greater the exhaust flowrate, the less the time for reseeded.

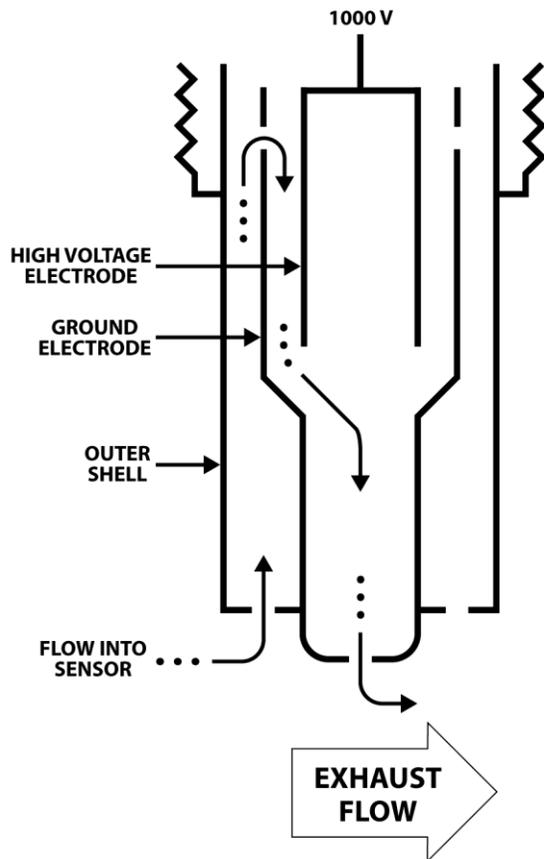


Figure 1: PM Sensor

Figure 2 contains a more descriptive diagram of the sensor and the external measurement electronics. Note from the figure the following:

1. The dendrites that look like black fur in the sensor. Broken off pieces of dendrites will carry charge across the electrodes (resulting in “IST” current). These pieces may remain on the other electrode, or trigger another dendrite break and charge transfer, or may exit the sensor. PM entering the sensor will contribute to the regrowth of broken and lost dendrites.
2. There are three currents measured and reported: IST, ILK, and ITP. IST is the current that is used to determine the density of PM in the exhaust. ILK is a leakage current from the shield surrounding the lead to the high voltage electrode. ILK has a steady-state value but will sometimes increase when the sensor is getting fouled (by PM or liquid). ITP is the current used to create the 1000V measured on the input side of the transformer. ITP also has a steady-state value and will increase when the sensor is getting fouled.
3. There are two separate grounds: the one shown as a triangle and the one that is hatched. The triangular one is used for the IST and ILK circuitry. The hatched ground is the ground of the power supply used to power pmCAN. Actually, there is a third separate ground, the ground for the CAN output.
4. An electrical connection between the exhaust pipe the sensor is mounted in and the ground of the power supply powering pmCAN is highly recommended because it often lowers the background noise on the IST (and hence PM) measurement. This connection is often the case with most vehicular applications, however, if the PM sensor is mounted in a piece of exhaust pipe attached with a piece of silicon hose to the end of the vehicle’s tailpipe, you will have to run some braided line from the piece of exhaust pipe to the vehicle’s exhaust. In some dynamometer applications, pmCAN will be powered by an external power supply. In these cases, you will have to run a piece of braided line from the exhaust pipe the PM sensor is mounted in to the negative terminal of the power supply powering pmCAN. When running on a set of chassis rolls, always ground the vehicle and dynamometer to earth ground. (i.e. bleed off static electricity).
5. In some cases, connecting the negative terminal of pmCAN’s power supply to pmCAN’s metal enclosure via a braided line will lower background noise on the IST measurement. Since pmCAN’s enclosure is anodized (and hence virtually non-conductive), you will have to connect to a screw inserted into one of the two non-anodized screw holes on the back of pmCAN in order to connect to pmCAN’s metal enclosure.
6. PM can be positively, negatively, or neutrally charged. This is represented in Figure 2 by the circles with “+”, “-“, or “N” in them inside the exhaust pipe and sensor.
7. There is some parasitic coupling through the circuitry creating the 1000V. This will cause some coupling between the triangular and hatched grounds.

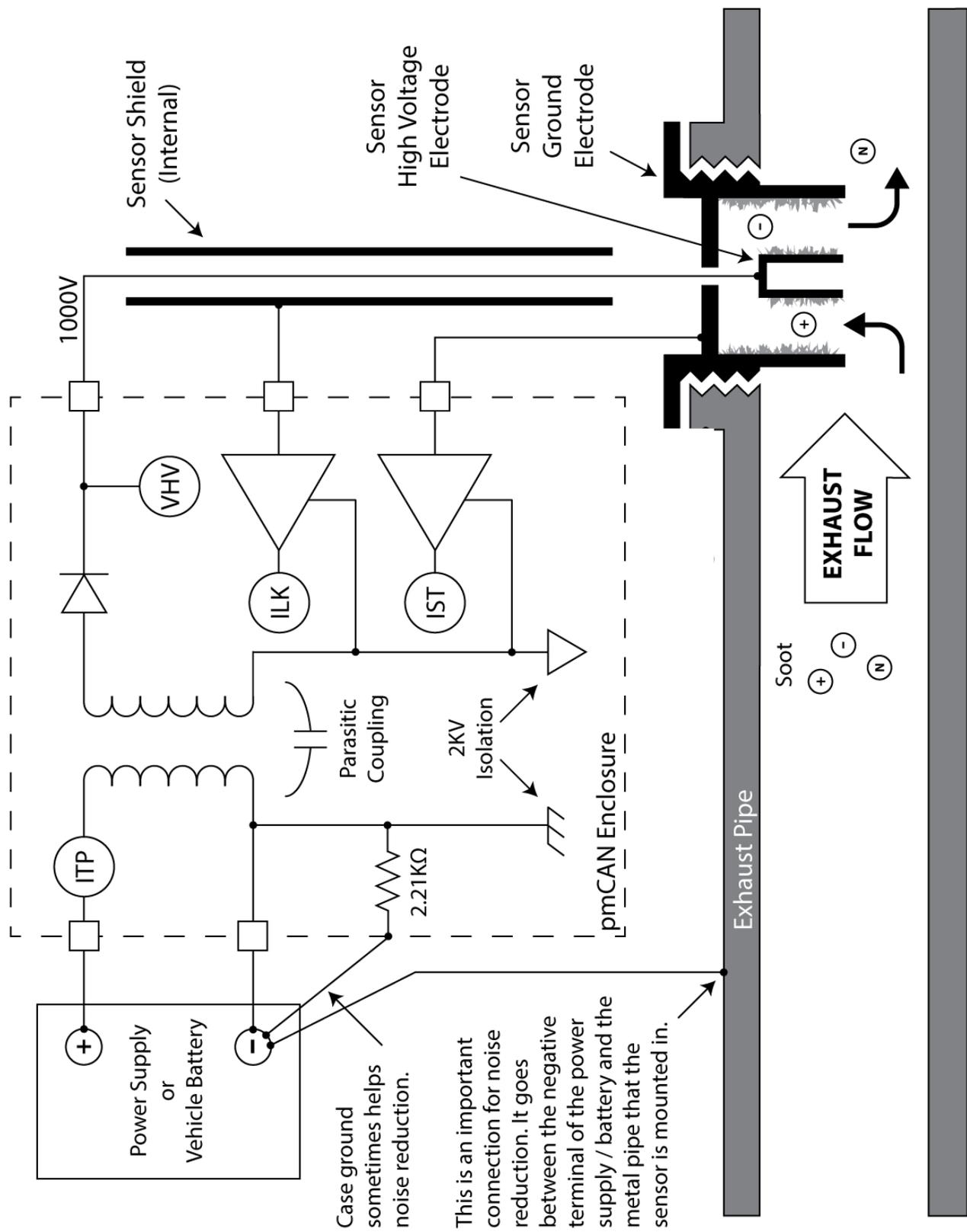


Figure 2: PM Sensor and Electronics

## Application Notes

**Safety Note:** To avoid getting shocked by the 1000V applied to the sensor or possibly damaging the pmCAN's electronics, always turn the 1000V off before removing or attaching the sensor from the cable (or the cable from the module). This is done using the Task: "Toggle High Voltage". When the indicator light on the front of the pmCAN is solid red, the 1000V is off. When the indicator light is solid green, the 1000V is on.

### **For the successful use of pmCAN, three issues must be understood: Seeding, Fouling, and Sources of Error.**

**Seeding the Sensor:** As described in "How the PM Sensor Works", for the sensor to work, it has to be seeded with PM. If the sensor is not seeded, it will report no PM. If the sensor is insufficiently seeded, it will report a lower than actual PM concentration. The art to using pmCAN is in keeping the sensor seeded. Here are some rules of thumb:

1. For the P/N 06-10T sensor, when the engine is at a PM level of 1.5 mg/m<sup>3</sup> (7.2 M/cc), seeding takes about 4 minutes. Half the PM level doubles the time. Double the PM level halves the time.
2. A sensor will slightly deseed itself when the engine stops running or pmCAN is powered down.
3. If the sensor is sprayed with liquid water (common during the first 15 minutes following engine start-up), fuel, oil, or DEF (diesel exhaust fluid), it will sometimes deseed and/or foul the sensor.
4. If the sensor is blown out with compressed air or is cleaned, it will be deseeded.

**Fouling the Sensor:** Fouling is the direct shorting (via carbon or a liquid) between two or more of: the high voltage electrode, the ground electrode, or the shield (see Figure 2). Most of the time, fouling occurs between the high voltage electrode and the ground electrode. Fouling often occurs as follows:

1. First there will be spikes in the PM and PN readings (ie. intermittent fouling/shorting).
2. Then a steady short between the electrodes will occur resulting in PM and PN values "pinned" at the upper range of the pmCAN.
3. The VHV will drop below 900V.
4. pmCAN will report an error and output PM and PN values of -1.

Liquid water fouling can occur during the first 15 minutes or so of engine operation (until the exhaust temperature reaches approximately 80 °C) and will often occur after a large acceleration (when liquid water is sloshed onto the sensor). Soot fouling can occur at high PM levels.

Fouling can be minimized by mounting the sensor vertical (i.e. wires going up, holes in the sensor pointing down).

Sometimes, the fouling will clean itself. It doesn't clear in 15 minutes, the sensor will have to be taken out of the exhaust and blown out with compressed air for about 10 seconds. In extreme cases, the sensor will need to be disassembled and cleaned. Appendix G describes how to clean the sensor which should take less than 5 minutes.

#### **Sources of Error:**

1. Effect of flow: Unfortunately, the sensor has a sensitivity to flow velocity. At a fixed particulate concentration, the reported PM (and PN) will scale with flow velocity. For that reason, the PM sensors have been calibrated at a mid-exhaust flow velocity.
2. Effect of flow changes: When quickly transitioning from a high (or low) exhaust flowrate to a low (or high) flowrate condition, an overshoot (or undershoot) in the reported PM may be experienced.
3. Effect of deseeding: At a long period of operation at zero or low PM levels, the sensor will sometimes deseed itself.
4. Effect of wiggling sensor cable: Tie the sensor cable down. Don't let it wiggle. If it does, noise will appear in the PM and PN signals due to the triboelectric effect.

**Usage:** pmCAN can be used in engine-out and tailpipe-out installations with diesel and spark-ignition engines. However in tailpipe-out installations, due to liquid water being in the exhaust, getting data during start-up can be problematic. Keep in mind that not every start-up will be affected by liquid water since during some start-ups, water droplets will not hit the sensor.

**Installation:** The PM sensor should be mounted perpendicular to the flow of exhaust gases using the supplied 18mm (thread diameter) x 1.5mm (thread pitch) x 6mm (tall) boss. Finger-tighten the sensor. Do not use a wrench on the sensor or you may overtighten it and crack the sensor body. Maximum tightening torque of 1.5 lbf-ft (2 N-m). Exhaust flow has to pass by the sensor for it to work. Therefore, do not mount the sensor in a non-straight piece of pipe where the flow past the sensor may be ambiguous. **It is preferential to mount the sensor vertical with the holes in the bottom pointing straight down.** This will help clear the sensor of water especially with tailpipe-out installations. To avoid the effects of triboelectric changing (ex. noise in the PM signal), tie down the cabling to the sensor so that it does not "wave in the wind".

**Exhaust Stratification:** PM is not necessarily evenly distributed over the cross-section of the exhaust. In bends in the exhaust, PM will go straight rather than turn the corner. Therefore the distribution of PM will be dependent of what is upstream of where the sensor is located.

**Power:** The pmCAN kit requires 6 to 32 VDC and consumes 140 mA at 12 VDC. Grounding is critical. **The negative terminal of the power supply should be electrically connected to the metal that the sensor is mounted in otherwise the system will be susceptible to seemingly random electrical noise.** With tailpipe-out installations, the PM sensor may be mounted in an extension that is connected to the exhaust system using a small length of silicon hose. In this case, a braided wire should be run from the extension to the ground of the vehicle (which for most vehicles is connected to the negative terminal of the

battery). Grounding the case of the pmCAN module to the vehicle can sometimes help as well. A good noise test is to mount the sensor in an exhaust with no flow (i.e. engine off) and to collect 0.5 minutes of parameter “IST” (sensor current) data at a sample rate of 10 ms and an averaging alpha of 1 (i.e. no averaging). This can be easily performed using the supplied Configuration Tool software and plotted using Excel. IST should have less than  $\pm 0.5$  nA of noise.

**Cleaning:** Occasionally the sensor will get fouled with PM. When this occurs, the electrodes will be shorted and the VHV parameter  $1000V \pm 100V$  potential will be unable to be maintained. When this occurs, take the sensor out and blow it out with air for about 10 seconds. Sometimes blowing the sensor out won't clear it so it has to be disassembled and cleaned. This takes only a few minutes. See Appendix G. Keep in mind that after blowing out or cleaning the sensor, it will be need to be operated in an engine for a period until it reseeds.

**Indicator Light:** On the front of the pmCAN is an indicator light which tells the status of pmCAN. When the light is solid red (ie. not flashing), the high voltage electrode is turned off and the sensor can be removed. When the light is solid green, the high voltage electrode is at 1000 V. The meanings of the light when it is flashing is explained in Table 3. PM, PN, PMR, and PNR are set to -1 if there is an error.

**Calibration:** All PM Sensors supplied by ECM are factory-calibrated. This calibration is stored in a memory chip in the sensor's connector and is read by the module. Fortunately, the sensor's calibration is robust and will not change with age or disassembly/cleaning. Sensors can be sent back to ECM for a calibration check and repair if they are damaged.

**The user may recalibrate or modify the output of the pmCAN in two ways: ZEROing and SPANing, and using Delta Tables.**

**ZEROing and SPANing:** PM (units: mg/m<sup>3</sup>) and PN (units: M/cc) can be individually ZERO'd and SPAN'd. The results of the ZEROs and SPANs are stored in the memory chip in the sensor's connector along with the factory calibration. A ZERO and SPAN can be cancelled, returning to the sensor to the factory calibration. Always perform a ZERO before a SPAN.

**Delta Tables:** The purpose of the Delta Tables is to allow the user to modify the factory calibration of the pmCAN to match another PM analyzer. With Delta Tables, the user recurves the calibration of the sensor by different amounts at different PM levels. Interpolation is performed between the points in the tables. Unlike the ZEROs and SPANs, the Delta Tables are stored in the pmCAN module and are applied to any sensor attached to that module. The Delta Tables are entered and programmed into the pmCAN module using the Configuration Software.

The procedure for the calculation of particulate matter is as follows:

1. IST current is measured and using factory calibration data stored in the memory chip in the sensor's connector, the factory particulate density parameters PMR (mg/m<sup>3</sup>) and PNR (M/cc) are calculated.
2. The parameters PMR and PNR are then modified by the Delta Tables located in the module to give PM and PN:

$$PM = PMR + \text{Delta Table for PM} \quad [1]$$

$$PN = PNR + \text{Delta Table for PN} \quad [2]$$

The Delta Tables are delivered from the factory full of 0s (zeros) so initially, PM = PMR and PN = PNR.

3. PM and PN are then modified by the ZERO and SPAN processes:

$$PM(\text{new}) = M_m \times PM(\text{old}) \times B_m \quad [3]$$

$$PN(\text{new}) = M_n \times PN(\text{old}) + B_n \quad [4]$$

When delivered from the factory, M<sub>m</sub> and M<sub>n</sub> are set to 1 and B<sub>m</sub> and B<sub>n</sub> are set to 0. Thus, PM = PMR + Delta Table for PM and PN = PNR + Delta Table for PN. When the user performs a ZERO or SPAN, the new M and/or B is stored in the sensor's memory chip and used in Equations [3] or [4]. The Configuration Software is used to perform the ZERO and SPAN procedures and also supports the cancelling of the user calibration and returning M<sub>m</sub> to 1 and B<sub>m</sub> to 0 (or M<sub>n</sub> to 1 and B<sub>n</sub> to 0).

Calibration is the matching of an instrument to a defined standard. Due to the complexity of PM, there is no absolute standard and as such, what is called PM often depends on the scientific principle and application of the instrument being used. This is not to say that various PM instruments available do not trend and approximate each-other, it is just that they will not all match each-other to the degree, for example, that various NO<sub>x</sub> instruments will match.

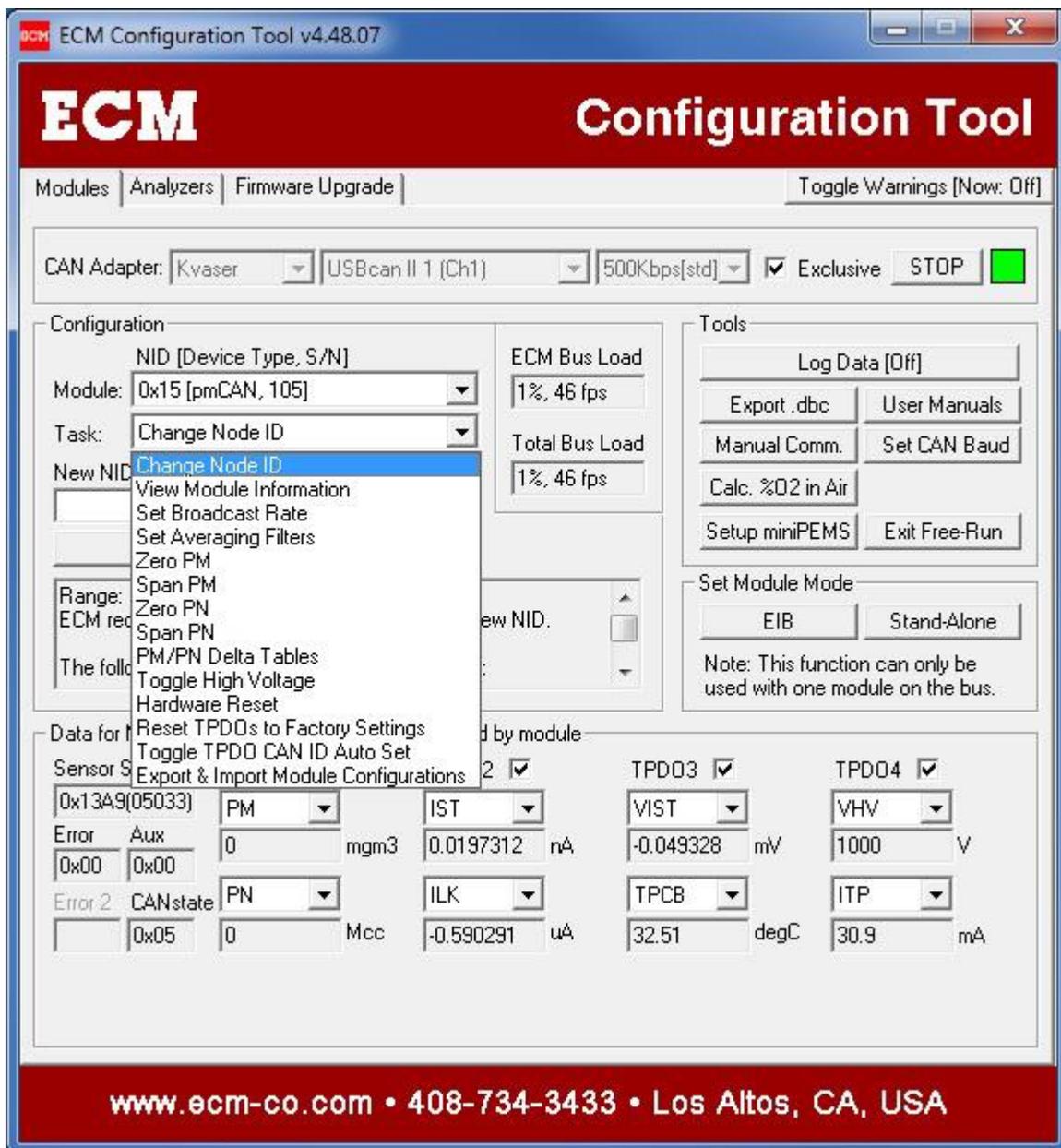
ECM's factory calibration is performed so that users of common laboratory-grade PM instruments will get results that generally match what they see on their instruments. For closer matching, the user can deploy the ZEROs and SPANs and Delta Tables features. Although both ZEROs/SPANs and Delta Tables can be used at the same time, it is expected that either one or the other will be used. Consistent with other instrumentation that ECM manufactures, ZEROs and SPANs travel with ECM's factory calibration in the sensor's memory chip while Delta Tables are in the modules. The reason for this is that once a user determines the Delta Table for one sensor, it is likely that all ECM sensors with a factory calibration will give similar results when connected to the same module. In addition, these Delta Tables can be downloaded into other pmCAN modules. When determining Delta Tables, it is important that the user looks at the PMR (or PNR) parameters or the PM (or PN) parameters with the ZEROs and SPANs cancelled. Otherwise, the Delta Table(s) may be specific to just that sensor (i.e. the Delta Table(s) should be a modification of the ECM factory calibration, not a ZERO'd or SPAN'd version).

**Appendix F:** Appendix F is located in the back of this manual and contains examples of pmCAN in use.

## Configuring a Module

Normally, you will be configuring a module to be used in stand-alone mode. Stand-alone mode is used when the modules are connected to a CAN bus that goes directly to a data acquisition or control system. In stand-alone mode, a module's configuration is performed by selecting one of the tasks in the "Task" field. When a module is connected to a NOx 5210, Lambda 5220, EGR 5230, NH<sub>3</sub> 5250, or miniSOOT 5260 Analyzer, it must be in EIB mode. In EIB mode, most of these tasks are performed using the analyzer. Appendix B describes how to configure a module to operate in one mode or the other.

The following assumes that the module is to be used in stand-alone mode. The tasks available for pmCAN modules are listed in Table 1.



**Change Node ID:** Allowable range 0x01 to 0x7F (hex). When you assign a Node ID (NID), the following CAN IDs **cannot be used** by any other devices on the bus: 0x00, 0x80 + NID, 0x180 + NID, 0x280 + NID, 0x380 + NID, 0x480 + NID, 0x580 + NID, 0x600 + NID, 0x700 + NID, 0x7E4, 0x7E5.

**View Module Information:** Manufacturer's Name, Hardware Version, Software Version

**Set Broadcast Rate:** All activated TPDOs are transmitted every "n" milliseconds. "n" can be programmed. 5 ms is the minimum. Default: 100 ms.

**Set Averaging Filter:** Before the data is transmitted by the module (at the broadcast rate), it can be averaged. The averaging filter is called Alpha, can range from 0.001 to 1, and is used in the recursive averaging filter:

$$\text{AvgData}_t = \text{Alpha} \times \text{Data}_t + (1-\text{Alpha}) \times \text{AvgData}_{t-1}$$

where:  $\text{AvgData}_t$  is the transmitted data at time "t".

$\text{AvgData}_{t-1}$  is the previously transmitted data.

$\text{Data}_t$  is the raw data at time "t".

This formula is executed every 5 ms regardless of broadcast rate. Note that if Alpha = 1, there is no averaging and the data taken at time "t" becomes the average value at time "t" and hence the broadcast value. Default Alpha is 0.010.

**Zero PM:** User enters displayed PM value (TPDO data) and the actual PM value of the exhaust (0 or close to 0), and an offset will be applied to shift the calculation to the actual PM value at this condition. The Zero is stored in the memory chip of the sensor.

**Span PM:** User enters displayed PM value (TPDO data) and the actual PM value of the exhaust. Preferentially Span near the upper PM value to be measured. The Span is stored in the memory chip of the sensor.

**Zero PN:** User enters displayed PN value (TPDO data) the actual PN value of the exhaust (0 or close to 0), and an offset will be applied to shift the calculation to the actual PN value at this condition. The Zero is stored in the memory chip of the sensor.

**Span PN:** User enters displayed PN value (TPDO data) and the actual PN value of the exhaust. Preferentially Span near the upper PN value to be measured. The Span is stored in the memory chip of the sensor.

**PM/PN Delta Tables:** These tables are used to modify the displayed PM and PN numbers to something other than the factory PMR and PNR calibrations. There are two tables; one for PM and one for PN. The delta tables are used as follows:

$$\text{PM} = \text{PMR} + \text{Delta Table for PM}$$

$$\text{PN} = \text{PNR} + \text{Delta Table for PN}$$

As delivered from the factory, both delta tables are full of zeros so  $\text{PM} = \text{PMR}$  and  $\text{PN} = \text{PNR}$ . Delta tables are stored in the module (not in the sensor memory chip as the Zeros and Spans are). The Zeros and Spans subsequently act on PM and PN.

Table 1: Task List for pmCAN Modules (continued on next page)

**Toggle High Voltage:** Turns the 1000V electrode on and off. To avoid getting shocked by the 1000V applied to the sensor or possibly damaging the pmCAN's electronics, always turn the 1000V off before removing or attaching the sensor from the cable (or the cable from the module).

**Hardware Reset:** Equivalent to powering the module down then up again.

**Reset TPDOs to Factory Settings:** These are the parameters displayed and transmitted. TPDO stands for Transmit Process Data Object.

**Toggle TPDO CAN ID Auto Set:** Enable and disable TPDO CAN ID Auto Set.  
Default: Enabled.

**Export & Import Module Configurations:** This simplifies the task of programming several modules the same way.

Table 1 (continued): Task List for pmCAN Modules

## Selecting What Data is to be Sent (TPDOs) and Error Codes

Data sent from pmCAN modules is packaged as TPDOs (Transmit Process Data Object). Each TPDO contains two pieces of data and each module can send up to four TPDOs. All selected TPDOs will be sent at the broadcast rate. For example, if the broadcast rate is 5 ms and four TPDOs were selected to be sent, then eight pieces of data would be transmitted every 5 ms. To avoid slowing down the effective data rate on the CAN bus, select the number of TPDOs to be sent and the broadcast rate sparingly. For the case of multiple modules sending multiple TPDOs on the same CAN bus, the minimum (i.e. fastest) broadcast rate is given by:

**Minimum Broadcast rate (ms) = The total number of TPDOs for all modules x 0.3125**

For example, if there are eight modules, each sending two TPDOs, the minimum broadcast rate is 5 ms.

The data transmitted is selected in the “Data” area of the Configuration Tool. Activate the number of TPDOs to be used by clicking in its box to put in a check mark. Select the data contained in each TPDO using the pull-down windows. The list of available parameters for the pmCAN module is given in Table 2.

Parameters PM and PN should be used for PM mass and number densities (not PMR and PNR). This is because the Zeros, Spans, and Delta Tables act on PM and PN, not PMR and PNR.

Name	Parameter Description
C1R	16 bit A/D Calibration (Bits)
C2R	16 bit A/D Calibration (Bits)
ERCD	ECM CANOpen Error Code (unsigned integer)
ERFL	Module Error Flags (unsigned long format)
ILK	Sensor Leakage Current (0-40 $\mu$ A)
IST	Sensor Current (0-1000 nA)
ITP	Transformer Primary Current (0-225 mA)
ITPC	Calculated Transformer Primary Current (0-225 mA)
PM	Delta Table Modified Particulate Matter Mass Density (mg/m <sup>3</sup> ), PM = PMR + Delta Table for PM. Use this parameter for PM.
PMR	Factory-Calibration Particulate Matter Mass Density (mg/m <sup>3</sup> )
PN	Delta Table Modified Particulate Matter Number Density (M/cc), PN = PNR + Delta Table for PN. Use this parameter for PN.
PNR	Factory-Calibration Particulate Matter Number Density (M/cc)
TPCB	Temperature of the Module Circuit Board (deg C)
VHV	Actual High Voltage Electrode Voltage (0-2000 V)
VHVC	High Voltage Electrode Voltage Command (0-2000 V)
VILK	Voltage output of Sensor Leakage Current Circuit (0-5000 mV)
VIST	Current Measurement Voltage (0-5000 mV)
VSW	Supply Voltage at pmCAN Module (0-40 V)

Table 2: pmCAN Parameter List

<b>ECM Error Code (hex)</b>	<b>LED Action (R=red, G=green)</b>	<b>Description of Error</b>
0x00	G On	All OK
0x01	Flash G @ 10hz	Start-Up
0x02	G,G&R,R @ 2s	Power ON Reset/Init Hardware
0x13	R On	High Voltage Off
0x14	Flash R 1x @ 2s	No Sensor Detected
0x15	Flash R 1x @ 2s	Water in Sensor
0x41	Flash R 4x @ 2s	ITP Too High
0x42	Flash R 4x @ 2s	ITP Too Low
0x52	Flash R 5x @ 2s	VHVC - VHV > 100V for 5s
0x61	Flash R 6x @ 2s	ILK Fault
0x62	Flash R 6x @ 2s	IST Fault
0xA1		Invalid Software State
0xB1		CAN Overrun
0xB2		CAN Passive Mode
0xB3		CAN Heartbeat Error
0xB4		CAN Recover Bus Off
0xB5		CAN Tx CAN ID Collision
0xB6		Serial Overrun
0xB7		CAN Overrun LSS
0xB8		CAN Overrun SDO
0xB9		CAN Overrun Rx
0xBA		CAN Overrun ECT5
0xFF	G&R On	Module Powering Down Within 500ms

Table 3: pmCAN Error Codes List

Notes:

1. “G,G&R,R @ 2s” means Green LED Flashes, then Red and Green LEDs flash together, then just Red LED. This pattern repeats every 2 seconds.
2. “Flash R 4x @ 2s” means Red LED Flashes 4x and this is repeated every 2 seconds.
3. If an error from 0x00 to 0x62 is present, PM, PN, PMR, and PNR are set to -1.

## Producing a .dbc File

A .dbc file describes to the device receiving data from one or more CAN modules what is in the data packages. For each module, the packages will contain data for the parameters selected in the activated TPDOs and an error code. The Configuration Tool has a tool called “Generate .dbc...” that will generate a .dbc file for all the CAN modules on a CAN bus. Make sure that each module is configured as desired and that all modules are on the bus before the “Generate .dbc...” button is pushed. Data package information from all the modules is stored in the one .dbc file produced.

Programs importing the .dbc file and applying it to the CAN data transmitted by the modules will see data, etc identified as follows:

Data: **name\_nid[units]**

where: name = parameter name. See Table 2.

nid = node id of module in hex

units = units of parameter

for example: PM\_0X01[%] which is the PM parameter from module with nid 0X01

Error code: **ECM\_Error\_Code\_nid**

where nid = node id of module in hex

error code is in hex and given in Table 3

for example: ECM\_Error\_Code\_0x13

Auxiliary: **ECM\_Auxiliary\_time[sec]**

where: time = decrementing countdown to module activation in hex

for example: ECM\_Auxiliary\_0X12[sec]

## Using the dashCAN\* Display

dashCAN\* (i.e. all dashCANs) is a small (105 mm x 63 mm x 63 mm for dashCAN and dashCAN2, or 105 mm x 63 mm x 165 mm for dashCAN+) display for CAN networks containing ECM CAN modules. dashCAN has two displays and no analog outputs. dashCAN2 has two displays and two programmable analog outputs. dashCAN+ has two displays and six programmable analog outputs. dashCAN\* comes with a two meter cable and a “T” (P/N 09-05). Simply attach dashCAN\* to the CAN bus and parameters from one or two ECM CAN modules can be displayed and converted to analog outputs (dashCAN2 or dashCAN+ only). The top display and half the analog outputs can be assigned to one module and the bottom display and the other half of the analog outputs can be assigned to the same or another module. Multiple dashCAN\* displays can be attached to the CAN bus.

dashCAN\* has two modes of operation: RUN (when measurements are displayed) and SYS (where dashCAN\* is set-up). The SYS key toggles between the modes.

While in RUN mode:

- i. If the ↑ button is pressed, the displays will show the serial numbers of the modules assigned to the displays.
- ii. If the ↓ button is pressed, the displays will show the parameter names assigned to the displays. See Table 2.
- iii. If the ENT button is pressed, the displays will show the units of the parameters. “PCTG” is %. “DIM” means dimensionless.

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

- i. “ERR” and “####” where “####” is an error code. See Table 3.
- ii. “....” which means that a module has not been assigned to that display.
- iii. “----“ which means that dashCAN\* has an internal problem.
- iv. “XXXX” which means that dashCAN\* is not receiving any data from the module assigned to that display.



When first entering SYS mode, either “MOd” will be on the top display or “LOCK” will be on the bottom display. If “MOd” is displayed, the ↑ and ↓ keys will roll through the setup options (see Table 4). First the options for the module assigned to the top display are shown on the top display, followed by identical options for the module assigned to the bottom 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 dashCAN\* has been locked and its setup cannot be changed until it is unlocked. Appendix E describes how to LOCK and unlock dashCAN\*.

Setup Option	Level 1	Function
MOd		Select module s/n to be assigned to the display. Default is NONE.
RATE		Set parameter averaging rate. Range 0.001 to 1.000 Default is 1.000. 1.000 means no averaging.
AOUT (dashCAN+ only)	A1 A2 A3 A4 A5 A6	Program analog output 1 from module assigned to top display Program analog output 2 from module assigned to top display Program analog output 3 from module assigned to top display Program analog output 4 from module assigned to bottom display Program analog output 5 from module assigned to bottom display Program analog output 6 from module assigned to bottom display
AOUT (dashCAN2 only)	A1 A2	Program analog output 1 from module assigned to top display Program analog output 2 from module assigned to bottom display
dISP		Select parameter. Note: Parameters available are those contained in TPDOs programmed to be transmitted from the module (programmed using the Configuration Tool).
CONF	LEdS  1V4V  LOCK	dashCAN+ only. Set display intensity. Default is 3333. dashCAN and dashCAN2 have a knob for display intensity.  dashCAN2 and dashCAN+ only. Command 1V and 4V outputs.  Lock and Unlock Display for Programming

MOd, RATE, AOUT, and dISP appear on the top display for the module assigned to the top display and then on the bottom display for the module assigned to the bottom display. CONF just appears on the bottom display and is for global dashCAN\* setup. All entries must be followed by pressing the ENT key.

Table 4: Menu Tree for dashCAN\*

## **MOd (Module) Setup Option**

---

In MOd setup, the serial number of the module assigned to the top or bottom display is entered. The serial number is written on a label on the module. The module assigned to the top display will be assigned the first half of the analog outputs. The module assigned to the bottom display will be assigned to the second half of the analog outputs. The same module can be assigned to both displays or different modules can be assigned to each display.

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

## **RATE Setup Option**

---

Data is transmitted from modules at the broadcast rate and the averaging that was programmed using the Configuration Tool. This transmitted data can then be further averaged before being displayed on the displays. Separate averaging can be programmed for the top display and the bottom display. RATE does not affect the analog outputs.

The averaging ( $\alpha$ ) is programmed with values from 0.001 (heavy averaging) to 1.000 (no averaging). The default is 1.000. The averaging is performed as follows:

$$\text{DisplayedValue}_t = \alpha \times \text{Parameter}_t + (1 - \alpha) \times \text{DisplayedValue}_{t-1}$$

where:

DisplayedValue<sub>t</sub> = the new displayed averaged value

$\alpha$  = The user-programmable averaging.  
Range: 0.001 (heavy averaging) to 1.000 (no averaging).

Parameter<sub>t</sub> = the latest value transmitted by the module

DisplayedValue<sub>t-1</sub> = the previous displayed averaged value

## **AOuT (Analog Outputs) Setup Option (dashCAN+ and dashCAN2 only)**

---

The dashCAN2 display head has two 0 to 5V programmable analog outputs. The dashCAN+ display head has six 0 to 5V programmable analog outputs. The analog outputs are updated at the module Broadcast Rate (see Table 1). This can be as fast as every 5 ms. Keep in mind that the data may be averaged (see **Set Averaging Filters** in Table 1) before being broadcast by the module.

Parameter information from the module assigned to the top display (see MOd) can be sent to analog output 1 (for dashCAN2) or 1, 2, and 3 (for dashCAN+). Parameter information from the module assigned to the bottom display can be sent to analog output 2 (for dashCAN2) or 4, 5, and 6 (for dashCAN+). Only parameters selected as active TPDOs for that module (using the Configuration Tool) can be output.

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

1. Press the SYS key so that “MOd” appears on the top display.
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.

If in the above example analog output 4 was being programmed, AOUT, A4, 0V, 5V, and your entries would be shown on the bottom display.

## **dISP (Display) Setup Option**

The dashCAN\* display head has two displays, the top display and the bottom display.

In dISP setup, a parameter from the module assigned to the display (see MOD) can be shown on the display. Only parameters selected as active TBDOS for that module (using the Configuration Tool) can be displayed.

Here is an example of setting the parameter to be displayed on the top display:

1. Press the SYS key so that “MOd” is displayed.
2. Press the ↓ key until “dISP” is on the top display. Then press the ENT key.
3. Press the ↑ and ↓ key until desired parameter name is displayed. See Table 2. Then press the ENT key.
4. Press SYS to return to RUN mode.

## **CONF (Configure) Setup Option (LEdS, 1V4V, LOCK)**

CONF setup appears at the end of the setup list on the bottom display. To enter CONF, press the SYS key so that “MOd” appears on the top display, press the ↓ key until “CONF” appears on the bottom display, and then press the ENT key. CONF is for global dashCAN\* setup.

### **◆ LEdS (dashCAN+ only)**

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

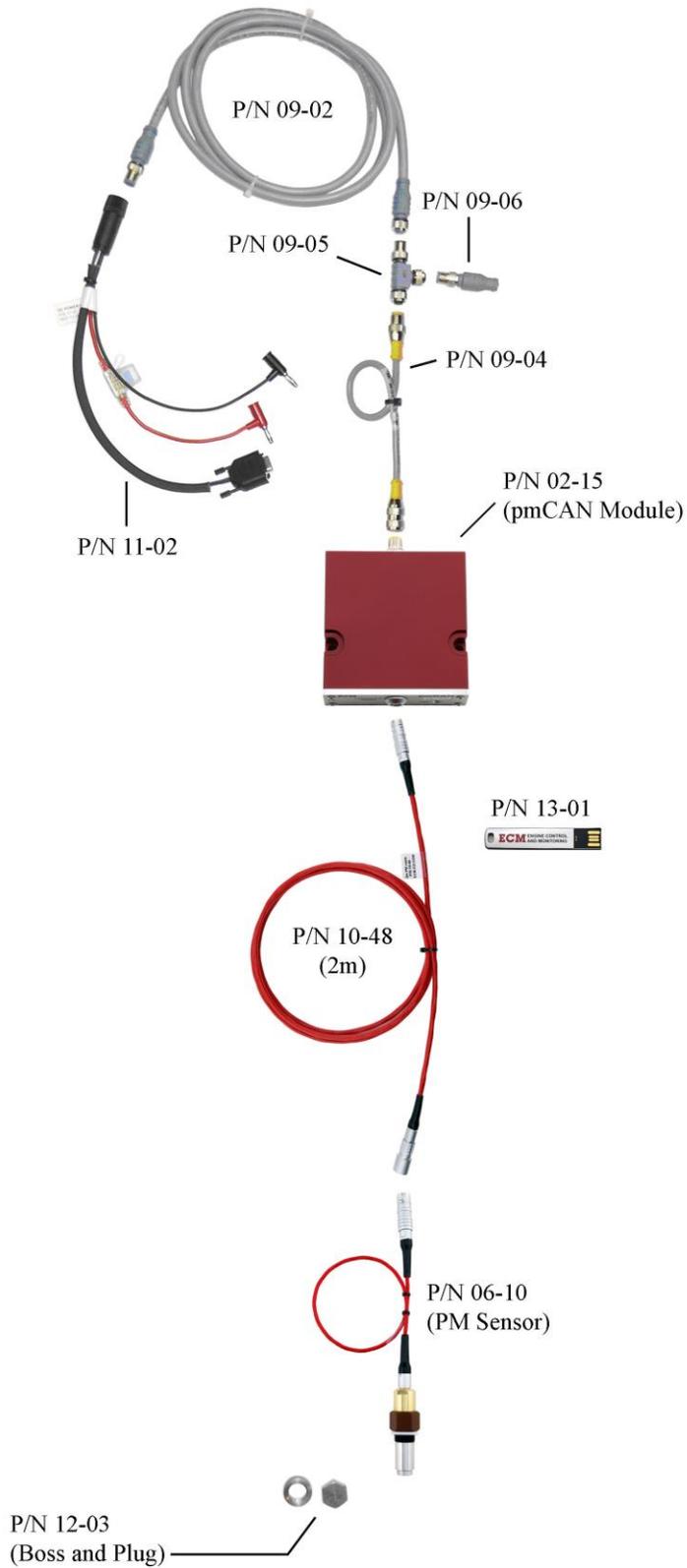
◆ **1V4V (dashCAN2 and dashCAN+ only)**

“1V4V” commands the analog outputs to go to 1V then 4V. This is used to verify that the data acquisition system reading the analog outputs is correctly reading them.

◆ **LOCK**

“LOCK” locks the MOd, RATE, AOUT, dISP, and LEdS setup. This stops unauthorized modification of the display. Refer to Appendix E for more information.

# Appendix A: pmCAN Kit Contents



The pmCAN Kit consists of:

<u>Description</u>	<u>P/N</u>	<u>Quantity</u>
1. pmCAN Control Module	02-15	1
2. PM Sensor (tailpipe application) or PM Sensor (diesel engine-out application)	06-10T 06-10E	1 1
3. PM Sensor Cable, (2m)	10-48	1
4. Flexi-Eurofast Cable, (0.3m)	09-04	1
5. Eurofast "T"	09-05	1
6. Eurofast Terminating Resistor	09-06	1
7. Eurofast 12mm Cable, (2m)	09-02	1
8. DC Power Cable, DB9F, Banana	11-02	1
9. Sensor Boss & Plug, SS, (18mm x 1.5mm)	12-03	1
10. Manuals and Configuration Software CD	13-01	1

Optional Components:

1. AC/DC Power Supply, Universal 24VDC @ 4.2A (requires P/N 11-17 Deutsch DTM3M to DB9F Cable)	04-01	1
2. Kvaser Leaf Light CAN Adapter	13-02	1
3. PM Sensor Cable (3m)	10-49	1
Note: pmCAN has been approved for use with no sensor cable, a 2m sensor cable, a 3m sensor cable, and any combination of cable lengths up to 6m. Tie the sensor cable(s) down since cable wiggling will generate noise in the PM and PN signals due to the triboelectric effect.		
4. PM Sensor Cleaning Kit	14-15	1
5. Spare PM Sensor Gasket	12-62	1

## Appendix B: Module Stand-Alone Mode and EIB Mode

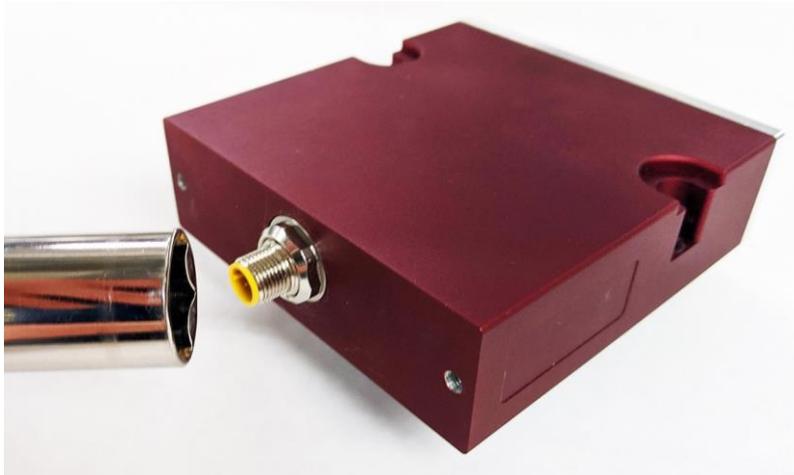
CAN data from CAN modules (ex. pmCAN, NH<sub>3</sub>CAN, NO<sub>x</sub>CAN, LambdaCAN) can either be taken directly from the modules themselves or from the CAN port of display heads connected to the modules. When data is taken directly from one or more modules, each module must be in Stand-Alone mode. When data is taken from one or more display heads of a NO<sub>x</sub> 5210, Lambda 5220, EGR 5230, NH<sub>3</sub> 5250, or miniSOOT 5260 analyzer, each module must be in EIB mode.

Therefore, the module must be properly configured in Stand-Alone mode or EIB mode depending on how it will be used. When CAN modules are sold alone, they are delivered in Stand-Alone mode. When CAN modules are sold as part of a NO<sub>x</sub> 5210, Lambda 5220, EGR 5230, NH<sub>3</sub> 5250, or miniSOOT 5260 analyzer, they are delivered in EIB mode.

To convert from one mode to the other requires the installation (to set to Stand-Alone) or removal (to set to EIB) of a jumper inside the module and software reprogramming of the module using the Configuration Tool.

### ◆ To convert a module from EIB to Stand-Alone Mode

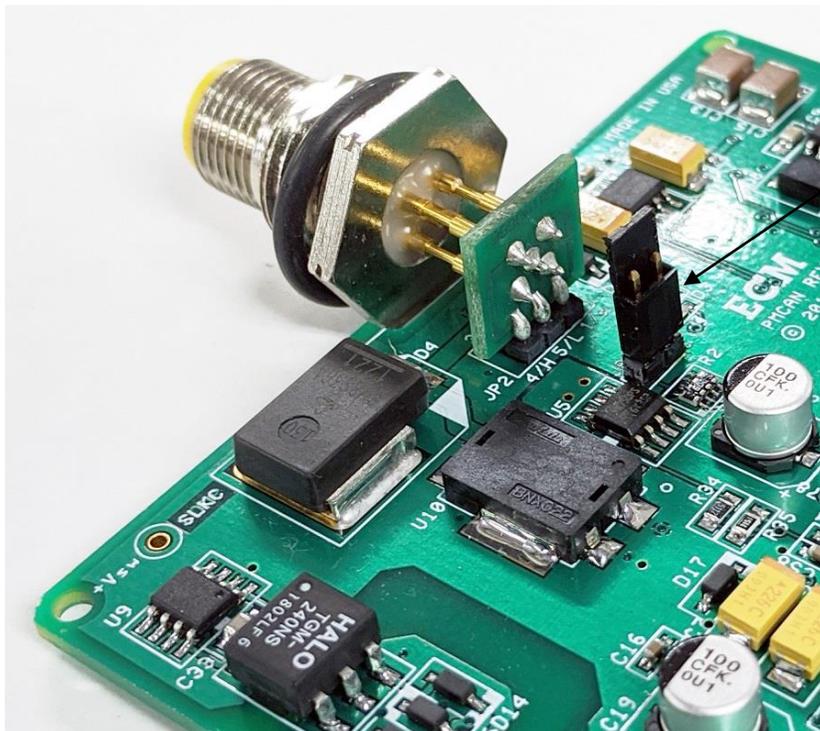
1. Using a 19mm socket, remove the nut and washer from the eurofast connector.



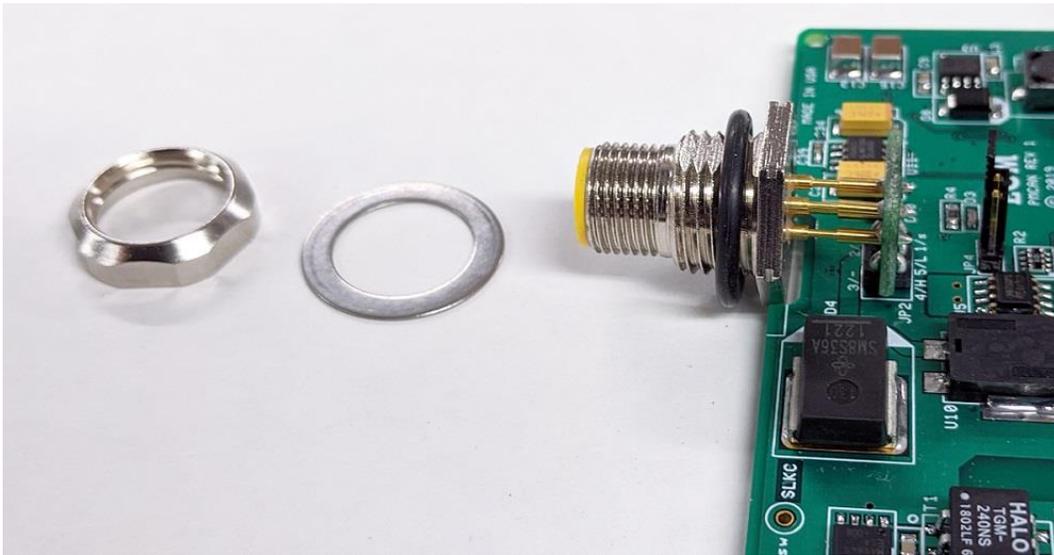
- Using 5/64" (or 2mm) hex wrench, remove the 4 screws on the front of the module.



- Slide the PCB out. Put the jumper on both pins for Stand-Alone Mode.



4. Make sure the O-ring is on the eurofast connector.



5. Slide the PCB back into the enclosure and reattach the four screws on the front of the module.
6. Put the washer and nut on the eurofast connector and tighten.
7. Connect the module to a power supply and a PC (via a CAN communication adapter) using the cabling shown. A sensor does not have to be connected to the module. Note that only one module is connected and a display head is not involved.

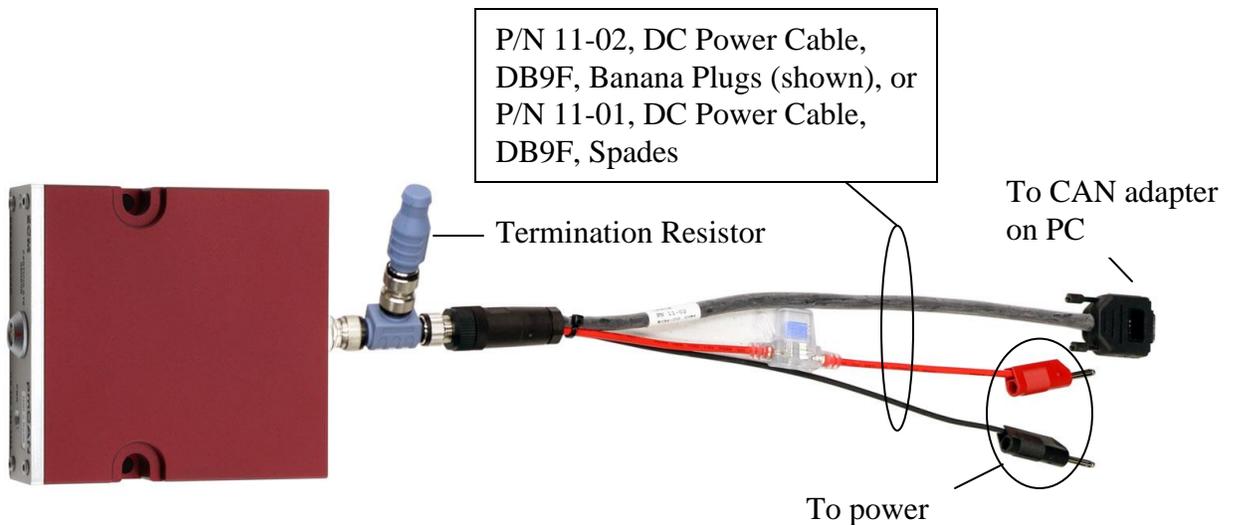
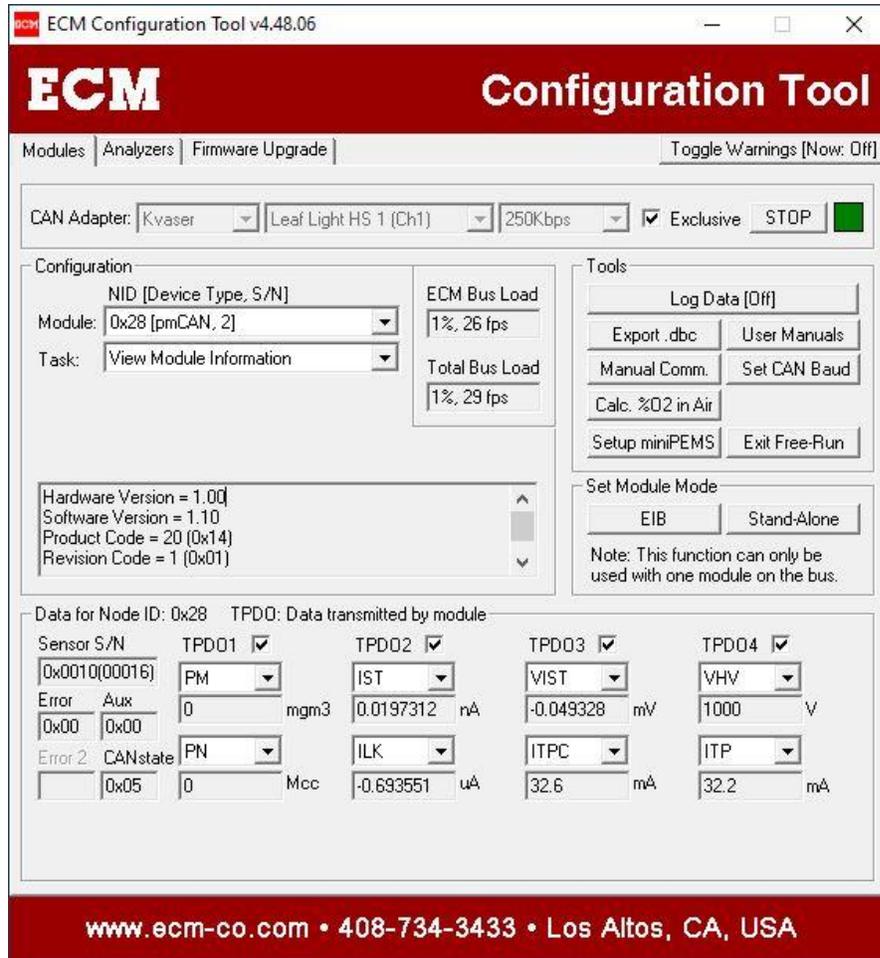


Figure A1: Module prepared for Reprogramming

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



9. Click on the “Stand-Alone” button. Wait for the “Done” Message. Stop communication and exit program. The module is in Stand-Alone Mode.

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

1. Connect the module to the Configuration Tool and click on the “EIB” button.
2. Open the module and put the jumper on just one pin (either one).
3. Close up the module.

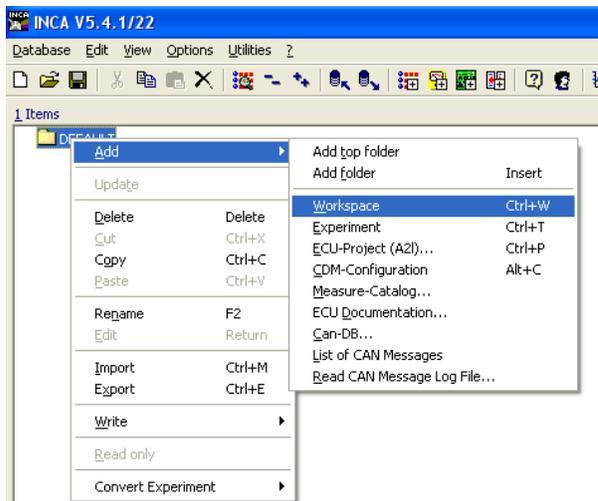
# Appendix C: Setting Up ETAS INCA for ECM Modules

## Hardware Setup: Using ETAS ES591.1

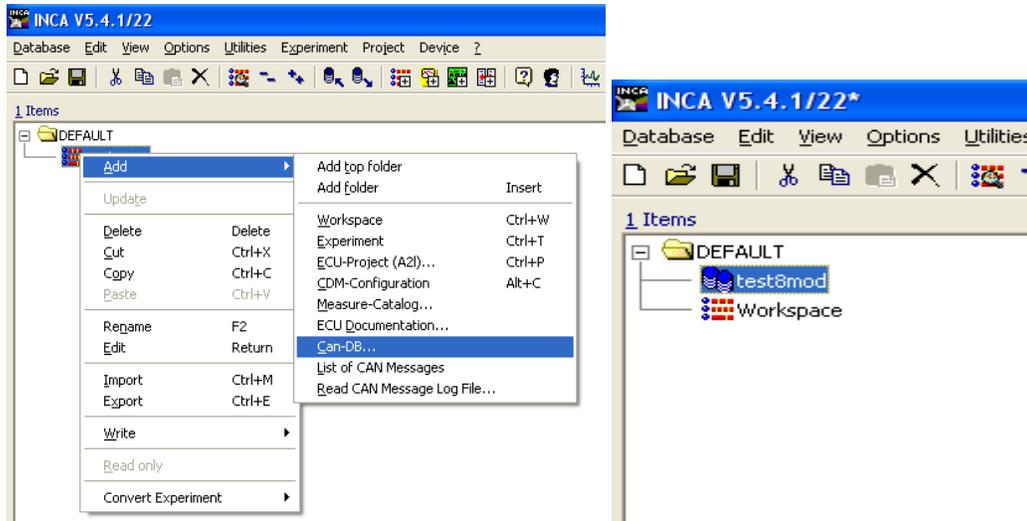
1. Connect the power port to a power source between 6V and 32V.
2. Connect the Ethernet port directly to the Ethernet port on your PC. This port does not use an internet/intranet connection like a router.
3. Connect either the CAN1 or CAN2 port to a CAN network (i.e. ECM modules or display heads).

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

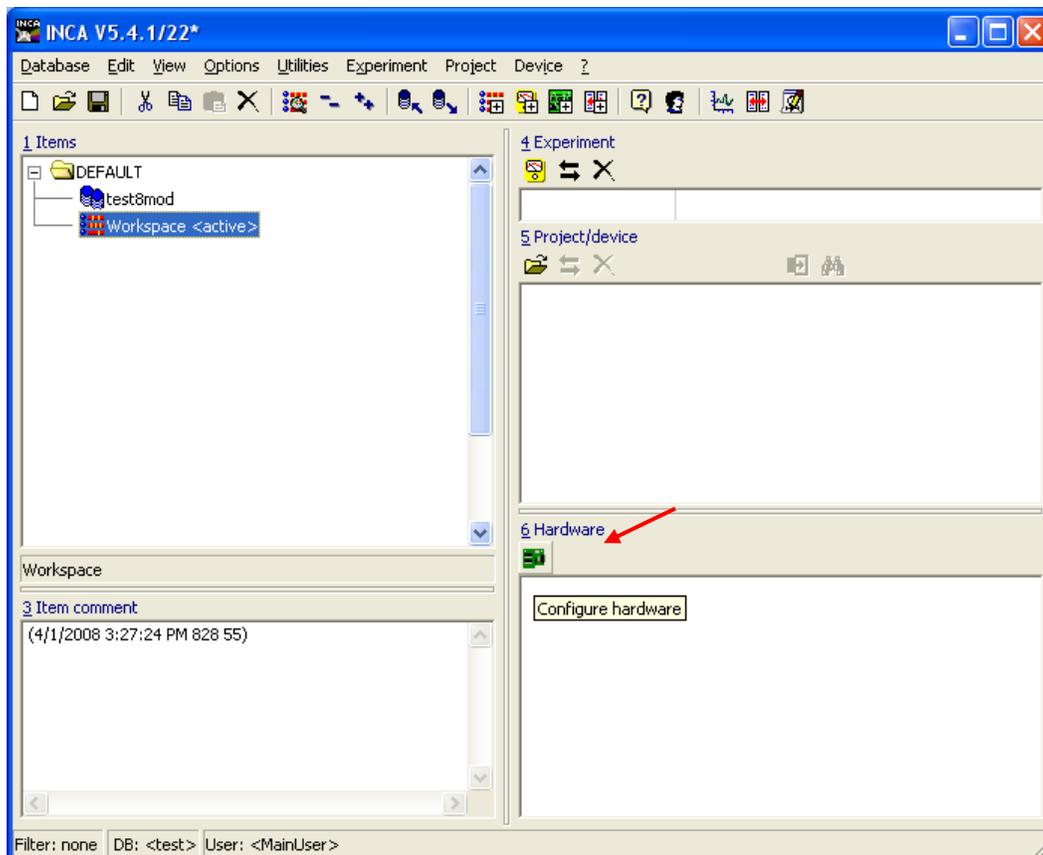
1. Double click the INCA V5.4 icon to open the software.
2. **Create a new Database.** In the Database menu, select New. Give your database a name (i.e. a folder name). In INCA, a Database means the current working directory. Each project is created in a unique directory. When INCA is opened, it will 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.



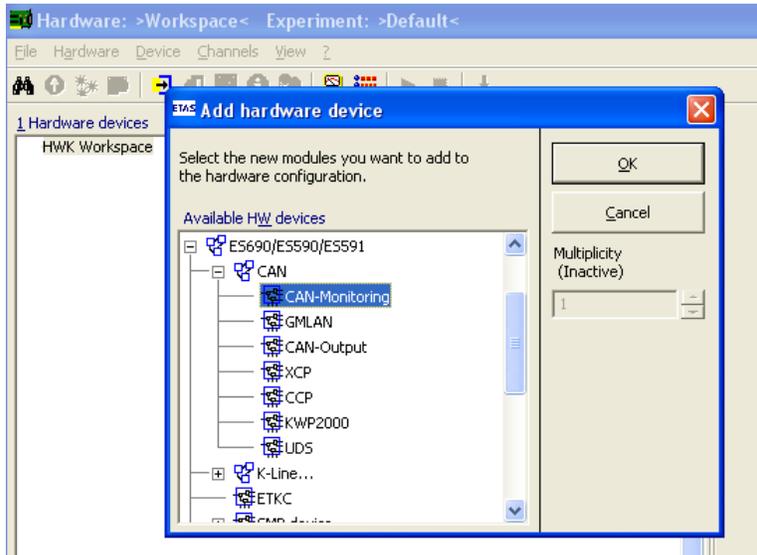
4. **Add a new dbc file for your project.** Right click on the workspace you created in step 3, select Add > Can-DB. Browse to your dbc file and click open. In this example, we are using a file named test8mod.dbc. An INCA log window will pop up. You can ignore this.



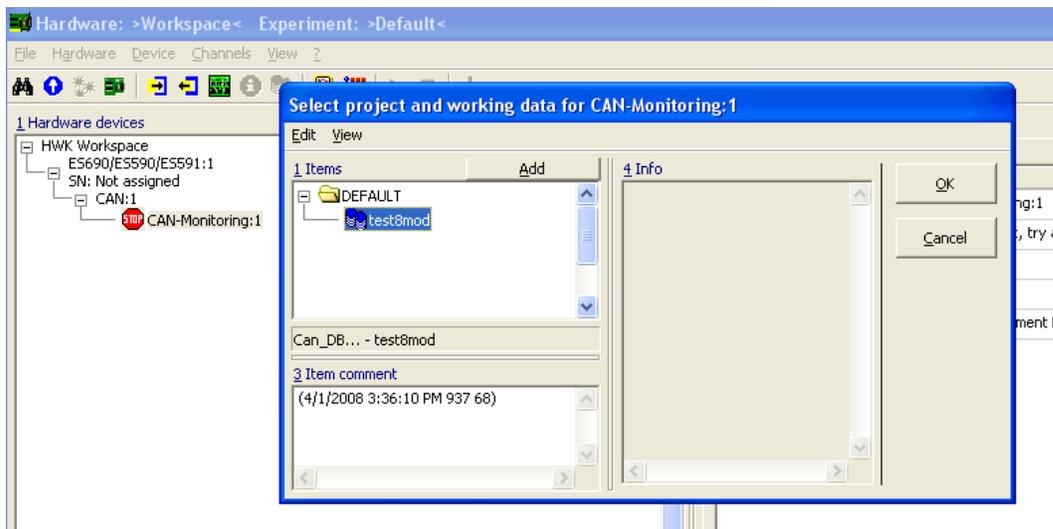
5. **Configure the hardware.** Click on the icon for the workspace you created in step 3. Open the Hardware Configuration icon under the section text “6. Hardware”. A hardware configuration window will open.



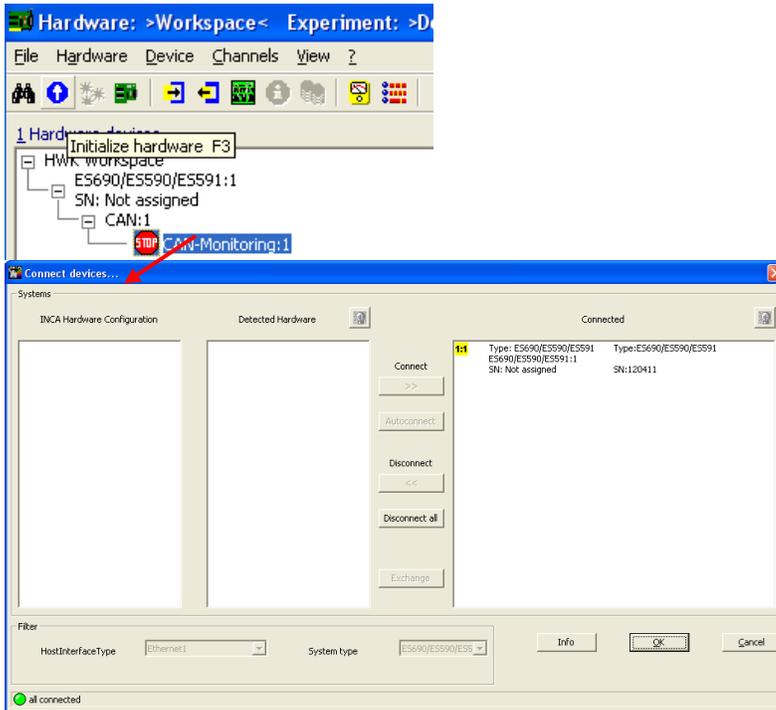
6. **Select the hardware.** In the hardware configuration window, right click the “HWK Workspace” listed under the section text “1. Hardware Devices”, and select Insert. Select the ETAS device you wish to use. In this example, we are using an ETAS ES591.1. Expand the selection tree by clicking the “+”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



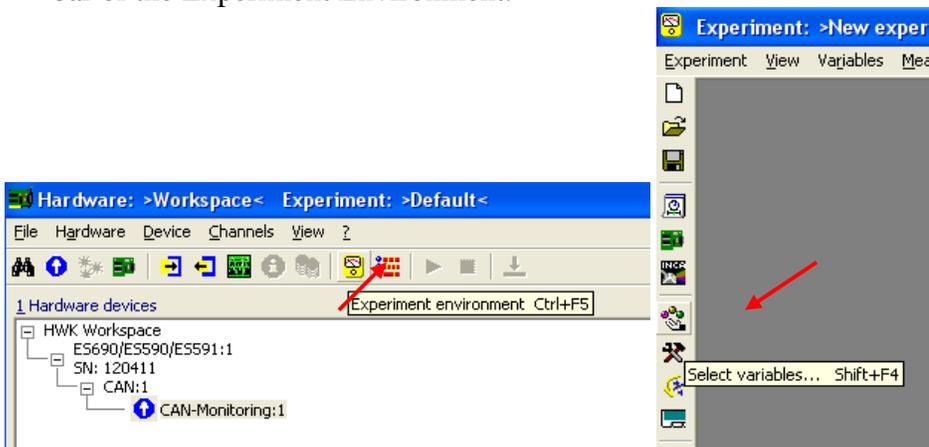
7. **Associate the dbc.** When you clicked OK in the last step, another window will pop up that will allow you to select a dbc that you have added to your workspace from step 4. Expand the selection tree, select your dbc file, and click OK.



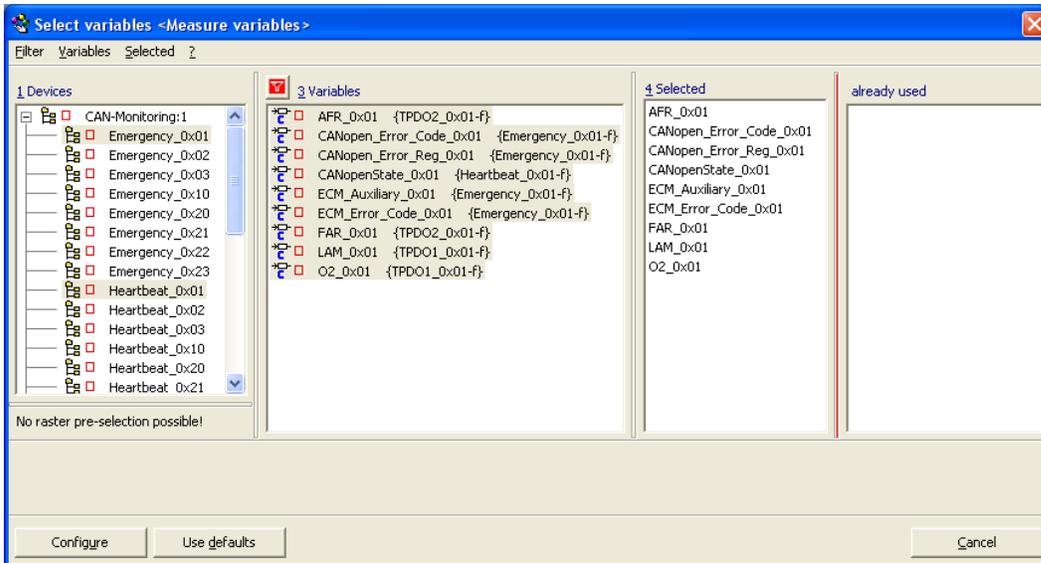
- Initialize hardware.** The hardware is currently stopped, as indicated by the red stop sign icon next to the selected hardware. You must initialize it before you can use it to collect data. Click on the Initialize Hardware button on the upper tool bar and wait for the hardware to complete its initialization.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



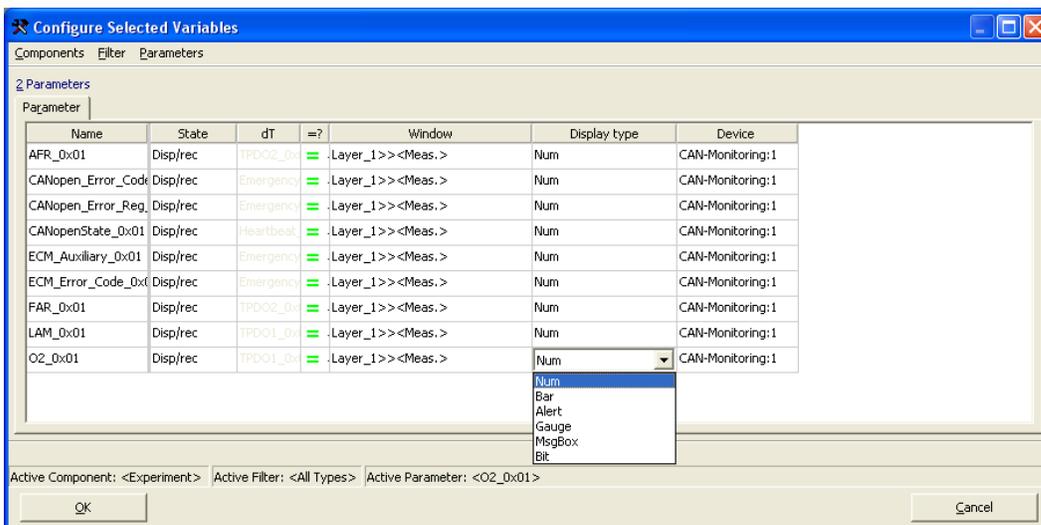
- Open an Experiment Environment.** Click on the Experiment Environment button on the upper tool bar to open an Experiment Environment. The Experiment Environment is where you can setup the monitoring of the CAN bus. By default, the Experiment Environment will be blank. You must select the variables 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.



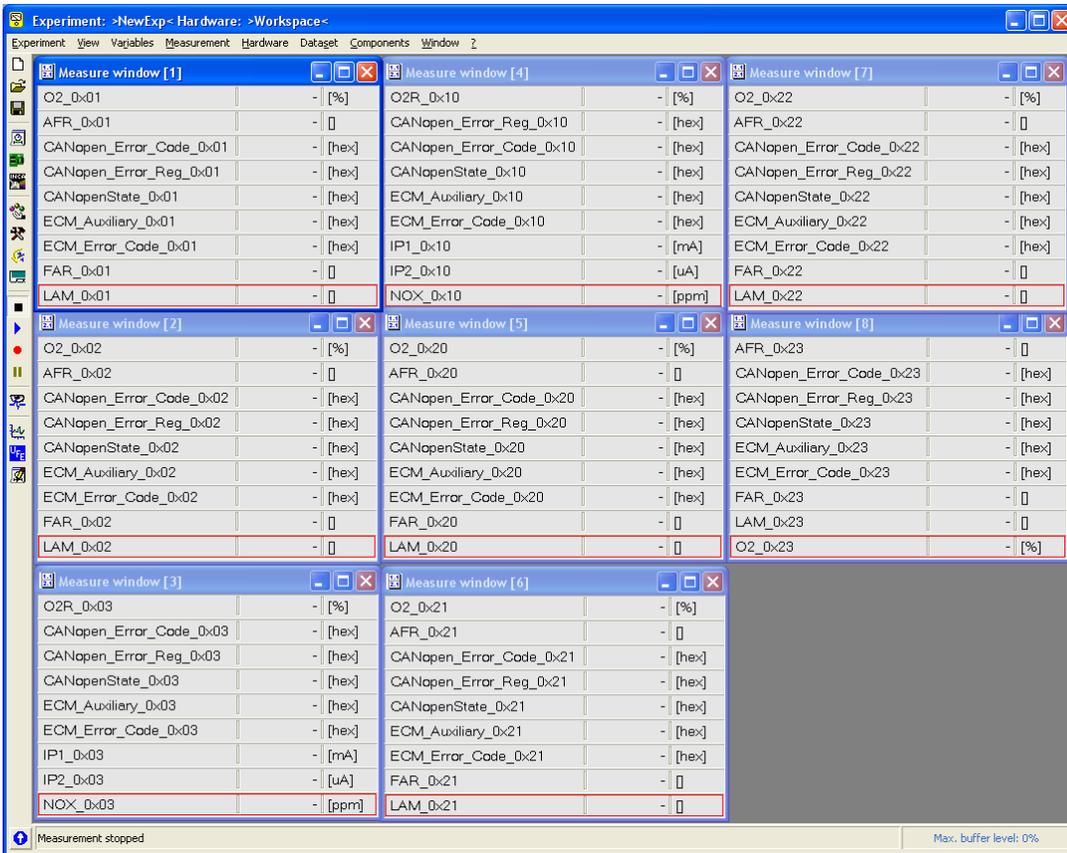
10. **Select and Configure Variables.** Select the variables that you wish to monitor in the Experiment Environment. These variables names are based on the data found in the dbc file. Click Configure.



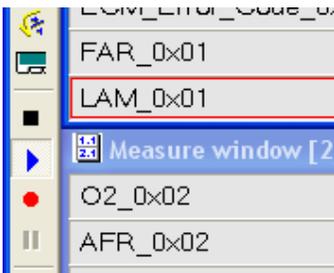
11. Another window will pop up to configure each selected variable. You can configure, for each variable, whether to record or simply display the data, how the data will be displayed (graphs, charts, gauges, numeric, etc.). When complete, click OK. We have left all configurations at default for this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

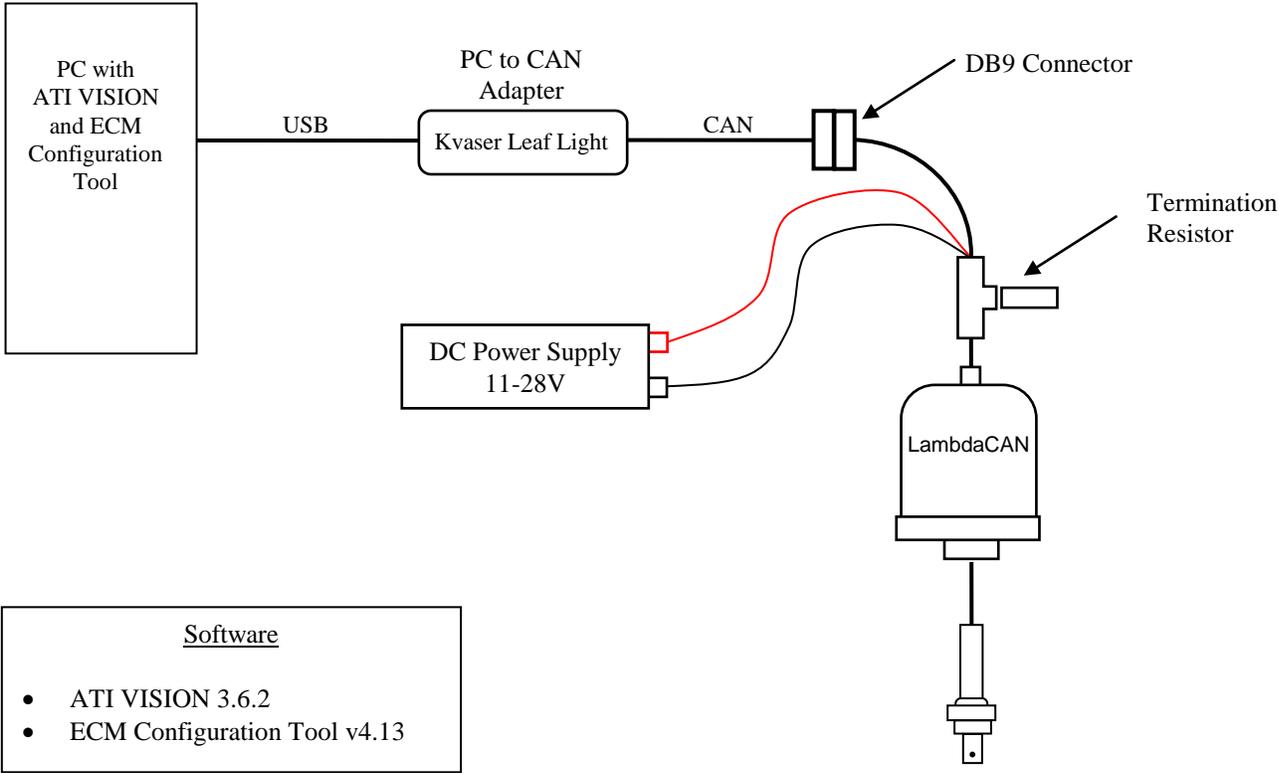


Figure 1: Equipment Schematic Layout

## Creating a .dbc File

The ECM Configuration Tool is used to create a .dbc database file for describing the CAN messages broadcast from the LambdaCAN. All ECM products with a CAN interface use the CANopen protocol at 500kHz by default. To generate a .dbc file using ECM Configuration Tool:

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.

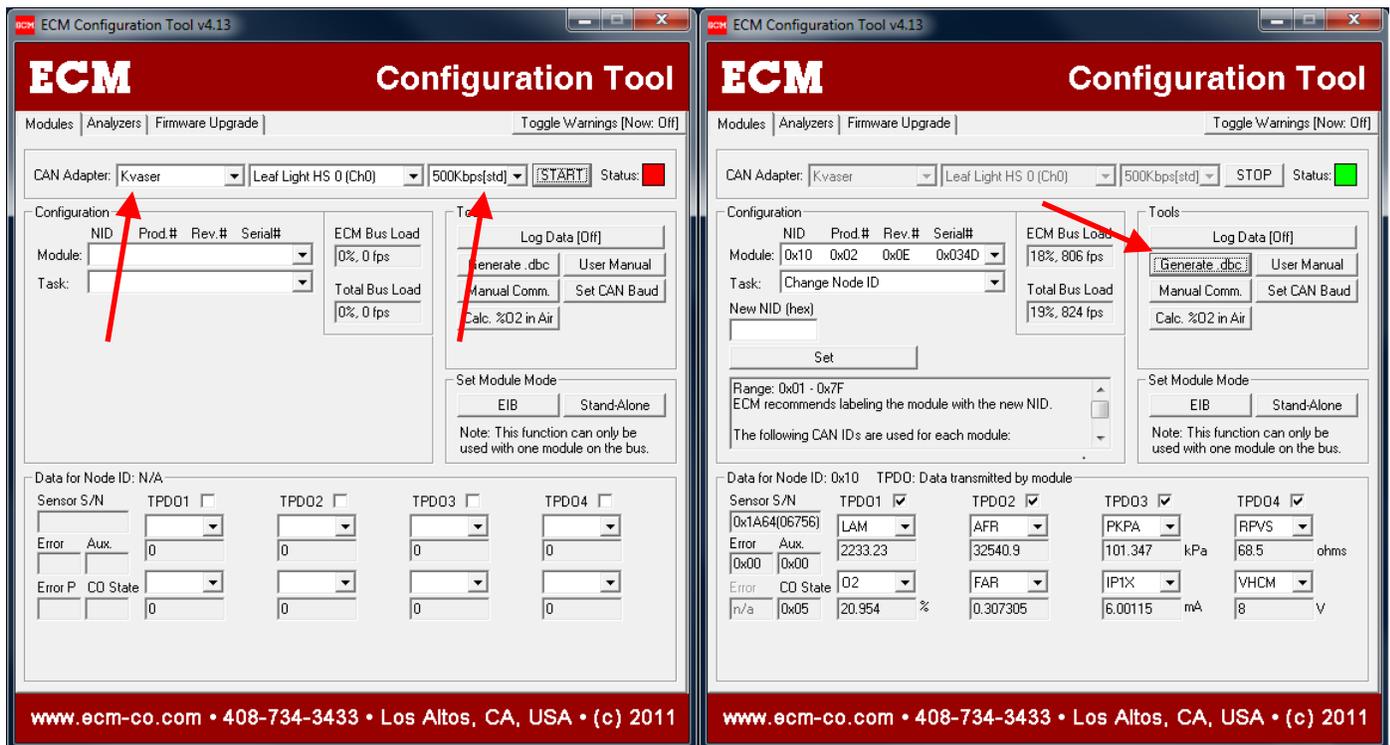
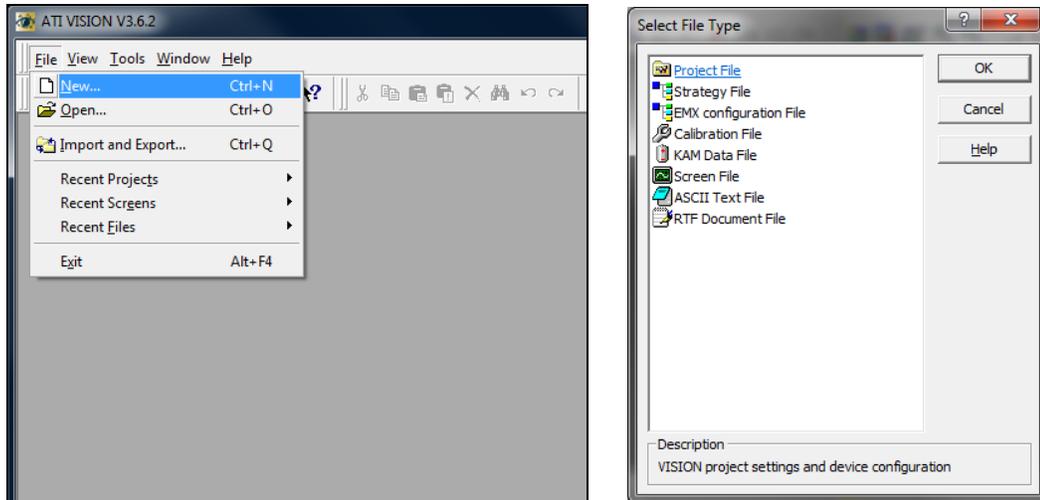


Figure 2: ECM Configuration Tool

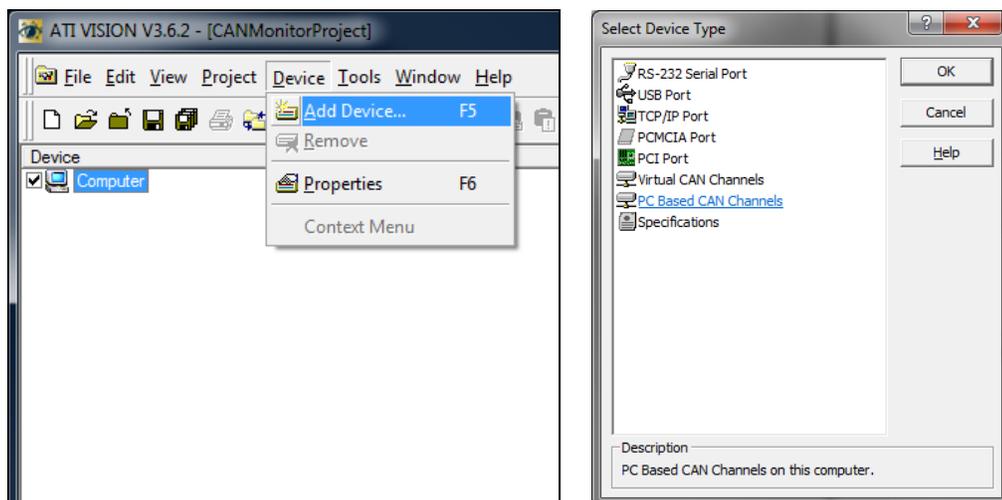
## Setup CANMonitor using ATI VISION

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:

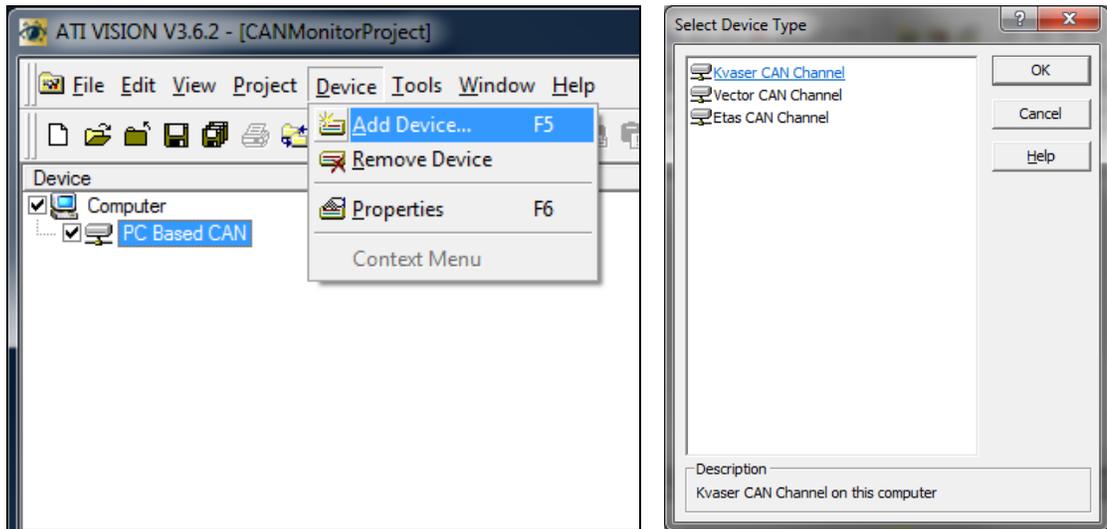
1. Run ATI VISION and open an existing Project File or create a new one by clicking File → New → Project File. In this example the Project has been named CANMonitorProject.



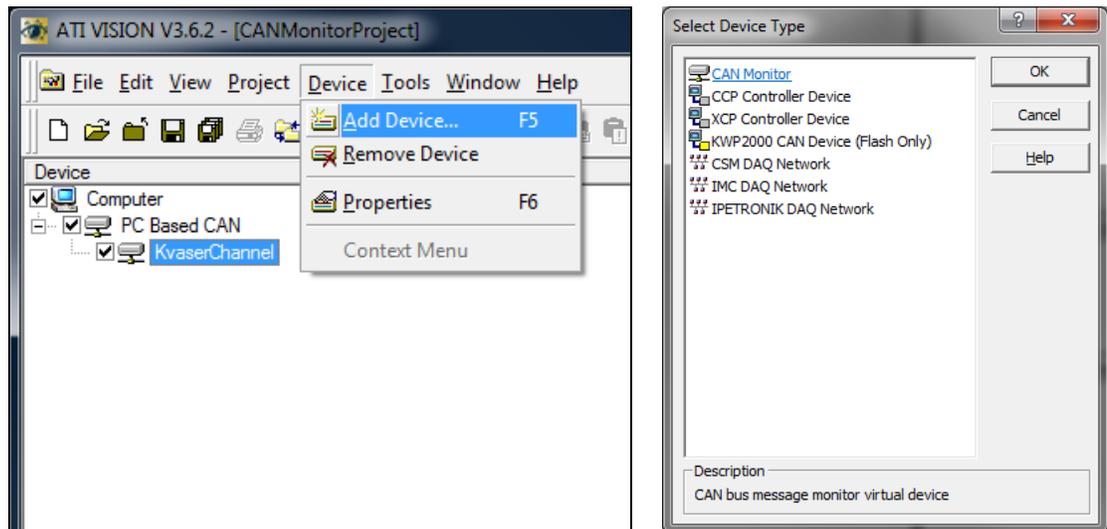
2. Add a Device by clicking Device → Add Device, select PC Based CAN Channels from the list.



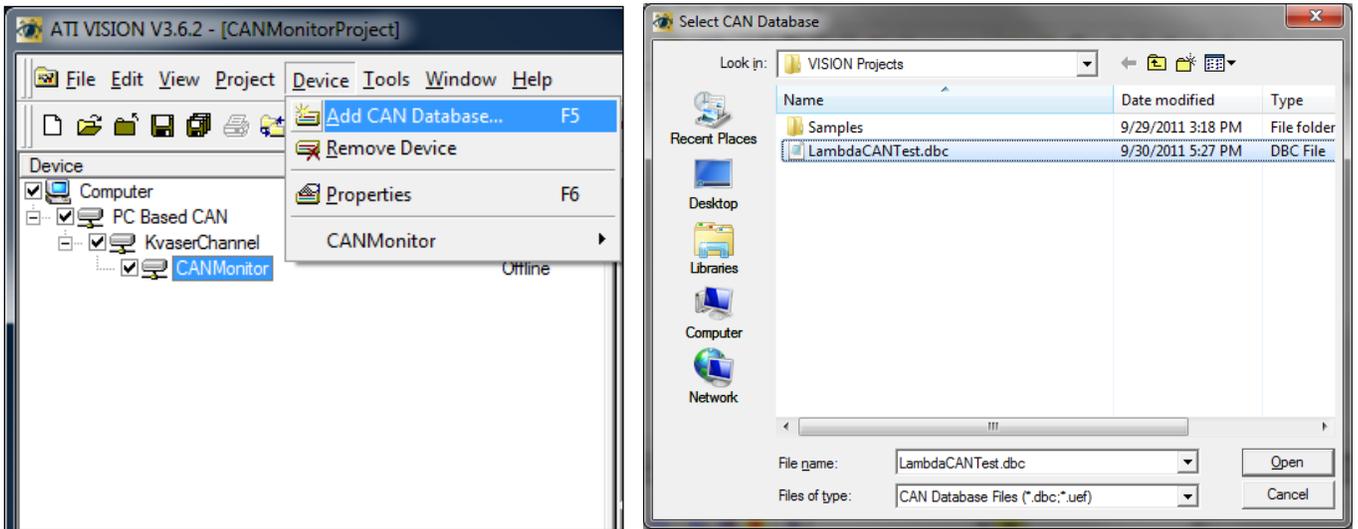
3. Add a physical hardware device by clicking Device → Add Device, and select Kvaser CAN Channel.



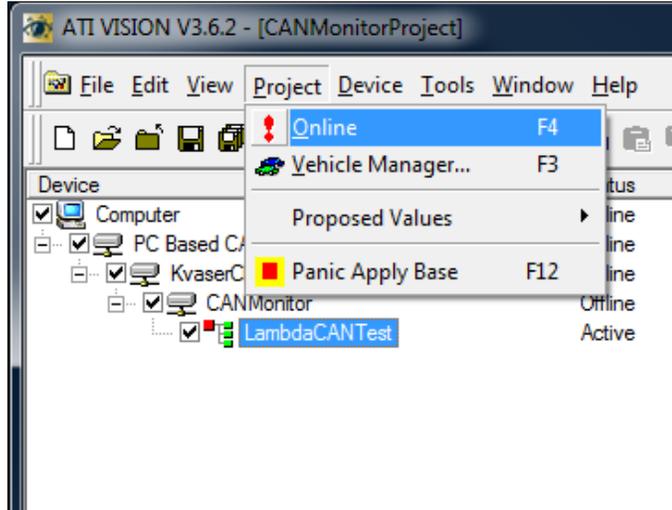
4. Select a CANMonitor device by again clicking Device → Add Device, and select CANMonitor.



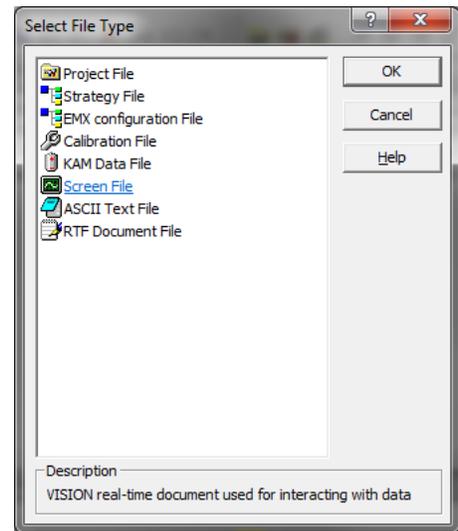
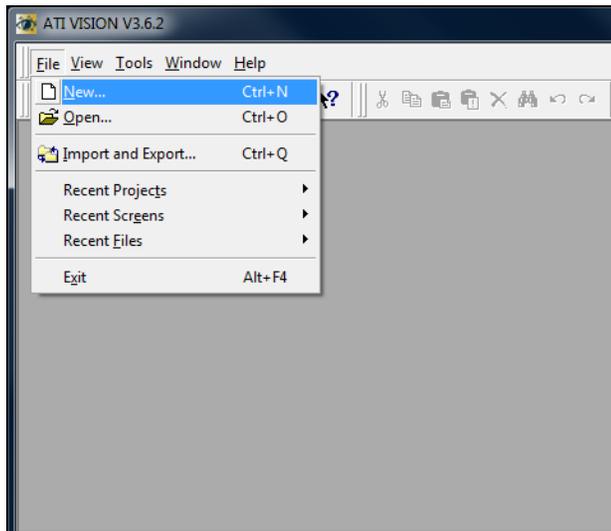
5. Add the .dbc file generated from the ECM Configuration Tool to CANMonitor by clicking Device → Add CAN Database and browsing to the previously created .dbc file.



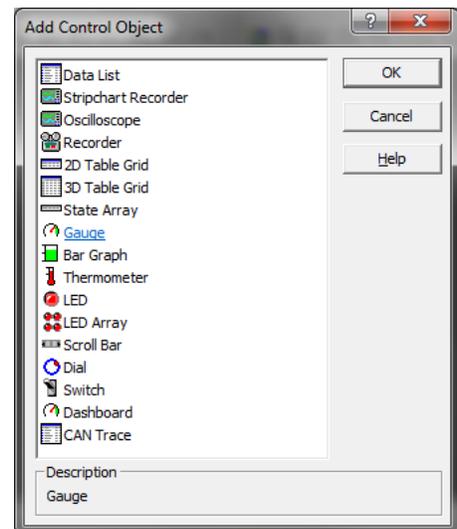
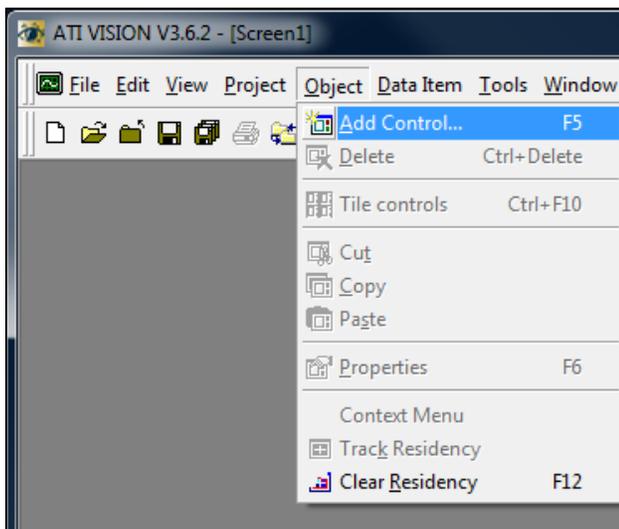
6. Enable the hardware by clicking Project → Online. The status of all of the devices should now show a Status of Online, and a value should appear in the Data Rate column of the Project window.



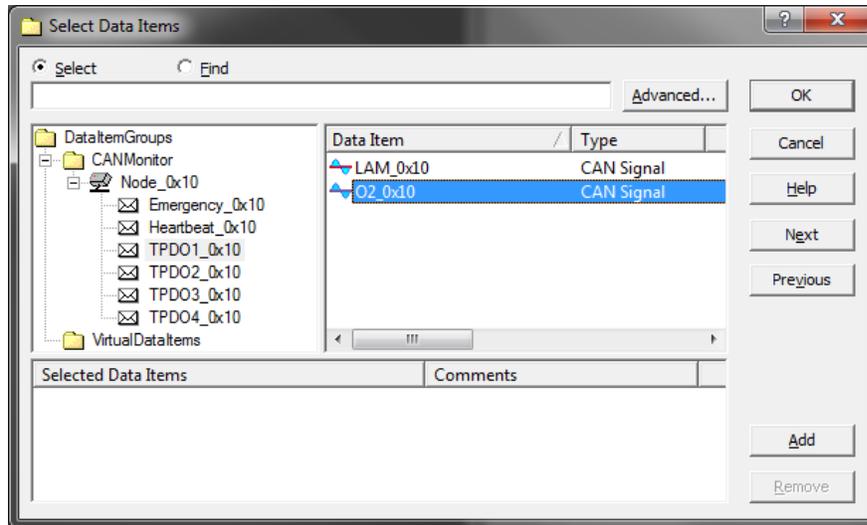
7. To view data, create a new Screen File and add a Control. Click File → New → Screen File



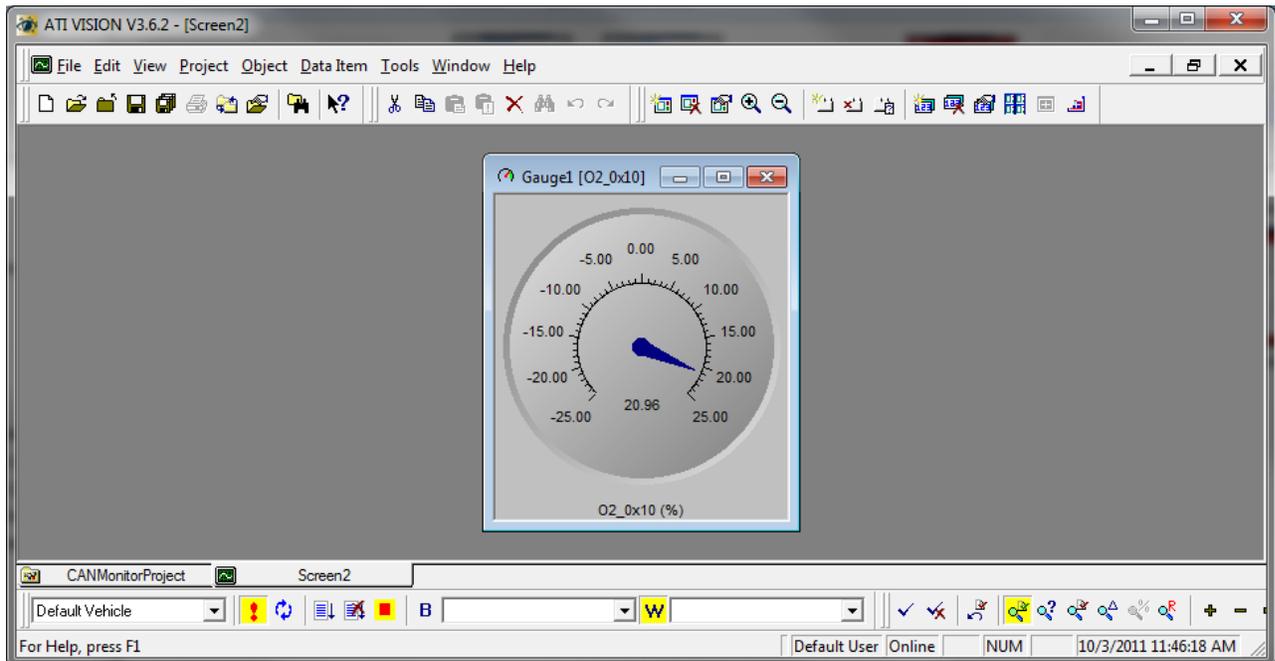
8. Select Object → Add Control → Gauge



- 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.



- Data should be visible on the gauge.



## **Appendix E: LOCKing and unLOCKing dashCAN\***

When dashCAN\* is locked, its setup cannot be modified.

### **◆ To LOCK dashCAN\***

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. dashCAN\* is now LOCKed.

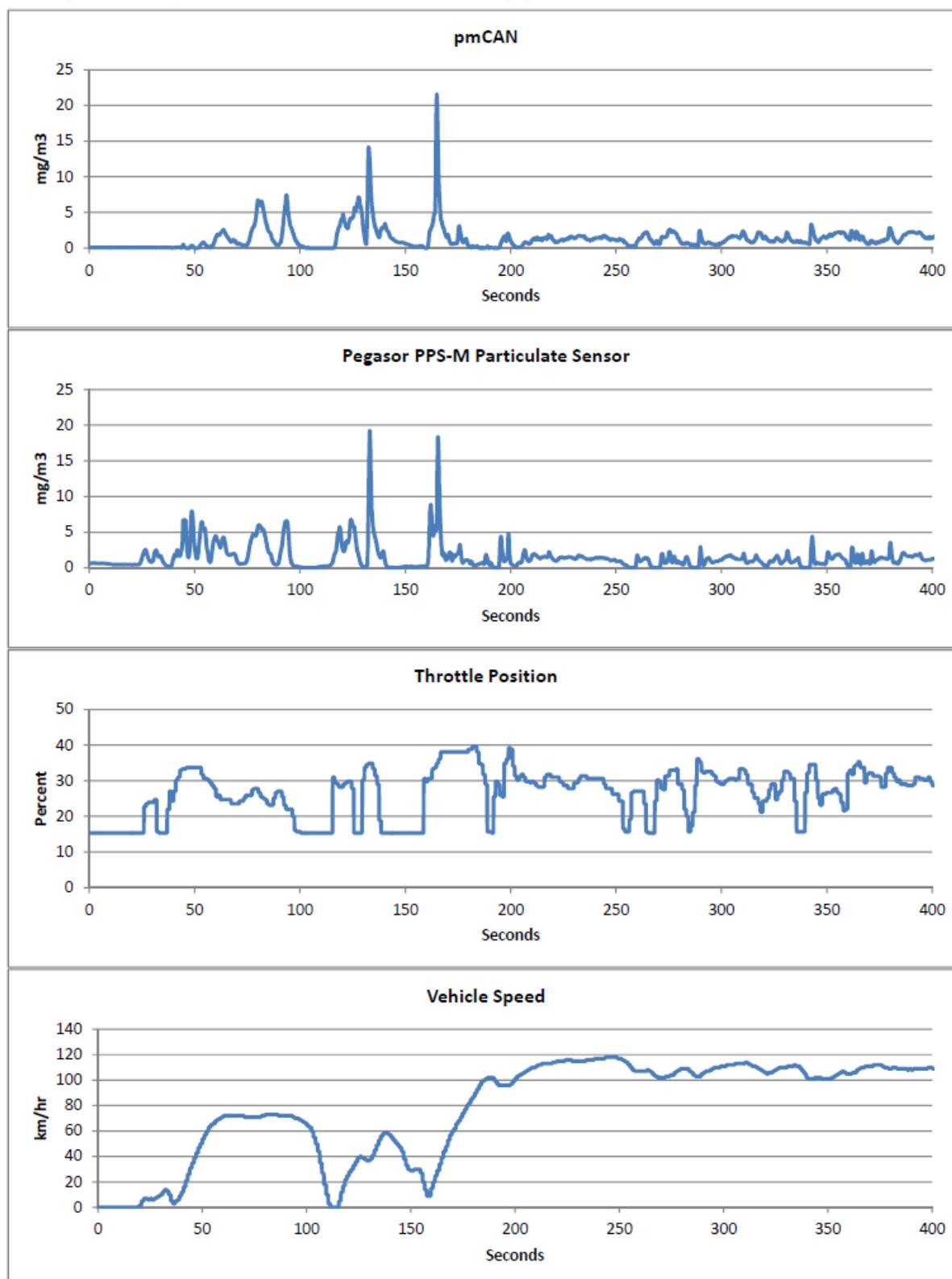
### **◆ To unLOCK dashCAN\***

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

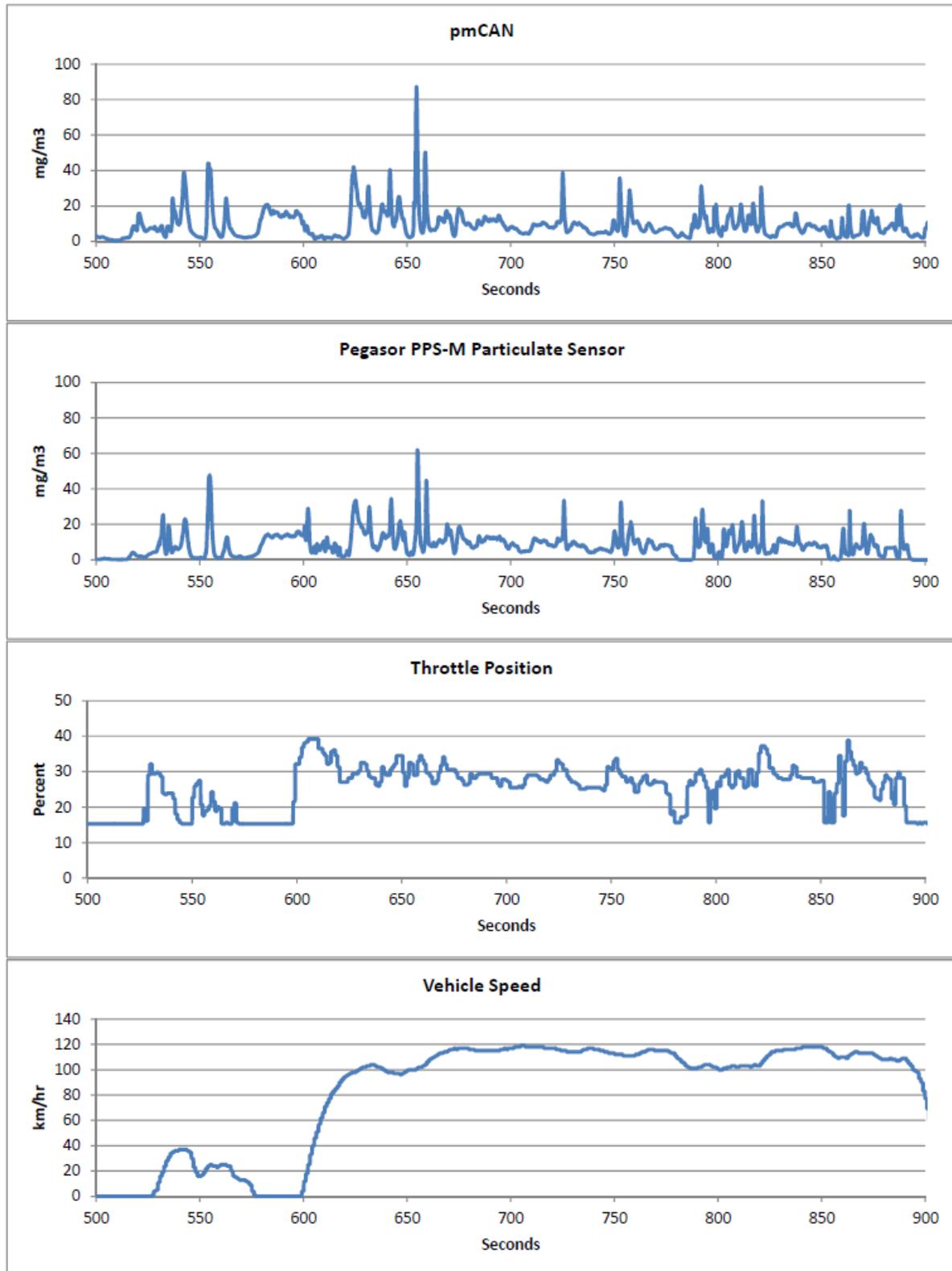
If an unauthorized person learns that 60 is the key number, contact ECM.

## Appendix F: Examples of Use

This example shows a light duty diesel truck with a DPF and 70,000 km getting on and driving on the highway. PM sensor mounted tailpipe-out.



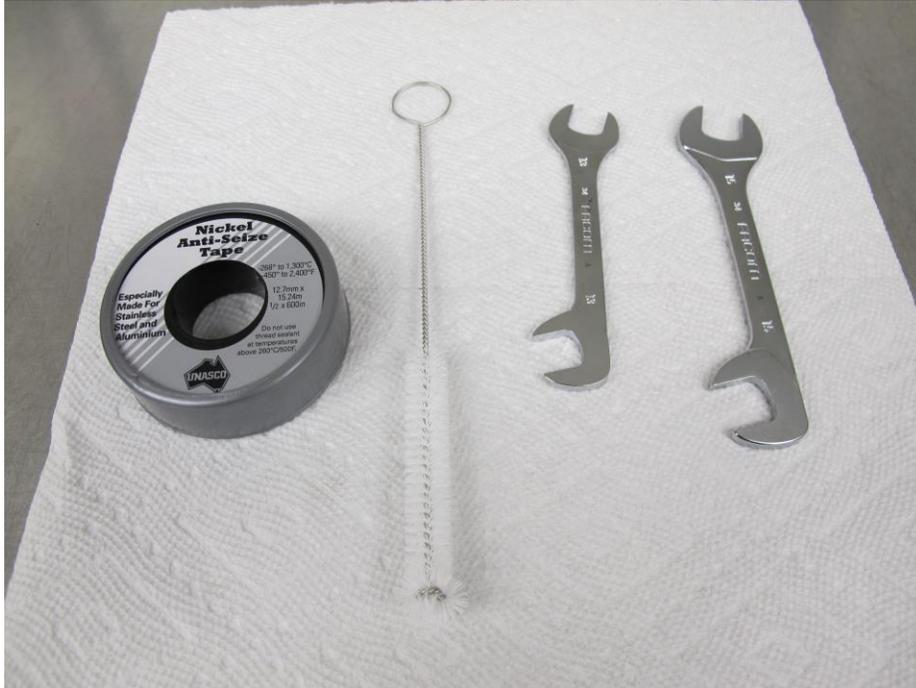
This example shows a light duty diesel truck with a damaged DPF getting on and driving on the highway. PM sensor mounted tailpipe-out.



## Appendix G: Cleaning the PM Sensor

Cleaning the PM sensor should take less than 5 minutes and will not affect the calibration.

This is the PM Sensor Cleaning Kit, P/N 14-15. The thin wrenches are key.



You will need some extra things to clean a sensor: a roll of paper towels, a can of brake cleaner (or acetone), a pair of scissors, and compressed air.



First step is to remove the outer shell. Sometimes it's a little sticky. Go easy.



Then remove the ground electrode:



Here's the high voltage electrode. Do not try to remove it. It should be centered in the body of the sensor, straight, and not loose. If it is not so, you will have to send the sensor back to ECM. Note the soot pattern.



Spray some brake cleaner on a piece of paper towel and wipe off the side and end of the high voltage electrode.



Then blow dry air on the electrode and the annulus between the electrode and the body of the sensor. You need to remove all the towel's particles, PM particles, and evaporate the solvent. Normally, you do not have to clean in the annulus. If you do, you can use a q-tip soaked in brake cleaner. Do not just spray all over the sensor body with brake cleaner. Always use a paper towel or q-tip.



Now spray some brake cleaner inside the ground electrode and clean the inside of the electrode with a small piece of paper towel soaked in brake cleaner. Sometimes you'll also want to use the brush but most of the time, the soaked paper towel will be sufficient.



Clean the outside and bottom of the ground electrode with a clean part of the towel, and blow it out with compressed air. It should be clean inside, outside, and all those little holes should be clean too.



During your cleaning and blowing, keep away from the teflon tape. Rarely will it need to be replaced. This is when it is flaking off. Cut off any little loose pieces that are waving around in the wind because they will cause jumpy PM readings.



If you have to replace the teflon tape, carefully clean the old tape completely from the treads, cut the tape to the width of the threads and wrap the tape tightly and clockwise around the threads once and overlapping by a few mm. The tape is wrapped on the threads in a clockwise direction so that when it is installed into the sensor body, it does not unravel.



Now clean the outer shell. Again, sometimes you'll want to use the brush but most of the time, a brake cleaner-soaked piece of paper towel is sufficient. Blow it out with air after cleaning.



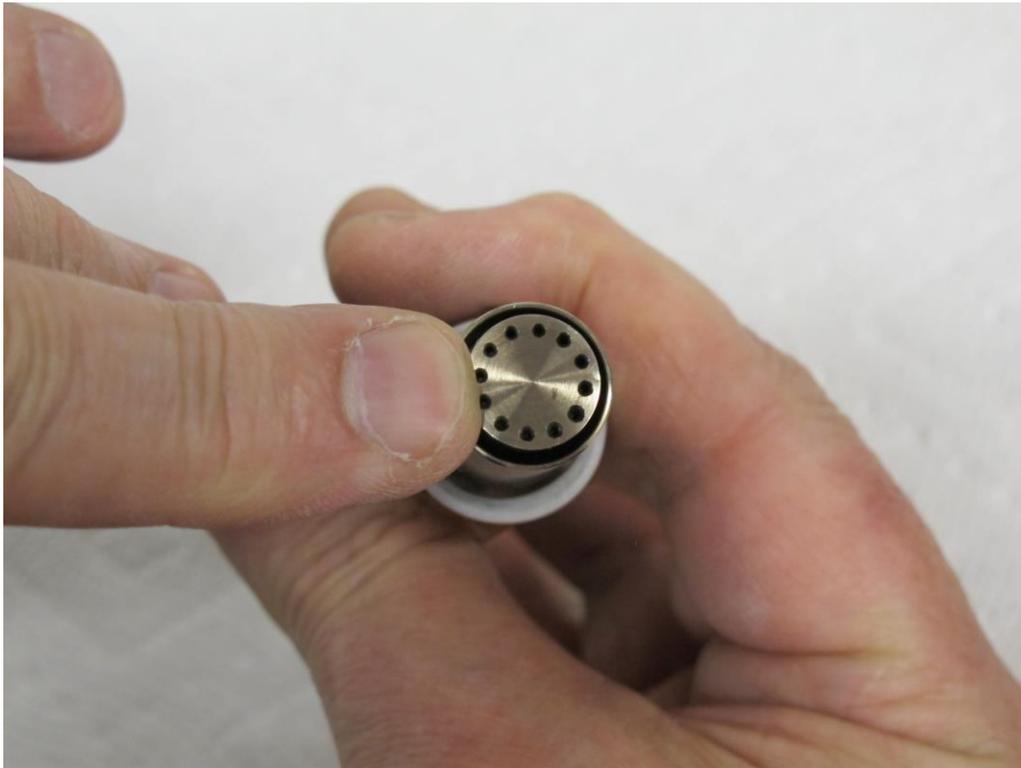
Time to reassemble the sensor. First screw in the ground electrode by hand and snug it down a bit with the wrench. Do not overtighten. Actually, the main purpose of the wrenches is to take the sensor apart so don't overtighten and strip the threads when reassembling.



Then screw on the outer shell. Again, be easy with the wrench! Don't ask us for torque targets; you're not going to run out and buy a tiny custom torque wrench and it's not critical. Just be easy and don't strip the treads.

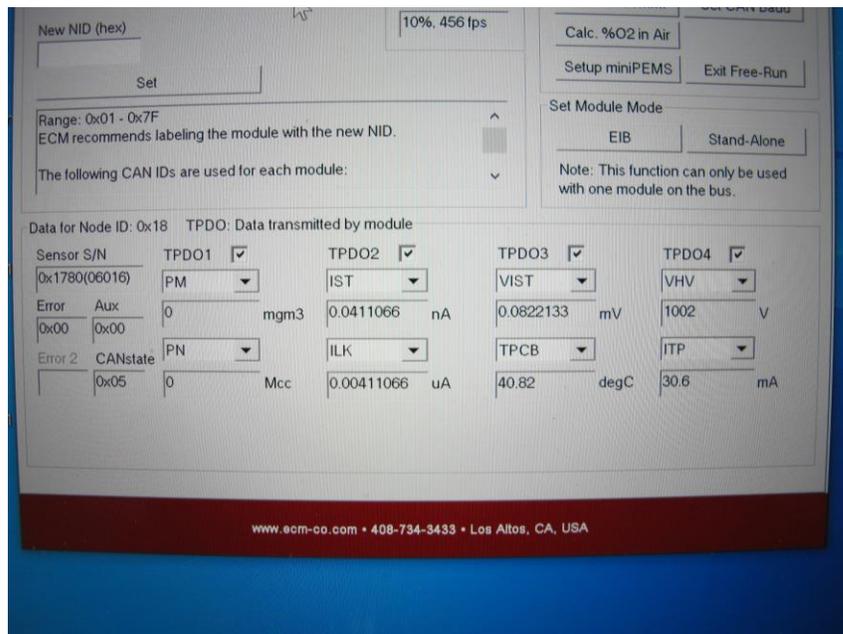


Holes look clean? You didn't drop the sensor, did you? The annulus should be even around the ground electrode (i.e. everything should be symmetric and centered).



Blow it out one more time. Yes, there is a lot of blowing out. You need to clean out flakes of soot, pieces of paper towel, and to evaporate any solvent. We recommend using DRY air. We attach one of those in-line air line desiccant dryer filters to the entrance of our spray nozzle. You can get those from a good auto parts or paint shop.

Lastly, attach the sensor to the pmCAN cable and electronics and see if the sensor shows low PM, PN, IST, and ILK numbers when the sensor is held in air. Note that VHV is at about 1000V.



## EC DECLARATION OF CONFORMITY

We declare under our sole responsibility that the products:

**AFM1540 Lambda Module**  
**AFM1600L, AFM1600D Modules**  
**DIS1000 Display head**  
**EGR 4830 Analyzer**  
**NO<sub>x</sub> 5210 NO<sub>x</sub> Analyzer**  
**Lambda 5220 Lambda Analyzer**  
**EGR 5230 EGR Analyzer**  
**NO<sub>x</sub>/NH<sub>3</sub> 5240 NO<sub>x</sub> and NH<sub>3</sub> Analyzer**  
**NH<sub>3</sub> 5250 Analyzer**  
**miniSOOT 5260 Analyzer**  
**LambdaCAN, LambdaCANc, LambdaCANd, LambdaCANp Lambda Modules**  
**NO<sub>x</sub> 1000, NO<sub>x</sub>CAN, NO<sub>x</sub>CANg, NO<sub>x</sub>CANt NO<sub>x</sub> Modules**  
**NH<sub>3</sub>CAN Module**  
**pmCAN**  
**baroCAN Module**  
**dashCAN, dashCANc, dashCAN+, dashCAN2**  
**appsCAN**  
**SIM200, SIM300, SIM400, SIM500, SIM600, SIM700, SIM800**  
**BTU200**  
**miniPEMS, miniPEMS2, PEMShen**

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)**



Ronald S. Patrick  
Vice President Sales  
September 2, 2019



**ECM** ENGINE CONTROL  
AND MONITORING

Los Altos, CA 94023-0040 • USA • (408) 734-3433 • Fax: (408) 734-3432 • [www.ecm-co.com](http://www.ecm-co.com)