ECM ENGINE CONTROL AND MONITORING

baroCAN

Humidity, %O_2, Dew Point, Temperature, and Pressure Module

Instruction Manual

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Introduction

baroCAN Description

baroCAN is a CANopen compliant module/sensor kit that measures relative humidity, temperature, and pressure. Based on these measurements, the $\%O_2$ in the air, water vapor pressure, humidity ratio, and dew point are calculated. All parameters are available for CAN transmission in all known units. The sensors can be user-calibrated.

baroCAN is useful for engine inlet air, engine intake manifold air, and cabin air monitoring.

baroCAN Kit Contents

The baroCAN kit consists of:

	Description	P/N
1.	baroCAN Control Module	02-06
2.	Humidity and Temperature (RH) Sensor, 0.6m cable	07-07
3.	Pressure Sensor, 0.6m cable (USA, 1/4" Swagelok) or	07-08
	Pressure Sensor, 0.6m cable (Metric, 6mm Swagelok)	07-09
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10.	2m Eurofast 12mm Cable	09-02
11.	DC Power Cable, DB9F, Banana	11-02
12.	Manuals and Configuration Software CD	13-01

Optional Components:

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2.	DC Power Cable, DB9F, Spades	11-01
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	(requires Deutsch DTM3m to DB9F, P/N 11-17)	
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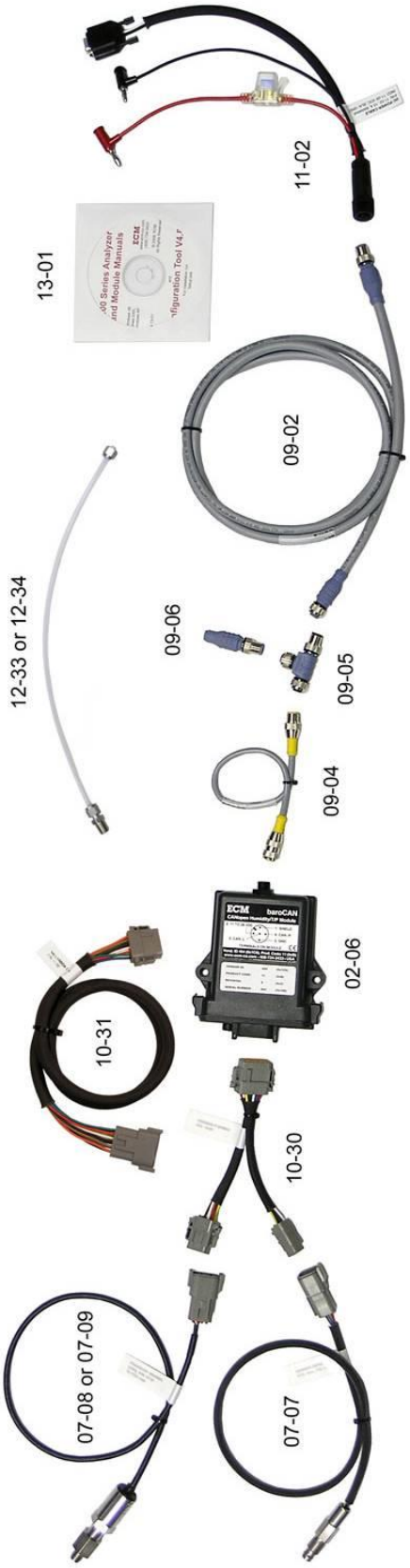
baroCAN Kit Appearance



Specifications and Limitations

Inputs:	Relative Humidity (RH) and Temperature Sensor Pressure Sensor		
Ranges:	RH	0 to 100%	
	Temperature	-40 to 125°C	
	Pressure	70 to 140 kPa Absolute	
	Dew Point	0 to 125°C	
	$\%O_2$	0 to 20.946%	
	Vapor Pressure	0 to 234 kPa Absolute	
	Humidity Ratio	0 to 100%	
Accuracies:	RH	±2%	(12-bit resolution)
	Temperature	±0.3°C	(14-bit resolution)
	Pressure	±0.2 kPa	(16-bit resolution)
	Dew Point	±0.88°C	
	$\%O_2$	±0.02%	
	Vapor Pressure	±0.09 kPa	
	Humidity Ratio	±0.06%	
Response Time:	1 sec (RH, Temperature, Dew Point, $\%O_2$, Vapor Pressure, Humidity Ratio), 25 msec (Pressure)		
CAN:	High Speed according to ISO 11898		
Configuration:	Via CAN bus with Configuration software. Programmable node ID.		
Size & Weight:	145mm x 120mm x 40mm (4 ¾" x 1 ½" x 5 ¾"), 234gm (8.25oz)		
Environmental:	IP67, -55 to 125°C, 100% humidity, environmentally sealed		
Sensor Cable:	0.6m		
Sensor Extension Cable:	1m (2m available)		
Power:	6 to 32 VDC, AC/DC (optional)		
Sensor Mounting:	1/4" NPT (RH & Temperature) 1/4" NPT/ISO (Pressure)		

General Notes

Please note the following in regards to this manual:

1. All numbers are decimal unless preceded by the “0x” suffix which denotes a hexadecimal value (e.g. 0x0F = 15).

2. 1 byte contains 8 bits.

3. One “unsigned character” contains 1 byte (unsigned 8) and has a range of 0x00 – 0xFF (0 – 255).

4. One “string” contains 1 byte (unsigned 8) and has a range of 0x00 – 0xFF (0-255). The number represents an ASCII character.

5. One “unsigned integer” contains 2 bytes (unsigned 16) and has a range of 0x0000 – 0xFFFF (0 – 65535).

6. One “unsigned long” contains 4 bytes (unsigned 32) and has a range of 0x00000000 – 0xFFFFFFFF (0 – 4294967295).

7. One “single float” contains 4 bytes (single float) that represent a decimal number using the IEEE-754 standard.

8. A “lo” byte and “hi” byte can be combined as follows to form a 2 byte unsigned integer: lo byte = 0x10 (16), hi byte = 0x1F (31), 2 byte integer = 0x1F10 = 31*256+16 = 7952.

9. “lo” byte can also be referred to as the least significant byte (LSB).

10. If a subindex value for an Object Dictionary (OD) is unspecified, it is assumed to be 0x00.

11. Data value boxes that are shown as blank are reserved; do not use these locations.

12. All messages on the CAN bus must have a unique identifier which is referred to as “CANid” in this manual but can also be referred to as “COB ID, communication object identifier”.

How to Use

Mounting the Sensors

There are two sensors: one sensor measures humidity and temperature (P/N 07-07) and one measures pressure (P/N 07-08 or 07-09). The humidity (and temperature) sensor has a ¼" NPT thread and can be threaded into objects that do not exceed 125°C. The pressure sensor cannot be directly threaded into hot objects (i.e. anything that exceeds 30°C). Therefore, pressure is to be routed to the pressure sensor via the supplied pressure line (P/N 12-33 or 12-34). The pressure sensor can be directly threaded into objects that do not exceed 30°C. To do this, remove the Swagelok fitting on the pressure sensor exposing the ¼" NPT thread.

Mount both sensors so that liquids cannot accumulate in the sensors.

Hardware Setup

Power and CAN connections to the module are made using the Eurofast 12mm connector on the module. The power input requirement is 6 to 32VDC at 0.25A (steady-state). Multiple modules can share the CAN bus. All modules are configured to broadcast CAN messages at the CAN baud rate of 500K. The maximum distance between any two nodes on the CAN bus at this baud rate is 100m. Each end of the CAN bus must have a terminating resistor of 121 Ohms.

Using the Configuration Tool

There are two ways to configure and retrieve data from the baroCAN module: via ECM's Configuration Tool or via CAN messages sent by another program. This section describes how to use the ECM Configuration Tool. For details on manually sending CAN messages, see the section on CAN Communication Protocol.

The Configuration Tool runs on your PC and uses a CAN communication device to communicate with one or more modules. While the tool is being used with modules, only ECM modules set to stand-alone mode (see Appendix C) should be connected to the CAN bus. baroCAN is shipped from the factory in stand-alone mode.

The Configuration Tool supports four CAN communication devices: Kvaser, ETAS, Peak USB to CAN adapters, and the VectorCAN CAN adapter card. Driver software for one of these adapters must be installed prior to using the Configuration Tool. These drivers will be supplied with the adapter or be available on-line from the manufacturer. The Configuration Tool is delivered on a CD.

Starting the Configuration Tool

Once the adapter's driver and the Configuration Tool software are installed, and with the baroCAN module(s) powered and connected to the CAN adapter, start the Configuration Tool software. Click on the "Modules" tab, select the CAN adapter, and click on the "START" button. The software will identify all 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. resistors). 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.

Once the Configuration Tool has identified all modules, you can select from the "Module" field the module to focus on. There are three things you can do for the selected module:

1. View data coming from that module in real-time and optionally logging it.
2. Configure a module. This includes programming the module's outputs.
3. Produce a .dbc file to be used by your data acquisition program.

View Module Data

A typical view of the Configuration Tool for a baroCAN module appears as shown below in Figure 1. On the bottom of the window, data from the module (TPDOs) is displayed. Each TPDO has two parameters. You can activate any combination of TPDOs by checking the box beside the TPDO. Available parameters are shown in Table 1. Minimize the number of activated TPDOs to minimize the bus load. The parameters transmitted in each TPDO are selected from the pull-down menus. Once a TPDO is activated, data appears in the display in real-time. Table 1 contains the names and meanings of the parameters available with baroCAN.

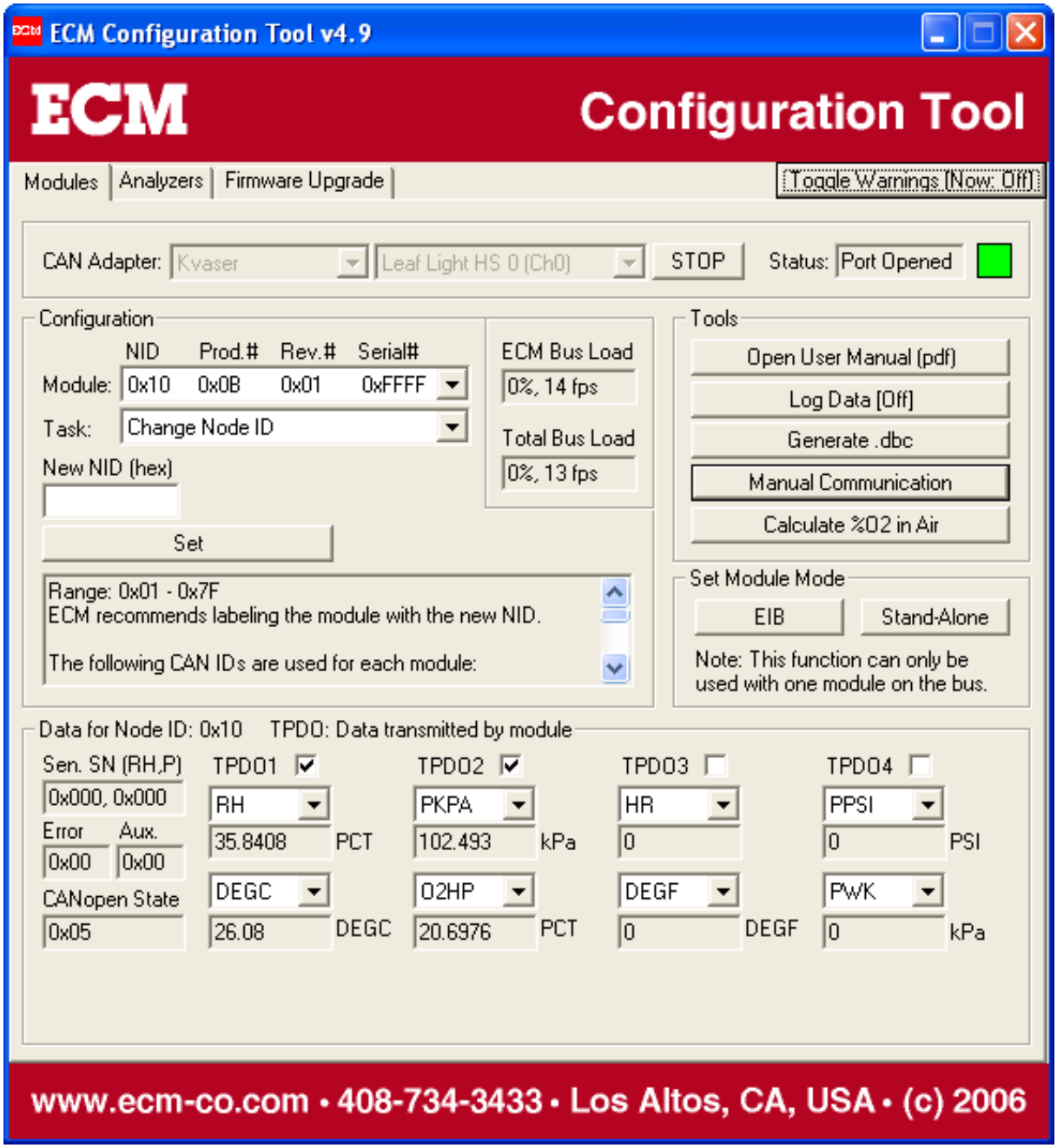


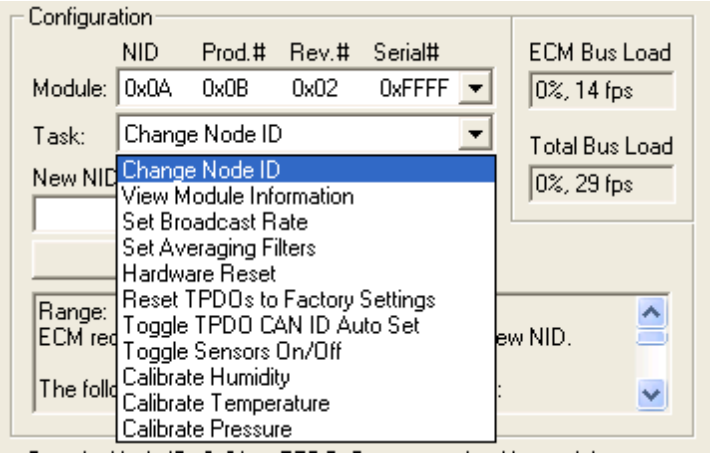
Figure 1: Configuration Tool window for baroCAN

Name	Full Parameter Name	Parameter Description	OD Index
VSW	Vsw (V)	Supply voltage to power control circuitry	0x2009
TEMP	Board Temp (°C)	Temperature of the module circuit board	0x200B
ERFL	Error bit flags (bits)	Module error flags (unsigned long format)	0x200E
ERCd	ECM CANOpen Error Code	ECM CANOpen Error Code	0x200F
P	Pressure (mmHg)	Pressure in mmHg	0x2016
PVLT	Pressure (V)	Analog voltage from pressure sensor	0x201E
PKPA	Pressure (kPa)	Pressure in kPa	0x201F
PBAR	Pressure (bar)	Pressure in bar	0x2020
PPSI	Pressure (psi)	Pressure in psi	0x2021
DEGC	Temperature (°C)	Temperature of sensor in Celsius	0x2029
DEGF	Temperature (°F)	Temperature of sensor in Fahrenheit	0x202A
DEGR	Temperature (°R)	Temperature of sensor in Rankine	0x202B
DEGK	Temperature (K)	Temperature of sensor in Kelvin	0x202C
PW	Vapor Pressure (mmHg)	Partial pressure of water vapor in mmHg	0x202D
PWK	Vapor Pressure (kPa)	Partial pressure of water vapor in kPa	0x202E
PWB	Vapor Pressure (bar)	Partial pressure of water vapor in bar	0x202F
PWP	Vapor Pressure (psi)	Partial pressure of water vapor in psi	0x2030
RH	Relative Humidity (%)	Relative humidity	0x2031
HR	Humidity Ratio	Humidity ratio	0x2032
TDWC	Dew Point (°C)	Dew point in Celsius	0x2033
TDWF	Dew Point (°F)	Dew point in Fahrenheit	0x2034
O2HP	%O2 in air	%O2 in air based on humidity & pressure	0x2035

Table 1: TPDO Parameter List

Configure Module

Configuration tasks are selectable in the “Task” field below the “Module” field. Below is an image of the available configuration tasks for the baroCAN. Each task is explained on the next page.



Change Node ID: Allowable range 0x01 to 0x7F (hex). When you assign a Node ID (NID), the following CANs **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 Ver., and Software Ver.

Set Broadcast Rate: All activated TPDOs are transmitted every "n" milliseconds. "n" can be programmed. 5ms is the minimum. Data is sent at a baud rate of 500 kbps. See the Broadcast Rate Limitation calculation on the next page. Default is 250ms.

Set Averaging Filters: Sensor data is averaged as it is retrieved by the module and before being broadcast. This averaging can be used to reduce the effect of noise or smooth the data. The averaging filter (α) can range from 0.001 (heavy averaging) to 1.000 (no averaging). The averaging filters (also called recursive averaging filters or digital low-pass filters) are used as follows: $AvgData_{n+1} = \alpha \times Data_n + (1 - \alpha) \times AvgData_n$

Where: $AvgData_{n+1}$ = Current averaged data value. This is the data sent in TPDOs.

α = User-programmable averaging filter, also called "alpha".

$Data_n$ = Current data value measured by the module.

$AvgData_n$ = Previous averaged data value.

Data is sampled and $AvgData_{n+1}$ updated every 1sec for RH and Temperature, and every 25ms for Pressure. Defaults for RH, Temperature and Pressure are: 1.000, 1.000, 1.000.

Hardware Reset: This is the same as power cycling the module.

Reset TPDOs to Factory Settings: Selects default input parameters.

Toggle TPDO CAN ID Auto Set: For advanced users, TPDO CAN IDs can be configured to an ID in the range 0x181 – 0x57F. However, they are automatically set to defaults again when the module is power cycled or node ID is changed. If you want the module not to reset the CAN IDs after the module is power cycled, then set to [Off]. Default is [On].

Toggle Sensors On/Off: Each of the two sensors used with baroCAN can be independently deactivated (ignored). When deactivated, the module will stop reporting error codes related to that sensor. Some baroCANs can be supplied without a pressure sensor. When a sensor is not connected to the baroCAN, it should be toggled off.

Calibrate Humidity: The RH (humidity and temperature) sensor is factory-calibrated. This factory calibration can be user-modified according to the formula: RHcorrected = RH x Gain + Offset. Both the factory calibration and user-modification data are stored in the sensor and stays with the sensor even if it is installed on another baroCAN.

Calibrate Temperature: Similarly, the temperature sensor can be user-modified according to the formula: Tcorrected = T x Gain + Offset

Calibrate Pressure: Similarly, the pressure sensor can be user-modified according to the formula: Pcorrected = P x Gain + Offset

Broadcast Rate Limitation

"Broadcast Rate (ms)" must be set to be greater than the "Total number of TPDOs for all devices x 0.3125"

Example: There are 8 devices on the CAN bus.

NID 0x01 has 3 TPDOs enabled, NID 0x02 has 1 TPDOs enabled
NID 0x03 has 4 TPDOs enabled, NID 0x04 has 2 TPDOs enabled
NID 0x05 has 4 TPDOs enabled, NID 0x06 has 4 TPDOs enabled
NID 0x07 has 4 TPDOs enabled, NID 0x08 has 4 TPDOs enabled

Minimum Broadcast Rate (ms) = (3 + 1 + 4 + 2 + 4 + 4 + 4 + 4) x 0.3125 = 8.125ms. Since the broadcast rate is valid only in increments of 1ms, round 8.125ms up to the next integer value, 9ms. Therefore no device can have a TPDO broadcast rate less than 9ms.

Generate a DBC File

A .dbc file describes to a device receiving data from one or more modules (e.g. a PC) 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 Software has a tool called "Generate .dbc…" that will generate a .dbc file for all the 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:

TPDO Data: name_nid[units]
Where: name = parameter name. See Table 1.
nid = node id of module in hex
units = units of parameter
For example:
TEMP_0x01[degC] which is the temperature of module with nid 0x01

Error code: ECM_Error_Code_nid
Where: nid = node id of module hex
(error code is in hex and given in Appendix A)
For example: ECM_Error_Code_0x11

CAN Communication Protocol

baroCAN provides CAN communication based on the CANopen protocol. The basics of the protocol are described in this section. This document assumes the user understands CAN, and only needs to know the details of the CANopen protocol as used by baroCAN.

CANopen Message Types

In CANopen, each device on the CAN bus is identified by a unique number called the Node Id (NID), which ranges from hexadecimal 0x01 to 0x7F. This means that you cannot have more than 127 devices on the bus at a time. The NID is also used to generate the standard 11-bit CANid of the messages transmitted and received by the device. The table below contains a list of the CANids used for each CANopen device. When connecting non-ECM or non-CANopen devices to the same CAN bus, ensure that these CANids are not used.

Message Type	CANid (hex)
NMT	0x00
Emergency	0x80 + NID
TPDO1	0x180 + NID
TPDO2	0x280 + NID
TPDO3	0x380 + NID
TPDO4	0x480 + NID
SDO Tx	0x580 + NID
SDO Rx	0x600 + NID
Heartbeat	0x700 + NI
LSS	0x7E4, 0x7E5

There is a master-slave relationship for all devices on the CAN bus. All ECM modules are slaves. A slave broadcasts data for the master to receive, and also listens for commands from the master. There can be no more than one master on the bus at any time. A master may or may not be assigned a NID. For example, communicating with the devices via software on a computer, such as the ECM Configuration Tool. Software on a computer is not a device, therefore, does not need to be assigned a NID.

Emergency Messages

Broadcast Rate = 0.5sec, DLC = 6.
This message is transmitted by the device and contains all errors codes.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x80 + NID	CO Error		Err Reg	ECM Error		0x00		

CO Error = Error codes defined by CANopen (big endian, LSB first). See Appendix A.
Err Reg = Error register defined by CANopen. See Appendix A.
ECM Error = ECM-specific error codes (bid endian, LSB first). See Appendix A.

Heartbeat Message

Broadcast Rate = 0.25sec, DLC = 1.
Transmitted by the device to indicate status and that the device is on, or "alive".

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x700 + NID	State							

State = NMT state, or CANopen state, of the device defined by CANopen.
The NMT states are:

0x00	Boot-up
0x04	Stopped
0x05	Operational
0x7F	Pre-operational

TPDOs (Transmit Process Data Objects)

A TPDO message consist of two pieces of data called Process Data Object (PDO) that is transmitted by the module. Each module can transmit up to four TPDOs at a programmable broadcast rate. The data contained in the TPDO is programmable from a list of available parameters (see Table 1). Each TPDO can also be enabled or disabled.

Each PDO is a single precision 32-bit floating point number that conforms to the IEEE-754 Standard, and is transmitted on the CAN bus in big endian format (LSB first).

TPDO1 CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x180 + NID	TPDO1, Parameter A				TPDO1, Parameter B			
TPDO2 CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x280 + NID	TPDO2, Parameter A				TPDO2, Parameter B			
TPDO3 CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x380 + NID	TPDO3, Parameter A				TPDO3, Parameter B			
TPDO4 CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x480 + NID	TPDO4, Parameter A				TPDO4, Parameter B			

SDOs (Service Data Objects)

SDO messages are used to read or write to elements in a table of configuration parameters called the Object Dictionary (OD) stored in the slave device, i.e. ECM modules. They consist of two types, received and transmitted. Received SDOs are messages sent from a master to slave device to command a read or write of parameters. Transmitted SDOs are messages sent by the module in response to a master's commands. Elements in the Object Dictionary are referenced by an Index and Subindex. See later sections for the commands and Object Dictionary locations of configurations for baroCAN.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	cmd	index		subindex	data 3	data 2	data 1	data 0
0x580 + NID	ack	index		subindex	data 3	data 2	data 1	data 0

cmd = master's command for read or write. Typical values are:
0x40 - command a read.
0x23 - command a write of 4 data bytes.
0x27 - command a write of 3 data bytes.
0x2B - command a write of 2 data bytes.
0x2F - command a write of 1 data byte.

ack = slave's acknowledge reply of master's command. Typical values are:
0x43 - read reply containing 4 data bytes.
0x47 - read reply containing 3 data bytes.
0x4B - read reply containing 2 data bytes.
0x4F - read reply containing 1 data byte.
0x60 - acknowledge a successful write.
0x80 - error, read/write command aborted.

index = Object Dictionary Index (little endian).

subindex = Object Dictionary Subindex.

data 0~3 = four available data bytes formatted as little-endian of configurations to write to or configurations read from the slave.

Configuring the baroCAN via CAN

Enable/Disable Humidity Sensor

To enable or disable the humidity sensor, use the following OS commands. Note that temperature readings will also be effected since temperature data is retrieved from the same sensor. See Appendix B for details about OS commands.

0x4B Turn on sensor
0x4C Turn off sensor

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x2F	0x23	0x10	0x01	OS cmd			

The reply from the module:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x580 + NID	0x60	0x23	0x10	0x01				

Enable/Disable Pressure Sensor

To enable or disable the pressure sensor, use the following OS commands. See Appendix B for details about OS commands.

0x46 Turn on sensor
0x47 Turn off sensor

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x2F	0x23	0x10	0x01	OS cmd			

The reply from the module:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x580 + NID	0x60	0x23	0x10	0x01				

Change Node Id

The Node ID (NID) can be programmed from 0x01 to 0x7F (1 to 127). To change the NID, several messages must be sent, followed by a reset of the device.

Start by sending the following message to place the module into pre-operational mode.

CAN id	byte 0	byte 1
0x00	0x80	NID

The next message(s) place the device(s) into LSS (Layer Select Services) configuration mode. If there is only one CANopen device on the CAN bus this process requires only one message. If there are several CANopen devices on the same CAN bus, the specific device must be identified using Product Code, Revision Number and Serial Number.

Multiple Devices on the Bus

CAN id	byte 0	byte 1	byte 2	byte 3	byte 4
0x7E5	0x04	0x00			
0x7E5	0x40	0xC6	0x01	0x00	0x00
0x7E5	0x41	Product Code			
0x7E5	0x42	Revision Number			
0x7E5	0x43	Serial Number			

Single Device on the Bus

CAN id	byte 0	byte 1
0x7E5	0x04	0x01

The device will reply with byte 0 = 0x44 on CAN id 0x7E4 if it enters LSS configuration mode successfully.

The next message sent contains the new NID as an unsigned hexadecimal character.

CAN id	byte 0	byte 1
0x7E5	0x11	new NID

The device will reply with byte 0 = 0x11 and byte 1 = 0x00 on CAN id 0x7E4 indicating a successful NID change.

The last message sent takes the device out of configuration mode.

CAN id	byte 0	byte 1
0x7E5	0x04	0x00

After the NID has been successfully changed, the device enters pre-operational mode and does not broadcast data. The device can be returned to broadcast mode 1 of 3 ways:

1. Power-cycle the device by flipping the switch off and on again.

2. Send a command instructing the device to perform a hard reset (similar to power-cycling but software controlled).

CAN id	byte 0	byte 1
0x00	0x81	NID

3. Send a command instructing the device to reset the CAN interface only.

CAN id	byte 0	byte 1
0x00	0x82	NID

TPDO Broadcast Rate

The broadcast rate of TPDOs is programmable from 5ms to 60000ms. The broadcast rate applies to all enabled TPDOs. The configuration for broadcast rate is stored at OD location 0x1800, 0x05. The value stored here is a 16-bit integer number.

To read the current configuration, send the follow message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x40	0x00	0x18	0x05				

The reply from the module:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x580 + NID	0x4B	0x00	0x18	0x05	Broadcast Rate			

Where Broadcast Rate is a 16-bit number formatted as little endian.

To set a new broadcast rate, send the follow message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x2B	0x00	0x18	0x05	Broadcast Rate			

Where Broadcast Rate is a 16-bit number formatted as little endian.

The reply from the module:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x580 + NID	0x60	0x00	0x18	0x05				

There is a minimum broadcast rate that is dependent on the number of devices transmitting on the CAN bus and how many TPDOs have been enabled for each module. If the broadcast rate is set too fast, the CAN bus will be overloaded, and communication will be unstable. The formula for calculating the minimum broadcast rate is as follows:

Minimum Broadcast Rate (ms) > Total number of TPDOs for all devices x 0.3125

Example: There are 8 devices on the CAN bus.
NID 0x01 has 3 TPDOs enabled
NID 0x02 has 1 TPDOs enabled
NID 0x03 has 4 TPDOs enabled
NID 0x04 has 2 TPDOs enabled
NID 0x05 has 4 TPDOs enabled
NID 0x06 has 4 TPDOs enabled
NID 0x07 has 4 TPDOs enabled
NID 0x08 has 4 TPDOs enabled

Minimum Broadcast Rate (ms) = (3 + 1 + 4 + 2 + 4 + 4 + 4 + 4) x 0.3125 = 8.125ms. Since the broadcast rate is valid only in increments of 1ms, round 8.125ms up to the next integer value, 9ms. Therefore no device can have a TPDO broadcast rate less than 9ms.

TPDO Enable/Disable

Each TPDO each can be individually enabled or disabled from transmitting. The OD Index of the TPDO enable/disable configurations for each TPDO are located in the table below. This OD location also configures the CAN ID from which the TPDOs will be sent. Below lists the default value.

TPDO	Config OD	CAN ID
TPDO1	0x1800	0x180 + NID
TPDO2	0x1801	0x280 + NID
TPDO3	0x1802	0x380 + NID
TPDO4	0x1803	0x480 + NID

To enable/disable a TPDO, perform a SDO write as follows:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x2F	0x180n		0x01	CAN ID		0x00	en/dis

Where 0x180n correspond to the configuration's OD location for the particular TPDO listed in the table above, CAN ID is the CAN ID from which the TPDO is sent (defaults listed above), and en/dis is either set to 0x40 (enable) or 0xC0 (disable). 0x180n and CAN ID are formatted as little endian.

If the CAN ID is to be left as is when configuring TPDO enable/disable, the default value can be written if the configuration is always set at default. Alternatively, read the current configuration, modify the list byte, and write it back.

TPDO Mapping

The two PDOs transmitted on each TPDO are configurable by the user. This is called TPDO mapping. The PDO parameter is said to be mapped to the TPDO to be transmitted.

The OD Index of the TPDO Mapping configurations for each TPDO are listed below.

TPDO	Config OD
TPDO1	0x1A00
TPDO2	0x1A01
TPDO3	0x1A02
TPDO4	0x1A03

TPDO mapping is a 4 step process:

1. Write a 0 to subindex 0x00 of the above listed TPDO Mapping configurations location.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x2F	0x1A0n		0x00	0x00			

2. Enter the OD index of the 1st PDO (see Table 1 for a list of parameters) at subindex 0x01.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x23	0x1A0n		0x01	0x20	0x00	PDO OD Index	

3. Enter the OD index of the 2nd PDO (see Table 1 again) at subindex 0x02.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x23	0x1A0n		0x02	0x20	0x00	PDO OD Index	

4. Write a 2 to subindex 0x00.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x2F	0x1A0n		0x00	0x02			

Where 0x1A0n correspond to the TPDO Mapping configurations OD location for the particular TPDO listed in the table above, and PDO OD Index is the index of the PDO parameter in Table 1. Both values are formatted as little endian.

Factory Reset

To reset all user-configurable parameters to factory defaults, use the OS command 0xDF. See Appendix B for details about OS commands.

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x2F	0x23	0x10	0x01	0xDF			

The reply from the module:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x580 + NID	0x60	0x23	0x10	0x01				

Appendices

Appendix A: Error Codes

CO ERROR CODE	DESCRIPTION OF ERRORS
0x0000 - 00FF	No error or error reset
0x1000 - 10FF	Generic
0x2000 - 20FF	Current
0x2100 - 21FF	Current - Device inputs
0x2200 - 22FF	Current - Inside the module
0x3000 - 30FF	Voltage
0x3100 - 31FF	Voltage - Main voltage
0x3200 - 32FF	Voltage - Inside the module
0x3300 - 33FF	Voltage - Output
0x4000 - 40FF	Temperature
0x4100 - 41FF	Temperature - Ambient
0x4200 - 42FF	Temperature - Device
0x5000 - 50FF	Device Hardware
0x6000 - 60FF	Device Software
0x6100 - 61FF	Device Software - Internal
0x6200 - 62FF	Device Software - User
0x6300 - 63FF	Device Software - Data set
0x7000 - 70FF	Additional Modules
0x8000 - 80FF	Monitoring
0x8100 - 81FF	Monitoring - Communication
0x8110	Monitoring - CAN Overrun (objects lost)
0x8120	Monitoring - CAN in error passive mode
0x8130	Monitoring - Node Guarding or Heartbeat Error
0x8140	Monitoring - Recovering from bus off
0x8150	Monitoring - Transmit COB ID collision
0x8200 - 82FF	Protocol
0x8210	Protocol - PDO not processed due to length error
0x8220	Protocol - PDO length exceeded
0x9000 - 90FF	External
0xF000 - F0FF	Additional functions
0xFF00 - FFFF	Device specific
ERROR REGISTER	
BIT	**DESCRIPTION**
0	Generic Error
1	Current
2	Voltage
3	Temperature
4	Communication Error
5	Device profile defined error
6	Reserved (always 0)
7	Manufacturer Specific Error

ECM ERROR CODE	LED ACTION	DESCRIPTION OF ERRORS
0x0000	Grn On	All OK, (green led constantly on)
0x0001	Flash Grn 10Hz	Sensor warm-up period
0x0002	Grn/Both/Red 2s	Power on reset/ Init hardware
0x0013	Red On	Sensors turned off (red led constantly on)
0x0014	Pulse Red 1x/2s	Pressure sensor disconnected
0x0015	Pulse Red 1x/2s	Humidity sensor disconnected
0x0021	Pulse Red 2x/2s	1wire bus shorted
0x0022	Pulse Red 2x/2s	No 1wire present
0x0023	Pulse Red 2x/2s	CRC16 error
0x0024	Pulse Red 2x/2s	Invalid 1wire parameter (sensor type)
0x0025	Pulse Red 2x/2s	1wire data format not compactible (old rev)
0x0031	Pulse Red 3x/2s	+Vsw < 6 for > 7sec
0x0032	Pulse Red 3x/2s	+Vsw > 32V
0x00A1	N/A	Invalid software state
0x00B1	N/A	CAN overrun
0x00B2	N/A	CAN passive mode
0x00B3	N/A	CAN heartbeat error
0x00B4	N/A	CAN recover bus off
0x00B5	N/A	CAN Tx CanId collision
0x00B6	N/A	Serial overrun
0x00B7	N/A	CAN overrun Lss
0x00B8	N/A	CAN overrun Sdo
0x00B9	N/A	CAN overrun Rx
0x00BA	N/A	CAN overrun ECT5
0x00FF	Both On	Module powering down within 500ms

Appendix B: OS Commands

CANopen allows for an addition set of operational commands for the device defined by the manufacturer. These are called OS commands. OS commands are sent as an SDO write message to OD location 0x1023, 0x01.

To activate an OS command, send the following message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x2F	0x23	0x10	0x01	OS cmd			

The reply from the module indicating a successful write:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x580 + NID	0x60	0x23	0x10	0x01				

Depending on the function of the OS commands, the action may not be instantaneous and may take some time to complete. An OS command status register will indicate the status of the OS command, which can be retrieved by requesting an SDO read of the OD location 0x1023, 0x02. Send the following message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x40	0x23	0x10	0x02				

The reply from the module:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x580 + NID	0x60	0x23	0x10	0x02	Status			

Where status can be one of the following values:

0x00	Last command completed. No error occurred. No reply.
0x01	Last command completed. No error occurred. The reply can now be read.
0x02	Last command completed. Error occurred. No reply.
0x03	Last command completed. Error occurred. The reply can now be read.
0x04 - FE	Reserved
0xFF	Command is executing.

Depending on the function of the OS command, the device may return an OS command reply, usually indicating a successful operation or details of its failure. If the OS status indicates a reply is ready, you can read it by requesting an SDO read of OD location 0x1023, 0x03. Send the following message:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x600 + NID	0x40	0x23	0x10	0x03				

The reply from the module:

CANid	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Bye 6	Byte 7
0x580 + NID	0x60	0x23	0x10	0x03	Reply			

Below is a list of OS commands for the module, along with the OS replies for each, if any.

Command	Value	Description	Reply
SensorOnP	0x46	Turn on pressure sensor.	None
SensorOffP	0x47	Turn off pressure sensor.	None
OWDisableP	0x48	Ignore 1wire memory calibration values for pressure sensor.	None
OWEnableP	0x49	Use 1wire memory calibration values for pressure sensor.	None
ForceOWReadP	0x4A	Force module to read 1wire memory (if OWEnabled) or EE memory (if OWDisabled) for pressure sensor.	
		defOWReadSuccessfully	0x00
		defEEReadSuccessfully	0x01
		defOWInvalidSenType	0xFD
		defOWZeroSpanDataCRCFail	0xFE
		defOWReadError	0xFF
SensorOnRH	0x4B	Turn on humidity sensor.	None
SensorOffRH	0x4C	Turn off humidity sensor.	None
OWDisableRH	0x4D	Ignore 1wire memory calibration values for humidity sensor.	None
OWEnableRH	0x4E	Use 1wire memory calibration values for humidity sensor.	None
ForceOWReadRH	0x4F	Force module to read 1wire memory (if OWEnabled) or EE memory (if OWDisabled) for humidity sensor.	
		defOWReadSuccessfully	0x00
		defEEReadSuccessfully	0x01
		defOWInvalidSenType	0xFD
		defOWZeroSpanDataCRCFail	0xFE
		defOWReadError	0xFF
FactoryReset	0xDF	Set all EE values to standard configuration.	None

Appendix C: Module EIB Mode and Stand-alone Mode

CAN data from modules can either be taken directly from the modules themselves or from the CAN port of display heads connected to the modules. When CAN data is taken directly from one or more modules, each module must in Stand-alone mode. When CAN data is taken from one or more display heads, 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 modules are sold alone (i.e. not with a 5210, 5220, or 5230 display head), they are delivered in Stand-alone mode.

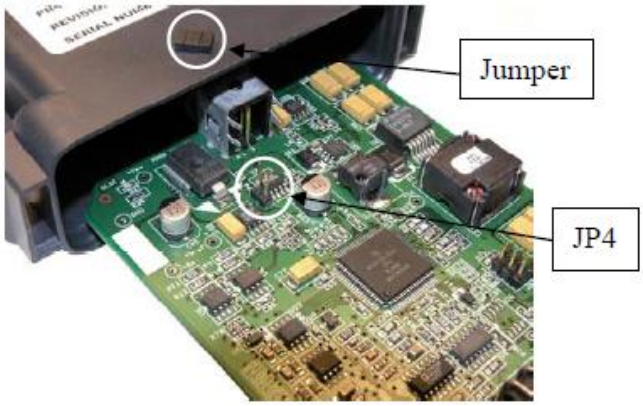
To convert from one mode to the other requires software reprogramming of the module followed by installation (for Stand-alone) or removal (for EIB) of a jumper inside the module.

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

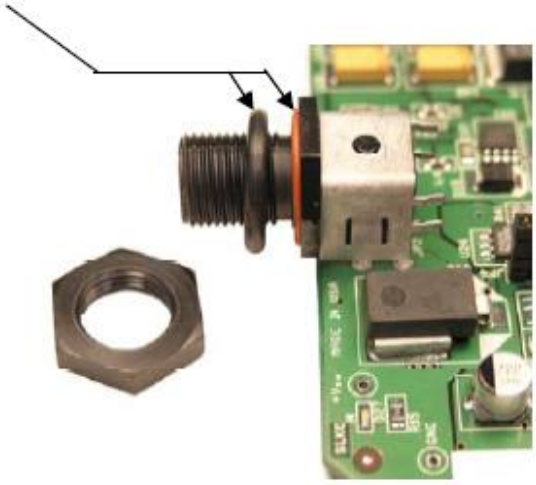
1. Take the nut off the end of the module. Use an 18mm socket without the wrench.

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

3. Slide the PCB out. Install a jumper on JP4.



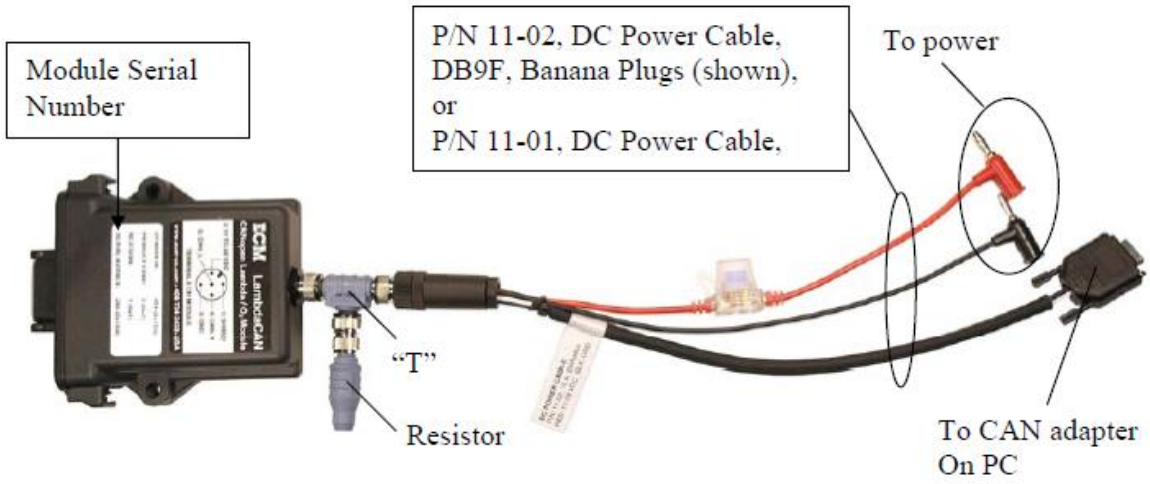
4. Make sure both O-rings are on the threaded connector.



5. Slide the PCB into the enclosure until the two tangs “click”.

6. Put the nut on and tighten ONLY ½ turn from where it is seated. If this nut is tightened too much, the connector will crack and the enclosure will not be sealed.

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.



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 "Set to Stand-Alone Mode". Wait for "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. Use the Configuration Tool (software) to "Set to EIB Mode".

2. Remove the jumper on JP4 in the module.

Appendix D: Using the dashCAN Display

The dashCAN display (see below) is a small (105 mm x 63 mm x 63 mm), two-channel remote display for CAN networks containing any ECM module (NOxCAN(g), LambdaCAN, appsCAN, baroCAN, etc). dashCAN comes with a two meter cable and a "T" (P/N 09-05). Simply attach dashCAN to the CAN bus and any two parameters being transmitted from modules can be displayed. dashCAN can display parameters from the same module or two different modules. 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 1.
iii. If the ENT button is pressed, the displays will show the units of the parameters. "PCTG" is %. "dIM" means dimensionless (ex. for AFR, FAR, PHI, Lambda).

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

i. "ERR" and "####" where "####" is an error code. See Appendix A.
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 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 2). First the options for the upper channel are shown on the upper display, followed by identical options for the lower channel on the lower display, ending with the global CONF (Configuration) setup. Pressing the ENT key will select the displayed setup option and allow its programming.

If "LOCK" is displayed, the 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. Default is NONE.
RATE		Set parameter averaging rate. Range 0.001 to 1.000 Default is 1.000 (no averaging)
dISP		Select parameter. Note: Parameters available are those programmed using Configuration Software.
CONF	LEdS LOCK	Set display intensity. Default is 3333. Lock and Unlock Display for Programming

MOd, RATE, and dISP appear on the upper display for the upper channel and on the lower display for the lower channel. CONF just appears on the lower display and is for global dashCAN setup. All entries must be followed by pressing the ENT key.

Table 2: Menu Tree for dashCAN

MOd (Module) Setup Option

In MOd setup, the serial number of the module assigned to the upper or lower channel is entered. The serial number is written on a label on the module. The module assigned to the upper channel will send information to the upper display and the module assigned to the lower channel will send information to the lower display. The same module can be assigned to both channels or different modules can be assigned to each channel.

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 programmed averaging that was programmed using the Configuration Software. This transmitted data can then be further averaged before being displayed on the displays. Separate averaging can be programmed for the upper display and the lower display.

The averaging 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:

$$\mathbf{DisplayedValue_{t+1} = \alpha \times Parameter_{t+1} + (1 - \alpha) \times DisplayedValue_t}$$

where:

$DisplayedValue_{t+1}$ = the new displayed value

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

$Parameter_{t+1}$ = the latest value transmitted by the module

$DisplayedValue_t$ = the previous displayed value

The selected display averaging does not affect the module's CAN transmission rate or averaging.

dISP (Display) Setup Option

In dISP setup, the parameters to be displayed are selected. Only parameters selected to be transmitted by the Configuration Software can be displayed.

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

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 desired parameter name is displayed. See Table 1. Then press the ENT key.
4. Press SYS to return to RUN mode.

CONF (Configure) Setup Option

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 is for global dashCAN 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.

◆ LOCK

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

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.

Warranty and Disclaimers

Warranty

The products described in this manual, with the exception of the RH 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 RH 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.

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