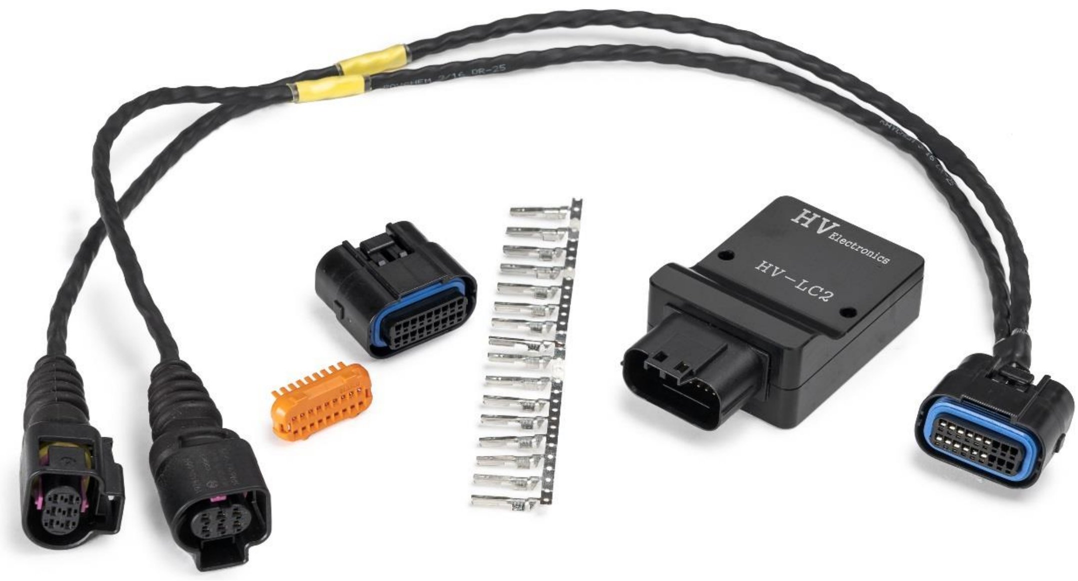


HV LAMBDA TO CAN USER MANUAL

HV-LC1 / HV-LC2

The HV-LC1 and HV-LC2 are single and dual channel devices used to control the Bosch LSU4.9 Lambda sensor. Precise sensor control is achieved using Bosch integrated circuit technology with CAN Bus 2.0B data communications.

HV Electronics

Rev 1.1

Table of Contents

1.0 Specification

Sensor Type

- Bosch LSU4.9. Supports Single or Dual channel

Power Supply

- Operating Voltage: 10.0 to 22.0 Volts DC
- Operating Average Current: 3A at 14.0V
- Operating Peak Current: 8A at 14.0V during sensor warm-up
- Reverse Battery Protection via External Fuse

Internal

- 64MHz 16-bit Automotive Processor
- Lambda range: 0.500 to 10.0
- Signal resolution 0.001 lambda
- Signal sampling rate 100 Hz
- EMAP Pump Current Compensation
- Analog Output(s): 12-bit 0.50V - 4.00V for Lambda 0.500 - 1.500.
    - 1.22mV Resolution
    - 22 Ohm Output Resistance

Communications

- CAN Baud Rate: 250kBaud, 500kBaud or 1Mbaud Auto Detect
- CAN transmit rate 100 Hz

Operating Temperature

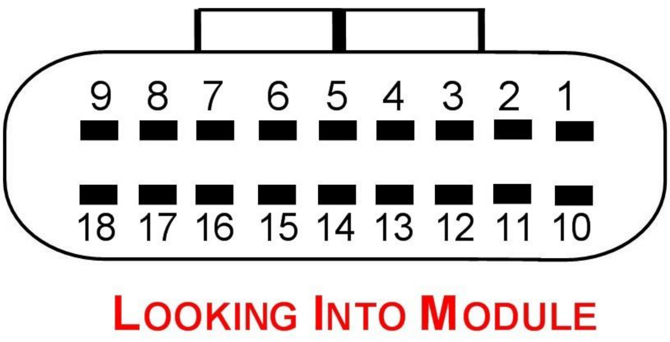
- Operating temperature range: -30 to 85°C (-22 to 185°F)

Physical

- Aluminium billet CNC enclosure
- Enclosure Size 50 mm x 38 mm x 15 mm
- 80g

2.0 Pinout

The device pinout is shown below in Table 2.0.



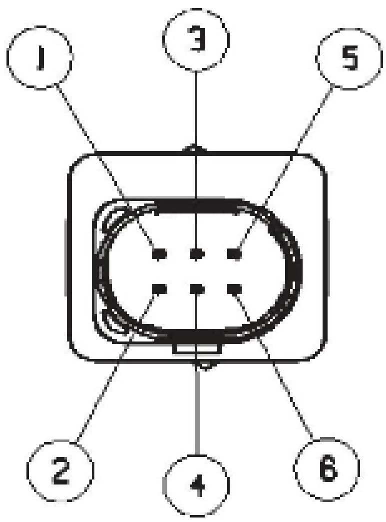
Pin Number	Function
1	Lambda 1 Heater Negative
2	Lambda 1 Heater Positive
3	Lambda 1 Virtual Ground
4	Lambda 1 Cal Resistor
5	Lambda 1 Nernst Cell
6	Lambda 1 Pump Current
7	Lambda 2 Analog Out
8	CAN Lo
9	14V
10	Lambda 2 Heater Negative
11	Lambda 2 Heater Positive
12	Lambda 2 Virtual Ground
13	Lambda 2 Cal Resistor
14	Lambda 2 Nernst Cell
15	Lambda 2 Pump Current
16	Lambda 1 Analog Out
17	CAN Hi
18	Ground

Table 2.0 . HVLC Module Pinout.

Lambda Connector: Bosch LSU 4.9 (F)

Pin	Function	Wire Colour
1	Pump Current (Ip)	Red
2	Virtual Ground	Yellow
3	Heater Ground (H-)	White
4	Heater 12 Supply (H+)	Grey
5	Cal Resistor (CalR)	Orange
6	Nernst Cell Voltage (Vs)	Black

Table 2.1. Bosch LSU 4.9 Connector Pinout



3.0 Device Installation

When mounting the HV-TEC4, it should never be placed where it can be exposed directly to radiated heat i.e. next to an exhaust manifold. Instead mount in cooler locations away from heat sources. Also in high vibration applications rubber mounting is recommended.

3.1 CAN Bus Wiring and Noise Immunity

To minimise signal contamination and maximise noise immunity, it is recommended to twist the following wire pairs as shown in Table 3.0. It is recommended to twist the wire pairs at a minimum one twist per 40mm of cable. This is very important and should always be implemented.

Pair 1		Pair 2
CAN High	<------->	CAN Low
Pump Current	<------->	Cal Resistor
Nernst Cell Voltage	<------->	Virtual Ground

Table 3.0. Wire twist paring

The HVLC does not include an on-board CAN termination resistor. CAN Bus termination must be done correctly by using a 120 ohm resistor at each end of the bus system.

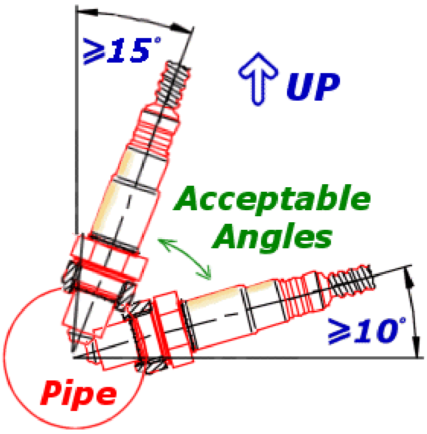
- The CAN Bus High and Low are differential signals, so twisted pair **MUST** be used. Failing to do so will compromise the entire CAN Bus System.
- In some extreme environments, shielded twisted pair may be required to help with reliability and data integrity.
- The less connectors in any transmission system the better. Unnecessary connectors are almost guaranteed to present an impedance discontinuity and hence may cause reflections and data loss.
- CAN Bus termination must be done correctly by using a 120 ohm 0.25W resistor at each END of the bus system.
- Maximum Stub length to a device from the main Bus is recommended at 0.3m, in accordance with High-Speed ISO 11898 Standard specification.

4.0 Lambda Sensor Installation

Installation angle must be inclined at least 10° towards horizontal (electrical connection upwards) up to a maximum of 75°. This prevents the collection of liquids between sensor housing and sensor element during the cold start phase.

The angle against the exhaust gas stream should be aimed as 90°. Maximum inclination should be 90°+15° (protection tube towards gas stream) or 90°-30°.

NOTE: NEVER mount the sensor directly on the horizontal or within 10 degrees of the horizontal. Doing so will result in intermittent sensor shutdown.



Also route the sensor cable to avoid high moisture locations – just a small amount of moisture is enough to provide a conductive path within the connector that will upset measurement from the sensor.
Winter and salted roads compound this issue. Always check for a cracked or broken connector when strange results occur.

5.0 Heater Control and Sensor Calibration

Heater Control

During engine startup, condensation forms in the exhaust which may damage the sensor. It is recommended to only start heating the LSU sensor after the engine is running and the moisture content in the exhaust has evaporated. CAN packets are provided to allow an ECU or Dash to control this (see section 8.4).

If the CAN bus is not used to control the heater, then by default the heater remains OFF for 15 seconds after the device is powered up.

Sensor Calibration

The sensor is calibrated by the HVLC on power up. During the Calibration process two important pieces of data are read:

- The optimal **Nernst Cell Temperature** which is used for sensor heater control. The HVLC applies duty cycle and a PID routine to maintain a constant and accurate heater temperature which results in a very stable and accurate Lambda value.
- The **Pump Current** that corresponds to a Lambda reading of 1.000 Lambda.

NOTE: A Free Air Calibration is NOT required on the LSU4.9. The sensor uses a reference pump current instead of reference air. The big advantage with this is the reference is a calibrated electrical signal and remains the same all the time.

6.0 Exhaust Back Pressure (EMAP) Compensation

Wideband Lambda sensors primarily count oxygen atom numbers through measuring the oxygen ion current within the sensors pump cell. The exhaust gas pressure affects this oxygen ion current – more pressure means more atoms per unit volume and a **higher** pump current at the same Lambda i.e. will cause the sensor to read farther from stoichiometric.

A rich reading will appear richer than it really is.
A lean reading will appear leaner than it really is.

This predominantly becomes an issue in Turbocharged applications. This is the main reason you should position the sensor after the turbo where exhaust back-pressure is lowest.

Excessive Exhaust Back Pressure (EMAP) can also damage the sensor. The following rule should be observed:

Exhaust Back Pressure	< 2.5 Bar

When measuring Exhaust Back Pressure an Absolute Pressure Sensor MUST be used. (i.e **do not** used a Gauge Pressure Sensor)

The HVLC can receive an EMAP value for this correction to be applied. The units must be in kPa to 1dp. See section 8.4.

7.0 CAN Communications

This section outlines the CAN Protocol used to communicate with the HVLC device(s). The CAN packets in most situations will be automatically decoded by the ECU to communicating with the HVLC. If manual decoding is required information is provided in this section.

7.1 Baud Rate

The device will Auto-scan the CAN bus until a successful baud rate has been detected. Once detected this rate will be stored by the device and used at the next power up.

The device will scan 3 different Baud rates at 500ms intervals moving from 1Mbaud -> 500kBaud -> 250k Baud -> 1Mbaud and so on.

For this process to function effectively, all new devices to the CAN bus should be connected one at a time.

7.1 Transmit Message Packet 1 - Data

This message contains Lambda, Pump Current data, Status and Diagnostic information. The channel addressing is sequential from Channel 1 to Channel 2. Two compound messages are transmitted per channel. By default:

- HVLC Channel 1 Transmits **2** compound messages on ID 671 , with byte 0 used for indexing.
- HVLC Channel 2 Transmits **2** compound messages on ID 672 , with byte 0 used for indexing.

For multiple HVLC devices on the CAN bus the Channel 1 ID can be reprogrammed. See section 8.2.

ID	671 /0x29F (Default)
Data	Lambda Channel 1
ID Type	Standard 11 bit identifier
Direction	Transmit from HVLC
Length	8 bytes
Rate	100Hz/10ms

ID	672 /0x2A0 (Default)
Data	Lambda Channel 2
ID Type	Standard 11 bit identifier
Direction	Transmit from HVLC
Length	8 bytes
Rate	100Hz/10ms

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
671/0x29F	Index Count = 0	Lambda 1		Pump Current 1		Fault 1	Status 1	Heat 1 DC

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
672/0x2A0	Index Count = 0	Lambda 2		Pump Current 2		Fault 2	Status 2	Heat 2 DC

Lambda (La)	
Byte 1	MSB (Big Endian)
Byte 2	LSB
Type	16 Bit Unsigned Integer
Multiplier	0.001
Offset	0

Pump Current (mA)	
Byte 3	MSB (Big Endian)
Byte 4	LSB
Type	Signed Integer
Multiplier	0.001
Offset	0

Fault - Byte 5	
Bit 0/1: Virtual Ground	0 = Error: Short to ground 1 = Error: IC Power Supply Low 2 = Error: Short to Vbatt 3 = Ok
Bit 2/3: Nernst Cell	0 = Error: Short to ground 1 = Error: IC Power Supply Low 2 = Error: Short to Vbatt 3 = Ok
Bit 4/5: Pump Current	0 = Error: Short to ground 1 = Error: IC Power Supply Low 2 = Error: Short to Vbatt 3 = Ok

Bit 6/7: Heater	0 = Error: Short to ground 1 = Error: IC Open Load 2 = Error: Short to Vbatt 3 = Ok

Status - Byte 6	
Byte 6	0 = OFF 1 = Normal Operation 2 = Sensor Warming up 3 = RPM Lockout (when available) 4 = Post Start Lockout (when available) 5 = Reading Calibration Data 14 = Heater Under Temperature (cannot reach 650 DegC) 15 = Heater Over Temperature 16 = Sensor Shutdown - Thermal Shock 17 = Cannot read Chip ID 18 = Set Pump reference command Invalid 19 = Calibrate Command Invalid 20 = Standalone Command Invalid 21 = Nernst Cal Data Invalid 22 = Pump Cal Data Invalid 19 = Lambda Stability Error 20 = Error Reading Chip ID 22 = System Voltage Low 22 = Cannot enter Calibration mode 23 = Cannot enter standalone mode

Heater Duty Cycle (%DC)	
Byte 7	
Type	Unsigned Integer
Multiplier	1
Offset	0

7.2 Transmit Message Packet 2 - Diagnostics

This is the second compound message for Channels 1 and 2. In most situations this is not required but can be useful for diagnostics.

ID	671 /0x29F (Default)
Data	Lambda Channel 1 Diag
ID Type	Standard 11 bit identifier
Direction	Transmit from HVLC
Length	8 bytes
Rate	10Hz/100ms

ID	672 /0x2A0 (Default)
Data	Lambda Channel 2 Diag
ID Type	Standard 11 bit identifier
Direction	Transmit from HVLC
Length	8 bytes
Rate	10Hz/100ms

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
671/0x29F	Index Count = 1	Nernst Cell FB Channel 1		Pump Cell Calibration Channel 1		Nernst Cell Calibration Channel 1		Err Count 1

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
672/0x2A0	Index Count = 1	Nernst Cell FB Channel 2		Pump Cell Calibration Channel 2		Nernst Cell Calibration Channel 2		Err Count 2

Nernst Feedback Voltage (V)	
Byte 1	MSB (Big Endian)
Byte 2	LSB
Type	16 Bit Unsigned Integer
Multiplier	0.001
Offset	0

Pump Calibration Voltage (V)	
Byte 3	MSB (Big Endian)
Byte 4	LSB
Type	16 Bit Unsigned Integer
Multiplier	0.001
Offset	0

Nernst Calibration Voltage (V)	
Byte 5	MSB (Big Endian)
Byte 6	LSB
Type	16 Bit Unsigned Integer
Multiplier	0.001
Offset	0

Error Counter	
Byte7	
Type	8 Bit Unsigned Integer
Multiplier	1
Offset	0

7.3 Receive Packet – Special Function

When this ID is received by the device with Mode = 25 (Byte 0 = 25) , the device with be updated with the data from each packet.

ID	671 /0x29F (Default)
Data	Special Function
ID Type	29 bit identifier
Direction	Receive from HVLC
Length	8 bytes

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
8192/0x2000 + Device SN	25	Reset Baud to Default	Reset IDs To Default	Heater Override	Exhaust Back Pres.			

Reset Baud Rate	
Byte 1	
Type	8 Bit Unsigned Integer
Multiplier	1
Offset	0
Notes:	When Byte 1 = 0xA1 baud rate will be reset to 1MBaud

Reset CAN IDs	
Byte 2	
Type	8 Bit Unsigned Integer
Multiplier	1
Offset	0
Notes:	When Byte 2 = 0xA2 the CAN IDs we reset to their defaults: Channel1 = 671, Channel2 = 672

Heater Override	
Byte 3	
Type	8 Bit Unsigned Integer
Multiplier	1
Offset	0
Notes:	**Byte 3** = **0xA3 (163)** the Lambda Heater(s) will be switched ON **Byte 3** = **0x93 (147)** Heater(s) are OFF. Any other value has no effect and heater control is done internally by the ELCM

Exhaust Back Pressure (kPa)	
Byte 4	MSB (Big Endian)
Byte 5	LSB
Type	Unsigned Integer
Multiplier	0.1
Offset	0
Notes:	If the value = 0 EMAP is OFF. With any other value the EMAP correction is ON. Value 1651 = 165.1 kPa

NOTE on Heater Override Control:

The Lambda heaters will turn on 15 seconds after the device is powered up, unless the specified values in Byte 3 (0xA3 or 0x93) are received by the device.

8.0 HVLC Emtron Setup Procedure

The HVLC can be connected to either the ECUs CAN Bus 1 or 2.

The device will Auto-scan the CAN bus until a successful baud rate has been detected. Once detected this rate will be stored by the device and used at the next power up. This means the device does not have to be setup/preconfigured for the ECU to detect it. The ECU will automatically detect it.

The device will scan 3 different Baud rates at 500ms intervals moving from 1Mbaud -> 500kBaud -> 250k Baud -> 1Mbaud and so on.

For this process to function effectively, all new devices to the CAN bus should be connected one at a time.

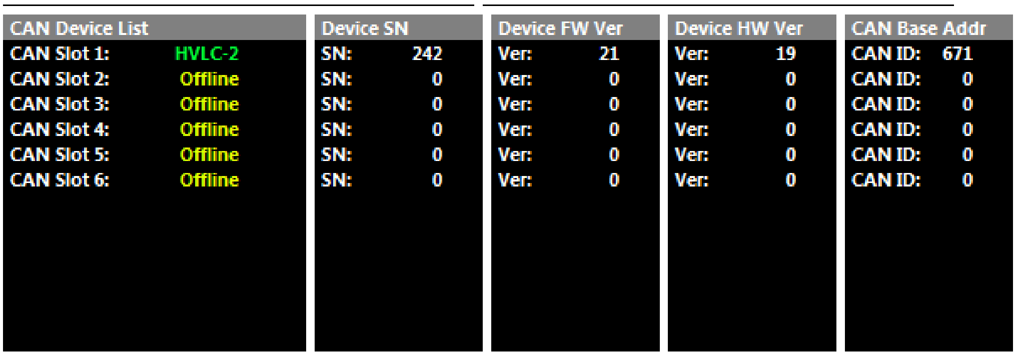
8.1 HVLC Single Device Setup

Once the HVLC and powered and connected to the ECUs CAN bus, the following steps should be taken to complete the setup. For this process to function effectively, all new devices to the CAN bus should be connected one at a time i.e. when installing multiple CAN devices ONLY connect one device at a time to the CAN bus.

STEPS:

1. **Check the HVLC Device has been detected by the ECU**
   Connect to Emtune. Open the ECU Runtime menu (F3) and select the Communications Tab. Within this tab will be a list of Emtron CAN devices the ECU has detected. It will list:
   a. CAN Device Model
   b. Device Serial Number
   c. Device Firmware Version
   d. Device Hardware Version
   e. CAN Base Address

   With one HVLC device (Single or Dual channel) connected to CAN 1, the data should look as shown in Figure 8.0. **Important**: Note the CAN Base Address. This is required in Step 2.



CAN Device List		Device SN		Device FW Ver		Device HW Ver		CAN Base Addr	
CAN Slot 1:	HVLC-2	SN:	242	Ver:	21	Ver:	19	CAN ID:	671
CAN Slot 2:	Offline	SN:	0	Ver:	0	Ver:	0	CAN ID:	0
CAN Slot 3:	Offline	SN:	0	Ver:	0	Ver:	0	CAN ID:	0
CAN Slot 4:	Offline	SN:	0	Ver:	0	Ver:	0	CAN ID:	0
CAN Slot 5:	Offline	SN:	0	Ver:	0	Ver:	0	CAN ID:	0
CAN Slot 6:	Offline	SN:	0	Ver:	0	Ver:	0	CAN ID:	0

Figure 8.0

2. **Configure the CAN Channel**

   Next step is to configure the CAN channel. For this example, CAN 1- Channel 1 has been selected.

   a. Set "Enable" to 1(ON)
   b. Set "CAN Base Address" to the ID shown in Figure 8.0. In this example its 671.
   c. Set "DATA Set" to 50 (HVLC Device 1). See Figure 8.1

   The ECU in now configured and reading the data from the HVLC Device.

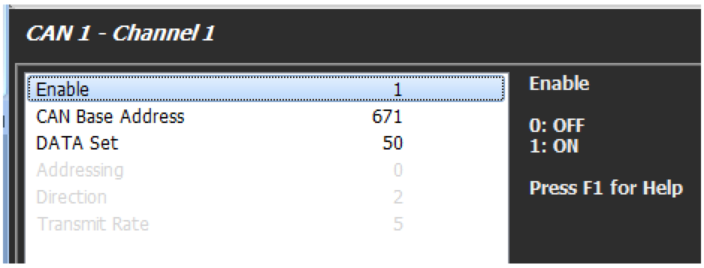


Figure 8.1

8.2 Multiple HVLC Device Setup

When multiple HVLC devices on installed on the BUS, the ID base address will need to be reconfigured to avoid any BUS conflicts.

Once the HVLC and powered and connected to the ECUs CAN bus, the following steps should be taken to complete the setup. For this process to function effectively, all new devices to the CAN bus should be connected **one** at a time i.e. when installing multiple CAN devices ONLY connect one device at a time to the CAN bus.

STEPS:

1. **Check the HVLC Device(s) have been detected by the ECU**
   Connect to Emtune. Open the ECU Runtime menu (F3) and select the Communications Tab. Within this tab will be a list of Emtron CAN devices the ECU has detected. It will list:
   a. CAN Device Model
   b. Device Serial Number
   c. Device Firmware Version
   d. Device Hardware Version
   e. CAN Base Address

   With a multiple HVLC device connected to CAN 1, the data should look as shown in Figure 8.2. In this example 2 HVLC devices are connected to the BUS. Device 1 with SN 107 and Device 2 with SN 100.

CAN Device List		Device SN		Device FW Ver		Device HW Ver		CAN Base Addr	
Device 1:	HVLC-2	SN:	107	Ver:	16	Ver:	16	CAN ID:	671
Device 2	HVLC-2	SN:	100	Ver:	16	Ver:	16	CAN ID:	671
Device 3	Offline	SN:	0	Ver:	0	Ver:	0	CAN ID:	0
Device 4	Offline	SN:	0	Ver:	0	Ver:	0	CAN ID:	0
Device 5	Offline	SN:	0	Ver:	0	Ver:	0	CAN ID:	0
Device 6	Offline	SN:	0	Ver:	0	Ver:	0	CAN ID:	0

   Figure 8.2

   Note. Both devices have the same Base Address. This will need to be changed so each device has a unique ID address to avoid any BUS conflicts. This can be any number but the following addresses are recommended.

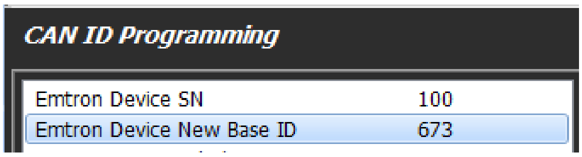
HVLC Device 1: ID Base Address 671
HVLC Device 2: ID Base Address 673
HVLC Device 3: ID Base Address 675
HVLC Device 4: ID Base Address 677
HVLC Device 5: ID Base Address 679
HVLC Device 6: ID Base Address 681
HVLC Device 7: ID Base Address 683
HVLC Device 8: ID Base Address 685

2. **Reprogram HVLC Base CAN Address**

In this example HVLC Device 2 will need to have its Base CAN Address re-programmed to 673. This is easily done from the Config view -> Communications Menu -> Emtron CAN Devices -> CAN Device Programming menu.

In this example select:
Emtron Device SN = 100
Emtron Device New Base Address = 673

Once 673 is entered programming the CAN module start automatically.



To check the device has been correctly programmed with the new ID address open the F3 menu -> Communications Tab. CAN device with SN 100 should have a new Base Address of 673.

CAN Device List		Device SN		Device FW Ver		Device HW Ver		CAN Base Addr	
Device 1:	HVLC-2	SN:	107	Ver:	16	Ver:	16	CAN ID:	671
Device 2	HVLC-2	SN:	100	Ver:	16	Ver:	16	CAN ID:	673
Device 3	Offline	SN:	0	Ver:	0	Ver:	0	CAN ID:	0
Device 4	Offline	SN:	0	Ver:	0	Ver:	0	CAN ID:	0
Device 5	Offline	SN:	0	Ver:	0	Ver:	0	CAN ID:	0
Device 6	Offline	SN:	0	Ver:	0	Ver:	0	CAN ID:	0

8.3 Assigning HVLC Lambda Data to an ECU Channel

Once the ECU has been configured to receive the HVLC data, the next step is deciding how the Lambda data is to be displayed. There are several options:

Options A:

Use the Lambda 1 and Lambda 2 input options. On a Dual HVLC set Lambda 1 to **CAN HVLC #1 Ch-A** and Lambda 2 to **CAN HVLC #1 Ch-B**. See Figure 8.3.

When this option is used the Runtime menu (F3) -> Lambda tab can be used to view the data from both channels. This includes Lambda data and Diagnostics data to help in fault finding should any issues occur. See Figure 8.4

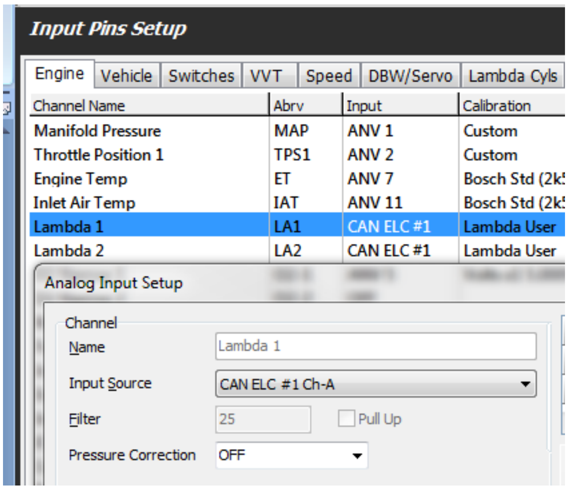


Figure 8.3

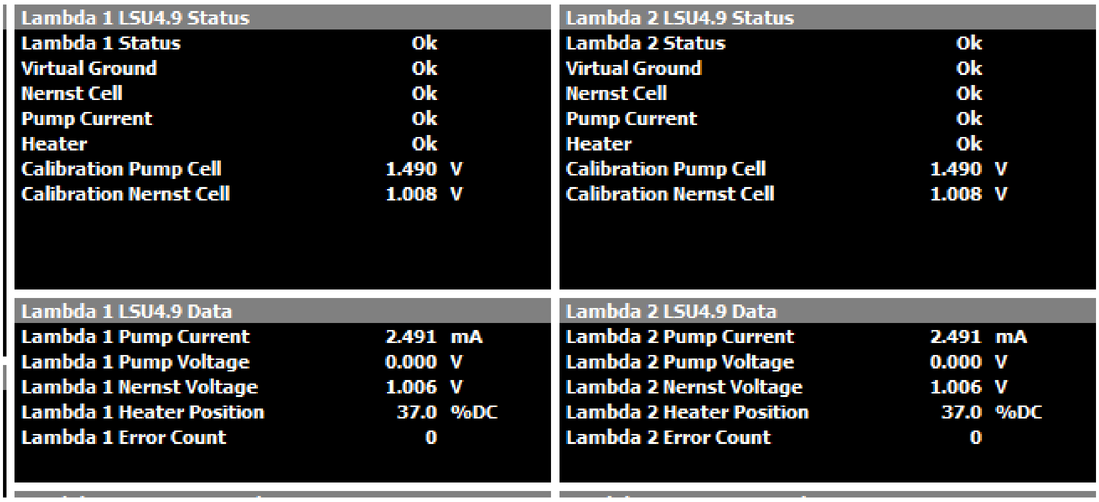


Figure 8.4

Options B:

Use the Lambda Cylinder Input Channels. This setup is normally done when multiple HVLC devices are used to measure the lambda on individual cylinders. For example:

- To configure the HVLC Channel A to Cylinder 1, set the Input Source on Lambda Cyl 1 Channel to **CAN HVLC #1 Ch-A**
- To configure the HVLC Channel B to Cylinder 2, set the Input Source on Lambda Cyl 2 Channel to **CAN HVLC #1 Ch-B**
  (See Figure 8.5)

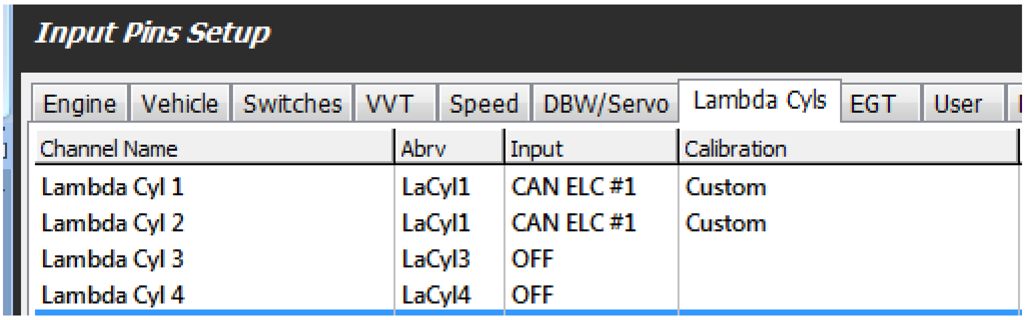


Figure 8.5

8.4 HVLC Device Setting

The following settings are available to control the HVLC. These settings get applied to ALL HVLC devices connected on the CAN bus.

1. Reset CAN IDs to Default
2. Enable Heater Override
3. Enable EMAP (Exhaust Pressure Correction)
4. HVLC Heater RPM Lockout (rpm)
5. HVLC Heater Post Start Lockout (sec)

These settings are available from the Config View -> Communications Tab -> CAN Device -> HVLC Device Settings. See Figure 8.6

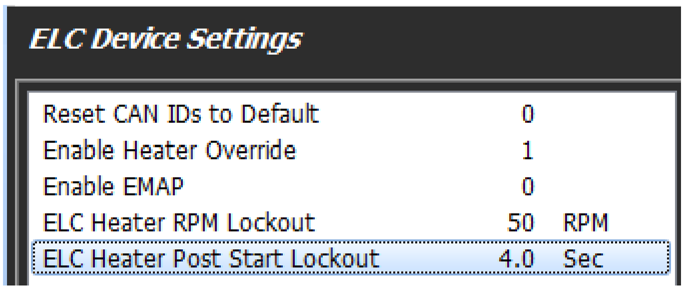


Figure 8.6

9.0 Analog Output(s)

The HVLC will output a high resolution output voltage proportional to the Lambda value. The scaling is shown below:

0.500 V = 0.500 Lambda
4.000 V = 1.500 Lambda

The calibration is linear and can also be viewed as shown below.

Output Voltage (V)	Lambda Value (La)
0.500	0.500
0.675	0.550
0.850	0.600
1.025	0.650
1.200	0.700
1.375	0.750
1.550	0.800
1.725	0.850
1.900	0.900
2.075	0.950
2.250	1.000
2.425	1.050
2.600	1.100
2.775	1.150
2.950	1.200
3.125	1.250
3.300	1.300
3.475	1.350
3.650	1.400
3.825	1.450
4.000	1.500

10.0 Ordering Information

Product	Part Number
Lambda to CAN Single Channel	HV-LC1
Lambda to CAN Dual Channel	HV-LC2

HV Electronics Ltd
74 Whiore Av, The Lakes
Tauranga
New Zealand

(See the www for contact information)
www.hvelectronics.co.nz