# EPAS Ultra Autonomous User Manual
# EPAS18A


**This document refers to the EPAS18A Autonomous Ultra ECU only.**
**Please consult DCE for confirmation of firmware installed into your Ultra ECU so that these instructions can be followed accurately.**

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dce motorsport electronics

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# 1 Getting Technical Support

For technical support, please contact:

sales@dcemotorsport.com (Europe) or salesusa@dcemotorsport.com (Americas)

The table below lists the ways to contact DC Electronics:

| Contact Method | Europe | Americas |
|---|---|---|
| Company: | DC Electronics | DCE Inc. |
| Website: | www.dcemotorsport.com | www.dcemotorsport.com |
| Email: | sales@dcemotorsport.com | salesusa@dcemotorsport.com |
| Telephone: | +44 (0)1621 856451 | +1 (704) 230 4649 |
| Mail: | DC Electronics – Motorsport Specialist Ltd<br>Units 1 & 2 Quayside Industrial Park<br>Bates Road<br>Maldon<br>ESSEX<br>CM9 5FA<br>United Kingdom | DCE Inc<br>119 Poplar Pointe Drive<br>Suite B<br>Mooresville<br>NC<br>28117<br>USA |

# 2 Operating Parameters

Here we list the operating parameters of the EPAS Ultra ECU.

| Parameter | Value | Notes |
|---|---|---|
| Voltage | Max 16V | Over voltage will cause the ECU to shut down and could cause permanent damage. |
| | Min 9V | Under voltage will cease control of the motor. |
| Temperature | Max 100°C | Over 100°C will result in half motor duty mode until temperature drops below 95°C.<br>Fault lamp will flash. |
| | Max 120°C | Over 120°C will result in ECU shutdown.<br>Fault lamp will be on solid.<br>Power cycle required to reset fault. |
| Current | Max 80A | The ECU regulates the motor duty PWM so that the average current is no more than 80A. |
| Time-out | 10s | If the torque input does not change by +/- 2 bits, after 10 seconds motor duty will cease.<br>This is a protection feature for the ECU and motor and cannot be disabled.<br>Under normal driving conditions, this time-out limit is not reached and will not activate.<br>If time-out has activated, any change in torque input by +/- 2 bits will cancel time-out. |
| PWM Frequency | 19.5kHz | The motor PWM control is set at 19.5kHz. |

# 3 Electrical Connections and Calibration Guide

**Before Installation is undertaken, please read the following notes.**

**NOTE 1: WELDING**

Electronic components situated within the motor assembly and control unit could be damaged if welding takes place upon the vehicle chassis or frame.

If welding is to take place it is advisable to remove both the motor assembly and the control unit from the vehicle.
If only the control unit can be removed, ensure both electrical connections to the motor assembly are disconnected and the vehicles battery is removed.

UNDER **NO** CIRCUMSTANCES SHOULD ANYTHING BE WELDED TO THE CASING OF THE MOTOR ASSEMBLY.

**NOTE 2: ELECTRICAL CONNECTIONS**

The electronic power assisted steering system should be connected using the EPAS Ultra interface loom (available separately) or by following the DC Electronics supplied wiring diagram.

***FAILURE TO CORRECTLY CONNECT VEHICLE POWER SUPPLY WILL DAMAGE THE CONTROL UNIT.***

## 3.1 EPAS ULTRA ELECTRICAL CONNECTION & SET UP GUIDE

### These instructions presume the use of our EPAS19 Ultra Wiring Harness.

1. Make all electrical connections as per the DC Electronics wiring diagram (available upon request) or if using the EPAS Ultra interface loom (available separately) follow steps 2 to 9.
2. Connect 2 pin connector marked “MOTOR” to the motor assembly.
3. Connect 4 pin connector marked ”TORQUE” to the motor assembly.
4. Find a suitable location for the ECU (within cabin, away from heat and moisture), fix using suitable cradle with anti-vibration mounts and connect to both Autosport connectors on the loom.
5. Find suitable location for rotary switch and mount.
6. Fit LED to loom (Red cable to Gold pin, White cable to Silver pin).
7. Connect 2 pin connector marked “POWER” to Vehicle power supply , #1 to +12v and #2 to ground

8. Connect 8 pin connector marked ”ELECTRONICS” as follows:-

| Pin No. | Description | Destination | Required? |
|---|---|---|---|
| 1 | +12v (Input) | Ignition Switched +12v | Yes |
| 2 | Ground (Input) | Chassis Ground | Yes |
| 3 | CAN Hi | Data Logger CAN Hi | Optional |
| 4 | CAN Lo | Data Logger CAN Lo | Optional |
| 5 | Sensor +5v Supply (Output) | Steering Angle Sensor +5v | Yes |
| 6 | Steering Angle (Analog Input) | Steering Angle Sensor Signal | Yes |
| 7 | Sensor 0v Supply (Output) | Steering Angle Sensor 0v | Yes |
| 8 | Not Used | | |

No CAN termination resistor is fitted within the ECU.

9. If no steering angle sensor is fitted, the over current protection for rack end stops will not be present. Holding the steering against the stops will ***SEVERLY DAMAGE THE CONTROLLER!*** We strongly recommend connecting a steering angle sensor.

***FAILURE TO COMPLY WITH THE ABOVE INSTRUCTIONS <u>WILL</u> DAMAGE THE CONTROL UNIT AND WILL VOID ANY WARRANTY.***

## 3.2 CALIBRATION OF COLUMN

It is normal for the steering wheel to move on initial power up and during calibration. Do not attempt to hold the wheel at this time or the settings may become corrupted.

- Set rotary switch fully counter clockwise.
- Switch on “Electronics +12v” until LED lights up. Immediately switch off and then back on until LED lights again.
- Continue to do this 3 more times until on the 4$^{th}$ time the LED lights and flashes, this is the calibration phase.
- The LED will extinguish at the end of calibration when you can now use the system.

Calibration only needs to be carried out once at installation as the settings will be retained even when power is removed.

## 3.3 CALIBRATION OF STEERING ANGLE SENSOR

- Attach a Steering Angle sensor to the specified pins in section 8.
- Calibrate column using the procedures above.
- Keep the rotary switch turned fully anticlockwise.
- Connect to the EPAS system using a suitable serial lead.
- Open EPAS Desktop Pro software and click ‘connect’ (the latest version can be downloaded from our website).
- Turn the Steering wheel fully anticlockwise until the stop is reached, release the wheel and note the steering angle value shown on the desktop.
- Repeat for fully clockwise stop.
- **NOTE:** The LH value must be lower than the RH value. If this is not true, the +5v and 0v wires need to be reversed in the Steering Angle sensor.
- Keeping the power on, click on ‘disconnect’ on the Desktop Pro software screen.
- Go to the ‘Setup’ menu and scroll to ‘Parameters’, pick ‘LH stop’
- Scroll to the value that had been noted for anticlockwise stop.
- Next pick ‘RH stop’ and put in the value noted for clockwise stop.
- Click on ‘apply’.
- Test calibration by setting rotary switch to position 1, turn steering fully anticlockwise and check if motor duty switches to 0% on the Desktop Pro when the pre-set angle is reached, repeat for clockwise steering.

# 4 Software

## 4.1 What is EPAS Desktop Pro?

The Program enables the operating parameters of the DC Electronics' EPAS Ultra ECU to be viewed in real time. EPAS Desktop Pro also provides facilities for configuring and re-programming the EPAS Ultra ECU via the serial port of the host PC.

With DCE's EPAS  you can:

- View real-time data for:
  - Battery voltage
  - Current consumption
  - Applied steering torque
  - Steering motor duty
  - ECU box temperature
  - Steering angle
  - Control switch setting
  - Digital input and output states
- Read ECU serial number, firmware version and system type
- Configure the EPAS Ultra ECU via the serial port of the host PC
- View and alter the relationship between torque input and motor duty for each control switch position
- Update the firmware of the EPAS Ultra ECU via the serial port of the host PC

## 4.2 System Requirements

Before attempting to install EPAS Desktop Pro, make sure that your computer meets the following minimum system requirements shown in the table below:

| Component | Requirement |
|---|---|
| Processor | Pentium class processor or equivalent |
| Operating System | Microsoft Windows 98/Me/NT4/2000/XP/Vista/10 |
| Hard Disk Space | 10Mb |
| System Memory | 32Mb (64Mb recommended) |
| Monitor/Display | Super VGA (800 x 600) or higher resolution with 256 colours |
| Serial Port | One serial port or USB port with USB-Serial adapter |
| Pointing Device | Microsoft Mouse or compatible pointing device |

## 4.3 Installing EPAS Desktop Pro

Before you can run EPAS Desktop Pro you must install it on the hard disk of your computer.

Follow these steps to install the software:

- Switch on your computer and log on in the normal way.
- Go to https://www.dcemotorsport.com/Home/EPAS
- Click on **EPAS Desktop Pro Software**
- Follow the on-screen instructions.
- The installation process places shortcuts to EPAS Desktop Pro on the computer's desktop and Start menu.

## 4.4 Uninstalling EPAS Desktop Pro

EPAS Desktop Pro can be removed from your computer by selecting the **Add and Remove Programs** option within Windows **Control Panel**. Find EPAS Desktop Pro in the list of installed software, select it, and then click **Remove**.

This will remove the EPAS Desktop Pro software together with its shortcuts and configuration entries.

# 5 Getting to Know EPAS Desktop Pro

This chapter provides an overview of the EPAS Desktop Pro user interface. It describes the main window, menu, and other important features. To help you better understand the program and become familiar with its features, please review this chapter thoroughly prior to connecting a PC to an EPAS Ultra ECU.

## 5.1 Tour of the EPAS Desktop Pro User Interface

When you start EPAS Desktop Pro the main program window appears as shown below.

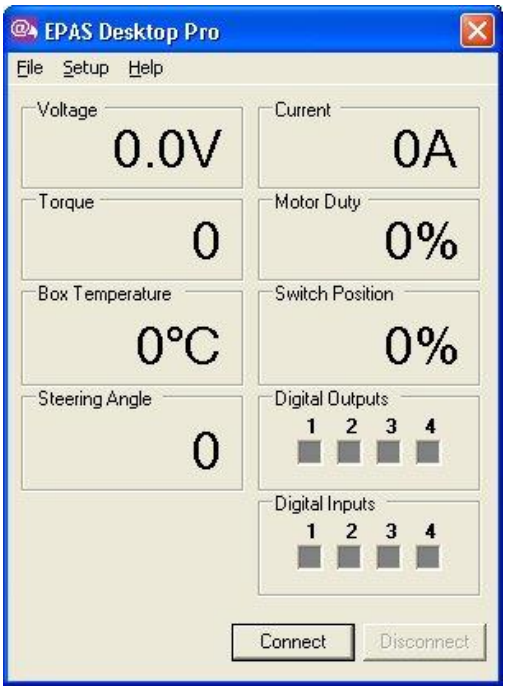


**Figure 1 - EPAS Desktop Pro Main Screen (Inactive)**

At the top of the main program window a menu provides access to a majority of the program's features.

## 5.2 Main Menu


**Figure 2 –EPAS Desktop Pro Main Menu**

The Main Menu (Figure 2), which is directly below the title bar, displays the menu headings. Click a menu heading to open the menu and choose a command.

Use either of the following methods to choose a menu command:

- Open the menu and click the command, or
- Open the menu, use the Up arrow or Down arrow key to highlight a command, and then press <Enter>.

# 6 Viewing EPAS Ultra ECU Status

This chapter describes how EPAS Desktop Pro allows you to connect to an EPAS Ultra ECU and view its status.

## 6.1 Connecting to EPAS Ultra ECU

The status of an active EPAS Ultra ECU can be viewed in the following way:

1. Connect the serial port connector on the PC to the “Comms” serial connector on the EPAS Ultra harness using a suitable cable. Alternatively, connect a Serial-USB adapter cable to the USB port on the PC and to the “Comms” connector on the harness supplied.

2. Click the **Connect** button on the main screen.

3. The live status of the EPAS Ultra ECU will be displayed in the various panels on the main screen and these will be updated every 500ms.

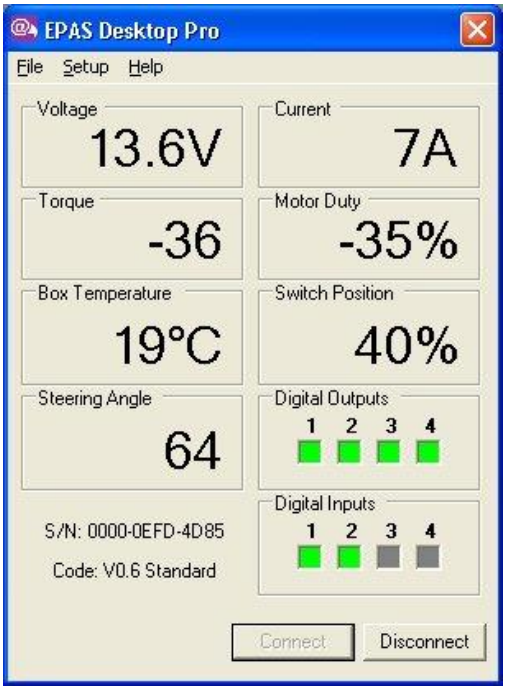


**Figure 3 - EPAS Desktop Pro Main Screen (Active)**

## 6.2 Main Screen Displays

The panels on the main screen display the following information:

| Item | Description |
|---|---|
| Voltage | Displays instantaneous EPAS Ultra ECU supply voltage in Volt. Resolution is 0.1V and maximum reading is 25.5V. |
| Current | Displays instantaneous EPAS Ultra ECU current consumption in Amp. Resolution is 1.0A and maximum reading is 128A. |
| Torque | Displays instantaneous applied steering torque in bits. Resolution is 1 bit and maximum reading is 255 bits. This value is positive when the applied steering torque is in the clockwise direction. |
| Motor Duty | Displays instantaneous motor duty in %. Resolution is 1%. A value of 100% indicates that the motor is operating at full power. |
| Box Temperature | Displays instantaneous EPAS Ultra ECU box temperature in °C. Resolution is 1°C and the EPAS Ultra ECU will shutdown if the box temperature rises above a preset safe limit. |
| Switch Position | Displays instantaneous steering control position in %.<br>Display / Result / Analog Input Voltages<br>0% / EPAS Off / > 0.00V, < 0.82V<br>20% / Map 1 / > 0.82V, < 1.67V<br>40% / Map 2 / > 1.67V, < 2.50V<br>60% / Map 3 / > 2.50V, < 3.33V<br>80% / Map 4 / > 3.33V, < 4.18V<br>100% / Map 5 / > 4.18V, < 5.00V |
| Steering Angle | Displays instantaneous steering angle in bits. Resolution is 1 bit and maximum reading is 255 bits. |
| Digital Outputs | Displays instantaneous status of the four digital outputs.<br>Note; these are not used and are for future expansion only. |
| Digital Inputs | Displays instantaneous status of the two digital inputs.<br>Note; these are not used and are for future expansion only. |
| S/N | Unique 64-bit serial number of EPAS Ultra ECU. |
| Code | Firmware version and system type. |

## 6.3 Disconnecting from EPAS Ultra ECU

To stop viewing the status of an active EPAS Ultra ECU click the **Disconnect** button on the main screen.

**NOTE:** It is important to disconnect in this way, rather than just closing the EPAS Desktop Pro application, as otherwise the connection to the EPAS Ultra ECU will remain active and any attempt to reconnect will fail unless the EPAS Ultra ECU is reset first.

# 7 Configuration

EPAS Desktop Pro provides facilities for the EPAS Ultra ECU to be configured via the serial port.

This chapter describes how this configuration is carried out.

**NOTE:** Configuration changes can only be made whilst EPAS Desktop Pro is not actively communicating with an EPAS Ultra ECU. Disconnect any active connection, by clicking the **Disconnect** button on the main screen, before attempting to make changes to the configuration.

## 7.1 Serial Port

To alter the serial port that EPAS Desktop Pro uses to communicate with the EPAS Ultra ECU do the following:

1. Choose **Setup ➡ Serial Port** from the main menu. The Setup Serial Port Dialog (Figure 4) appears.

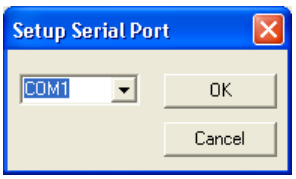


**Figure 4 - Setup Serial Port Dialog**

2. Select the new serial port from the list.

3. Click **OK** to update the serial port or **Cancel** to leave it unchanged.

## 7.2 Firmware

The firmware of the EPAS Ultra ECU can be re-programmed via the serial port.

The **Setup ➡ Firmware** option from the main menu has been provided to enable this.

**IMPORTANT**: Do not attempt to upload new firmware to the EPAS ECU without first contacting DC Electronics and obtaining the correct file for your system and application.

**Procedure**

Do the following to update the firmware:

1. Connect the PC to the EPAS ECU via the serial lead.
2. Start EPAS Desktop or EPAS Desktop Pro.
3. Ensure that the EPAS ECU is not powered up.
4. Select **Setup ➡ Firmware** from the main menu, the File Open dialog will be displayed.
5. Locate the required .hex file and click **Open**, the Upload Hex File dialog (Figure 1) will be displayed.
6. Check the connection between the PC and the EPAS ECU and click **OK** or **Cancel** to abandon the firmware update process.
7. The Upload Hex File dialog shows that EPAS Desktop is attempting to communicate with the EPAS ECU (Figure 5).

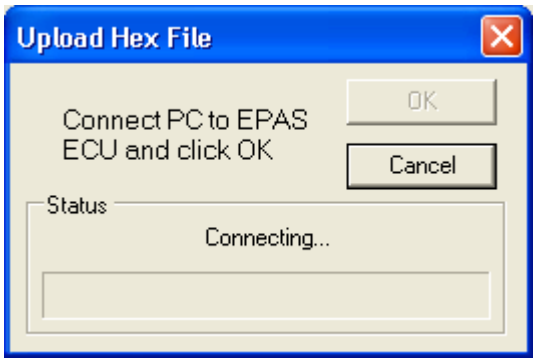


**Figure 5 - Upload Hex File Dialog (Connecting)**

8. Switch on the EPAS ECU, the Upload Hex File dialog shows that the selected hex file is being uploaded to the EPAS ECU (Figure 6).

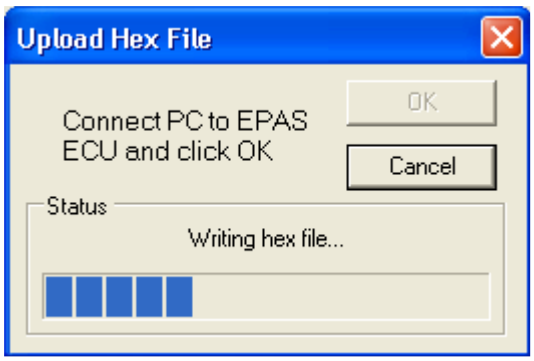


**Figure 6 - Upload Hex File Dialog (Writing)**

9. Once the entire hex file has been written the EPAS ECU will reset and run with the new firmware.

## 7.3 Changing Parameters & CAN Message IDs

The operating parameters of the EPAS Ultra ECU can be viewed and altered via the serial port in the following way:

1. Select the **Setup ➡ Parameters** option from the main menu. The Setup Parameters dialog (Figure 7) is displayed.

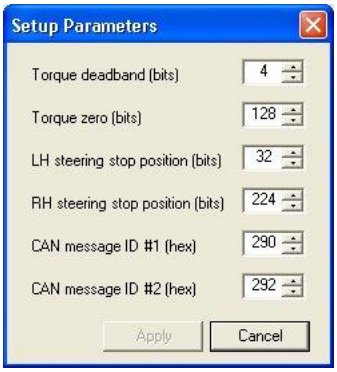


**Figure 7 - Setup Parameters Dialog**

2. The Setup Parameters dialog displays the current values of all the user configurable parameters of the EPAS Ultra ECU.

3. Make any changes that are required and click **Apply** or **Cancel** to leave the parameters unchanged.

**WARNING:** Care must be observed when changing EPAS Ultra ECU parameters. Using the wrong values could damage both the EPAS Ultra ECU and the steering unit.

Currently, the following six parameters are defined:

- Torque deadband
- Torque zero
- LH steering stop position
- RH steering stop position
- CAN message ID #1
- CAN message ID #2

These will be described in detail in the following sections.

**Torque Deadband**
The torque deadband, measured in bits, defines the amount that the steering torque sensor value needs to move from the zero value before any steering power assistance is delivered.

The default value for the torque deadband is 4 bits. Decreasing the torque deadband value can make the steering more responsive but can also lead to 'hunting' where the control unit constantly attempts to counteract a very small steering torque offset.

Increasing the torque deadband value will make the steering less responsive but can compensate for a drifting or noisy torque sensor.

**Torque Zero**
The torque zero, measured in bits, defines the steady state torque reading where no steering torque is applied. All the steering torque sensors encountered so far have a zero of 128 ±10 bits. The default value for the torque zero is 128 bits.

The torque zero parameter value is normally altered using the zeroing procedure built into the firmware of the unit which does not need a computer to be connected. In this procedure the power to the unit is switched on and then off (before the fault LED has gone out) three times in succession. The next time power is applied the fault LED will flash while the torque zero parameter is updated. It is important that, during this procedure, no steering torque is applied otherwise a false zero value will be set.

If the torque zero parameter is incorrect then the steering will tend to be more responsive, or lighter, in one direction than the other.

**Steering Stop Settings**
A steering angle sensor can be used to limit the motor power when the steering reaches either end stop. This sensor must be fitted so that its output voltage is at its lowest point when the steering is against the left-hand steering stop and at its highest when the steering is against the right-hand steering stop.
When the steering reaches either end stop the motor power is progressively reduced over a 1.5 second period.

**LH Steering Stop Position**
The LH steering stop position, measured in bits, is the position of the left-hand steering stop as indicated by the steering angle sensor.
Motor power reduction will occur when the measured steering angle is less than the LH steering stop position setting.

**RH Steering Stop Position**
The RH steering stop position, measured in bits, is the position of the right-hand steering stop as indicated by the steering angle sensor.
Motor power reduction will occur when the measured steering angle is greater than the RH steering stop position setting.

**CAN Message IDs**
The EPAS Ultra ECU has a CAN interface through which instantaneous sensor values and operating status are transmitted. Standard Baud rate is 1Mbit/s.

This information is grouped into three 8-byte messages each with their own ID. The CAN interface employs 11-bit message IDs so valid CAN message ID values lie in the range 0x001 to 0x7FF (1 to 2047).

**CAN Message ID #1**
Sets the ID for the first CAN message.

**CAN Message ID #2**
Sets the ID for second CAN message.

## 7.4 Transmitted CAN Messages

Three CAN messages are currently defined.

The 11-bit ID for each CAN message can be set by the user but the format of the payload of each message is fixed and is described in the following sections.

## 7.5 CAN Message #1

Message ID: 0x290 (default)

Update rate: 5ms

| Message Byte | Description |
|---|---|
| D0 | Torque (bits) |
| D1 | Motor duty (%) |
| D2 | Current (A) |
| D3 | Supply voltage (1 bit = 100mV) |
| D4 | Switch position (0 to 15) |
| D5 | Box temperature (ºC) |
| D6 | Torque A (raw value in bits) |
| D7 | Torque B (raw value in bits) |

## 7.6 CAN Message #2

Message ID: 0x292 (default)

Update rate: 5ms

| Message Byte | Description |
|---|---|
| D0 | Steering angle, 8-bit version (bits) |
| D1 | Steering angle, 10-bit version MSB (bits) |
| D2 | Steering angle, 10-bit version LSB (bits) |
| D3 | Selected map (0 to 5) |
| D4 | Active error code |
| D5 | Bit field of digital I/O values |
| D6 | Bit field of status flags:<br>b0 – Program paused<br>b1 – Motor moving forwards<br>b2 – Motor moving in reverse<br>b3 – Host mode active<br>b4 – Fault light status<br>b5 – Reserved<br>b6 – CAN map available<br>b7 – Reserved |
| D7 | Bit field of limit flags:<br>b0 – Steering at LH stop<br>b1 – Steering at RH stop<br>b2 – Over-temperature condition<br>b3 – Motor protect active<br>b4 – Not used<br>b5 – Not used<br>b6 – Not used<br>b7 – CAN map selection active |

## 7.7 CAN Message #3

A third CAN message has been defined to allow an external system to set the steering map remotely. The steering map is only accepted via CAN when the steering map control switch connected to the EPAS ECU is in the 'off' position.

Message ID: 0x296 (fixed)

Update rate: 10ms

| Message Byte | Description |
|---|---|
| D0 | Steering map: |
| | 0 to 5 – Steering map |
| D1 | Not used |
| D2 | Not used |
| D3 | Not used |
| D4 | Not used |
| D5 | Not used |
| D6 | Not used |
| D7 | Not used |

**Note:**
**The analogue rotary map switch has priority over the CAN steering map input.**
**The CAN map switch input is only active when rotary map switch is set to 0%.**

## 7.8 CAN Error Messages

Theses error code resides in byte d4 of CAN Message #2.

Defined error codes are as follows:

100 Low battery voltage
101 Torque sensor not connected
102 Torque sensor fault
103 Current sensor fault
104 Motor power fault
105 Motor not connected
106 Motor is stalled or shorted
107 Clutch not connected
108 Clutch is stalled or shorted
109 Over current
110 Over temperature
111 Internal error

Not all error codes can be produced by all systems, e.g. EPAS01 Motorsport assembly does not have a clutch so error codes 107 and 108 cannot occur.

## 7.9 Maps

The relationship between steering torque input and motor duty output for each control switch setting can be altered via the serial port in the following way:

1. Select the **Setup ➡ Maps** option from the main menu. The Setup Maps dialog (Figure 8) is displayed.

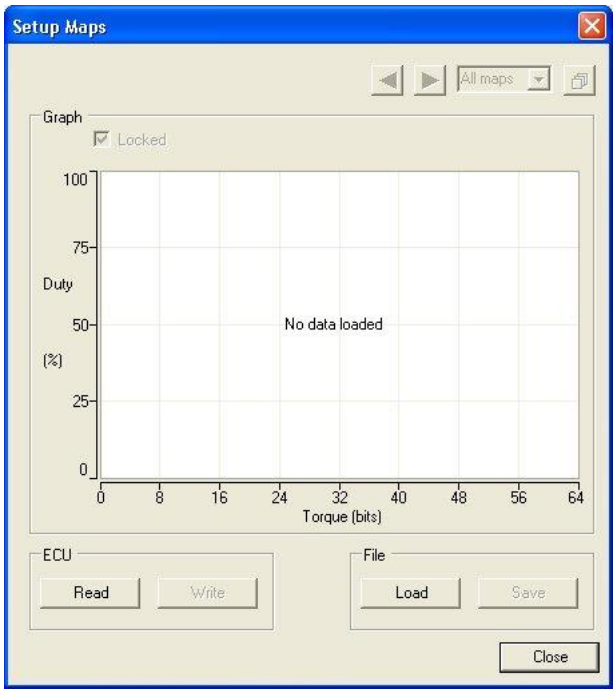


**Figure 8 - Setup Maps Dialog (No Maps)**

2. Click **Read** to read the maps from the EPAS Ultra ECU or **Load** to load map data from a disk file.

3. Once map data is available the Setup Maps dialog displays all five maps on the same set of axes (Figure 9).

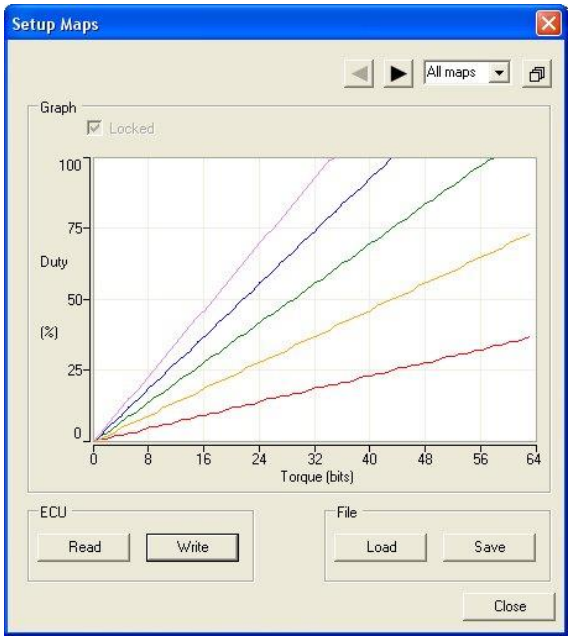


**Figure 9 - Setup Maps Dialog (All Maps)**

4. Use the arrow buttons or the drop-down box in the top right-hand corner of the dialog to select the map to be edited (Figure 10).

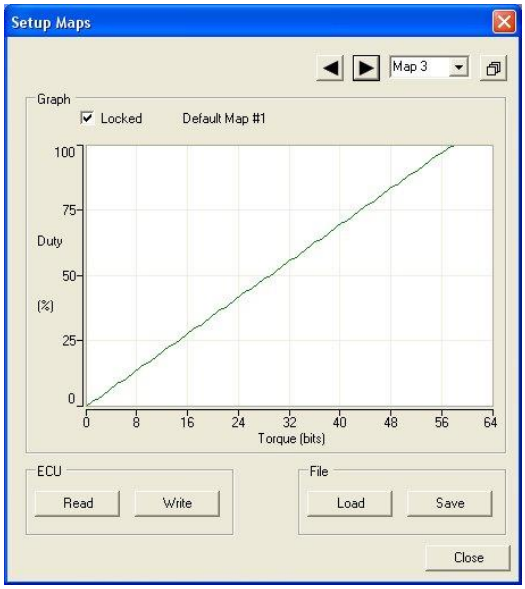


**Figure 10 - Setup Maps Dialog (One Map)**

5. When the **Locked** checkbox is not checked edit markers are displayed at 16 places along the map (Figure 11). Use the mouse to drag each of the markers until the required map shape is obtained. Note that each marker is constrained by the markers either side of it.

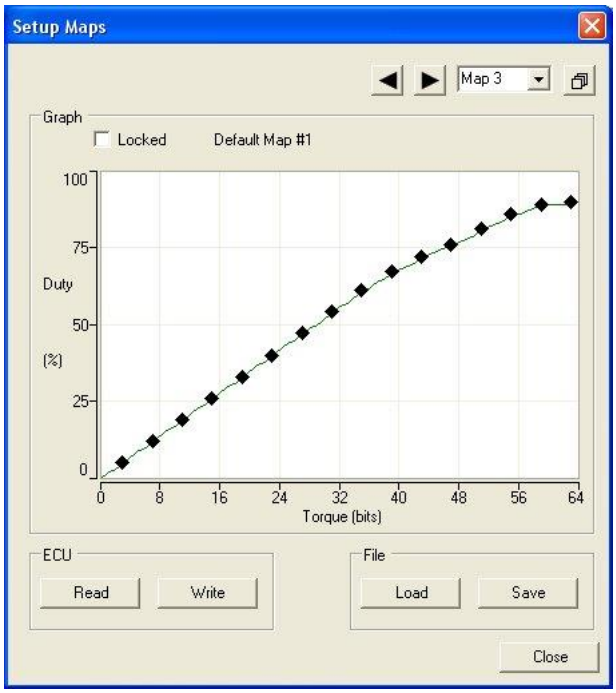


**Figure 11 - Setup Maps Dialog (Map Edit)**

6. When the map changes are complete click **Write** to write the map data to the EPAS Ultra ECU or **Save** to save the map data to a disk file.

7. When editing a map clicking the right mouse button in the graph area brings up a context menu that allows the comment associated with the map to be edited. When this menu option is selected the Edit Map Comment dialog (Figure 12) is displayed. Make any changes that are required and then click **OK** or **Cancel** to leave the comment unchanged. Note that these comments are only stored in the disk file and are not read from or written to the EPAS Ultra ECU.


**Figure 12 - Edit Map Comment Dialog**

# 8 AUTONOMOUS OPERATION

This section describes how the EPA1S8A Ultra Controller can be operated by an external system for autonomous applications.

## 8.1 Important Notice:

**The EPAS18A Controller is designed to be a simple gateway between the users PLC that operates the autonomy and the EPAS motor. Therefore, the user and the user's logic have full control of the EPAS system. This means that all safety functionality and system protection is the responsibility of the user and the user's logic.**

## 8.2 Operation

The EPAS Ultra Controller uses a CAN interface to provide sensor and status information (e.g. motor duty, steering angle, etc) to external systems.

The EPAS18A Ultra Controller also allow an external system to use this CAN interface to operate the system autonomously.

All transmitted CAN messages used are described in Section 7. An external system uses an additional CAN Message #4 to periodically provide control information to the EPAS18A Ultra Controller.

There are 3 main types of firmware available for autonomous control:

- Motor duty, from -100% to +100% in increments of 1%
- Steer-to-angle, where a demand angle is sent to the ECU
- Simulated Torque, where a simulated driver is turning the steering wheel

The EPAS18A Controller can be used in autonomous mode or manual mode.
Autonomous Mode = the EPAS motor is solely controlled by an external PLC.
Manual Mode = the EPAS motor is solely controlled by a person applying a load to the steering wheel.
The external PLC can swap between these modes via a CAN message.

## 8.3 Manual Override Of Autonomous Mode

If the system is to be used in autonomous mode where the driver may want to take control of the system, then the external PLC should be used to monitor the transmitted internal torque sensor signals in CAN message 1, byte D6 and D7.

During autonomous operation, these values should remain fairly static. Should the steering wheel then be subjected to an external force (a driver taking the wheel) these values will spike and this should be used to trigger a response where CAN message #4 stops the autonomous request.

## 8.4 CAN Messages

The CAN bus interface for the EPAS18A Ultra Controller uses 11-bit IDs and operates at 250kb/s, 500kb/s or 1Mb/s. This message ID is set to 0x298.

The external system needs to transmit CAN Message #4 at a fairly high rate; between 50Hz and 200Hz is ideal. If the EPAS Ultra Controller does not receive this message for 200ms, autonomous mode will cease and the system will revert to manual mode.

## 8.5 CAN Message Formats

This section describes the various CAN message formats available for autonomous control.

These different message formats for the different autonomous control methods are pre-installed into the EPAS18A Controller.

Please define the control method and CAN baud rate required at time of purchase.

It is possible, at a later date, to change the control method and CAN baud rate by installing different firmware into the EPAS18A Controller.

Below can be found the various CAN message formats for the different control methods available. These include:

### 8.5.1 Steer-to-Angle CAN Message # 4 (receive)

Message ID: 0x298 (fixed)

Update rate: 5ms

| Message Byte | Description |
|---|---|
| D0 | 0 – Manual Mode<br>1 to 5 – Autonomous Mode *'Controller Gain'* value |
| D1 | Steering Angle Demand |
| D2 | Not used |
| D3 | Not used |
| D4 | Not used |
| D5 | Not used |
| D6 | Not used |
| D7 | Not used |

Steer-to-Angle firmware utilizes the analog steering angle sensor input as the reference angle.
The user sends a Controller Gain and Demand Angle value via CAN.
The EPAS18A Controller then moves the motor towards the demand angle at a speed relative to the Controller Gain.

The Controller Gain setting changes the rate at which the motor reduces speed as the demand angle is approached.

Within the EPAS18A controller, the Controller Gain is multiplied by the angle error (difference between the demanded angle and actual angle) to give a motor duty output.

If the angle error is large, then 100% motor duty may be achieved for any of the Controller Gain values.
Along with some other maths that are not relative to the user, the total gain is 2.35 multiplied by the CAN message Controller Gain value.

Example 1:
If CAN message Controller Gain value = 1.
1 x 2.35 = 2.35 (total gain)
Motor Duty Out = Angle error x 2.35.
If angle error = 7 bits, then motor duty = 16%
If angle error = 20 bits, then motor duty = 47%
If angle error = 50 bits, then motor duty = 100%

Example 2:
If CAN message Controller Gain value = 3.
3 x 2.35 = 7.05 (total gain)
Motor Duty Out = Angle error x 7.05.
If angle error = 7 bits, then motor duty = 49%
If angle error = 20 bits, then motor duty = 100%
If angle error = 50 bits, then motor duty = 100%

The gain affects how quickly the motor duty reduces as the demand angle is achieved. For low gain values the demand angle may not be achieved (undershoot) and for high gain values there may be overshoot and, in extreme cases, oscillation. The performance of the system very much depends on the damping in the system and the gain employed.

It is possible for the external PLC to regulate the speed of the motor by regulating the angle error.

In autonomous mode, the gain is a multiplier based on the CAN Controller Gain value and does not relate to the stored maps from section 7.9 or the physical rotary switch in any way.

In manual mode, the system uses the stored maps from section 7.9 and the physical rotary switch.

Note: For this version of firmware, CAN Message # 2 is not as described within this document and there is no time-out function. Please contact DCE for further information.

### 8.5.2 Steer-to-Dual Angle CAN Message # 4 (receive)

Message ID: 0x298 (fixed)

Update rate: 5ms

| Message Byte | Description |
|---|---|
| D0 | 0 – Manual Mode<br>1 to 5 – Autonomous Mode *'Controller Gain'* value |
| D1 | Steering Angle Demand |
| D2 | Not used |
| D3 | Not used |
| D4 | Not used |
| D5 | Not used |
| D6 | Not used |
| D7 | Not used |

Steer-to-Dual Angle firmware uses the same control message as seen in section 8.5.1. Please reference this section for examples of control messages and useful information.

Steer-to-Dual Angle control firmware uses an additional analog steering angle input.

This firmware compares the two analog steering angle voltages and flags an error if these two voltages are different by more than 32 bits (or ~0.63V).
If there is a steering angle sensor error, then the EPAS18A controller will disconnect the motor and the fault light will be illuminated.

Note: For this version of firmware, CAN Message # 2 is not as described within this document and there is no time-out function. See next page for additional information.

**Steer-to-Dual Angle CAN Message # 2 modified message format:**

Message ID: 0x292 (default)
Update rate: 10ms

| Message Byte | Description |
|---|---|
| D0 | Steering angle A (bits) |
| D1 | Steering angle B (bits) |
| D2 | Not used |
| D3 | Selected map (0 to 5) |
| D4 | Last error code |
| D5 | Bit field of digital I/O values |
| D6 | Bit field of status flags:<br>b0 – Program paused<br>b1 – Motor moving forwards<br>b2 – Motor moving in reverse<br>b3 – Host mode active<br>b4 – Fault light status<br>b5 - Reserved<br>b6 - Reserved<br>b7 - Reserved |
| D7 | Bit field of limit flags:<br>b0 – Steering at LH stop<br>b1 – Steering at RH stop<br>b2 – Over-temperature condition<br>b3 – Not used<br>b4 – Not used<br>b5 – Not used<br>b6 – Not used<br>b7 – Remote mode active |

### 8.5.3 Steer-to-Angle and Duty Cycle CAN Message # 4 (receive)

Message ID: 0x298 (fixed)
Update rate: 5ms

| Message Byte | Description |
|---|---|
| D0 | 0 – Manual mode<br>1 – Autonomous Mode Motor Duty Control<br>2 to 5 – Autonomous Mode *'Controller Gain'* for Steer-to-Angle |
| D1 | Steering Angle Demand |
| D2 | Motor Duty Demand.<br>Defined as a Two's Complement value.<br>For example:<br>0x64 = +100%<br>0x32 = +50%<br>0x00 = 0%<br>0xCE = -50%<br>0x9C = -100% |
| D3 | Not used |
| D4 | Not used |
| D5 | Not used |
| D6 | Not used |
| D7 | Not used |

Steer-to Angle and Duty Cycle firmware allows two different control methods in one version of firmware.
The user can either control the EPAS by Steer-to-Angle logic or Motor Duty logic.

For Steer-to-Angle, please see section 8.5.1 for examples of control messages and useful information.

For Motor Duty control, Two's Complement is used to define the direction and speed of the motor, where a negative value turns the motor counter-clockwise.

### 8.5.4 Simulated Torque CAN Message # 4 (receive)

Message ID: 0x296 (fixed)
Update rate: 5ms

| Message Byte | Description |
|---|---|
| D0 | 0 – Manual mode<br>1 to 5 – Autonomous Mode Steering Map |
| D1 | Torque A (raw value in bits) |
| D2 | Not Used |
| D3 | Not used |
| D4 | Not used |
| D5 | Not used |
| D6 | Not used |
| D7 | Not used |

Note:
In autonomous mode, the EPAS18A Controller logic only uses Torque A value in this version of firmware. There is no error check that Torque A and Torque B sum is 255 bits. In Manual Mode, Torque A and Torque B analog values are compared within the EPAS18A Controller and if there is a deviation beyond the allowable limits, then the fault light will be illuminated and the motor will be disconnected.

Simulated Torque control firmware uses simulated values of the analog torque sensor on the motor to make the EPAS motor function.

When autonomous mode is active, the EPAS18A controller looks at the D1 message byte information and uses this in the same way it would use the analog torque sensor when in Manual mode.

The Steering Map value changes the gain of the motor duty and uses the stored maps as described in section 7.9.

Note: this version of firmware no longer allows the function of CAN Message # 3.

In Manual Mode, when byte D0 value is 0, the EPAS18A Controller operates as normal using the analog map switch and torque sensor connected to it. An external PLC can activate Autonomous Mode by specifying a value of 1 to 5 in byte D0 via CAN Message #4. A torque demand value in bytes D1 will activate motion in the motor.

Torque demands are signed 8-bit values that treat 128 bits (80h) as the zero point (which simulates no driver input).

Example 1:
To turn the motor clockwise slowly:
Autonomous Mode Steering Map value = 1 bits
Torque A = 143 bits

Example 2:
To turn the motor clockwise more quickly:
Autonomous Mode Steering Map value = 1 bits
Torque A = 158 bits

Example 3:
To turn the motor counter-clockwise slowly:
Autonomous Mode Steering Map value = 1 bits
Torque A = 122 bits

The limits of the torque demand values are 64 bits to 192 bits.

The EPAS18A Controller is supplied with default maps that mean in the above examples, if the Autonomous Mode Steering Map value is increased then the motor duty will be increased too.

The user has access to the Steering Maps as described in section 7.9 and can edit the relationship between Torque input (either received by the analog sensor in Manual Mode or via the CAN message in Autonomous Mode) and the motor duty output.

Note:
For this version of firmware, CAN Message # 2 is not as described within this document and there is no time-out function. Please contact DCE for further information

## 8.6 Operating two EPAS18A Controllers on the same CAN Bus

DCE offers a dual-motor system that is operated by two separate EPAS18A Controllers.
This dual-motor system allows either motor and controller redundancy or additional power by activating both motor at the same time.


If it is required to operate both EPAS18A Controllers on the same CAN Bus, DCE can provide a modified version of the Steer-to-Angle and Motor Duty firmware that utilizes a different CAN receive ID.

The CAN message format is as described in section 8.5.3.

Modified firmware for secondary EPAS18A Controller CAN receive ID = 0x299 hex.

# 9 Troubleshooting

| | |
|---|---|
| **Problem** | **I can't connect to the EPAS Ultra ECU or read/write its parameters.** |
| Cause | The EPAS Ultra ECU is not powered up. |
| Action | Turn on the Master switch, and the ignition switch (if necessary). |
| Cause | The serial lead is not connected. |
| Action | Connect the EPAS Ultra ECU to the serial port of the host computer using the correct cable and try again. |
| Cause | The lead is not making a good connection. |
| Action | Ensure both connectors are fully home and that the lead is not damaged in any way. |
| Cause | The serial port is not configured correctly. |
| Action | Choose **Setup ➡ Serial Port** from the main menu and select the correct serial port. If you are using a USB to serial adapter use Windows Device Manager to determine the COM port number. |
| Cause | A previous connection was not disconnected correctly. |
| Action | Reset EPAS Ultra ECU and try again. |

## 10 Error Messages

One of the following error messages will be displayed whilst trying to connect to an EPAS Ultra ECU using EPAS Desktop Pro when the EPAS Ultra ECU fault light is lit:

| | |
|---|---|
| **Message** | Error 100 : Low battery voltage |
| **Meaning** | The battery supply voltage has fallen below a preset threshold and the EPAS Ultra ECU cannot continue to operate safely. |
| **Message** | Error 101 : Torque sensor not connected |
| **Meaning** | The torque sensor is not responding either because it is faulty or because it is not connected correctly. |
| **Message** | Error 102 : Torque sensor fault |
| **Meaning** | The reading from the torque sensor is incorrect either because it is faulty or because it is not connected correctly. |
| **Message** | Error 103 : Current sensor fault |
| **Meaning** | The reading from the internal current sensor is incorrect. |
| **Message** | Error 104 : Motor power fault |
| **Meaning** | The power drawn when the motor power relay is energised is higher than expected. |
| **Message** | Error 105 : Motor not connected |
| **Meaning** | The power steering motor is not drawing enough current indicating that it may not be connected. |
| **Message** | Error 106 : Motor is shorted or stalled |
| **Meaning** | The power steering motor is drawing too much current indicating that it is either shorted or stalled. |

| | |
|---|---|
| **Message** | Error 107 : Clutch not connected |
| **Meaning** | The motor clutch is not drawing enough current when energised indicating that it may not be connected. |

| | |
|---|---|
| **Message** | Error 108 : Clutch is shorted or stalled |
| **Meaning** | The motor clutch is drawing too much current when energised indicating that it is either shorted or stalled. |

| | |
|---|---|
| **Message** | Error 109 : Over current condition detected |
| **Meaning** | The internal current limit has been exceeded. |

| | |
|---|---|
| **Message** | Error 110 : Maximum safe temperature exceeded |
| **Meaning** | The box temperature has exceeded the maximum safe value. |