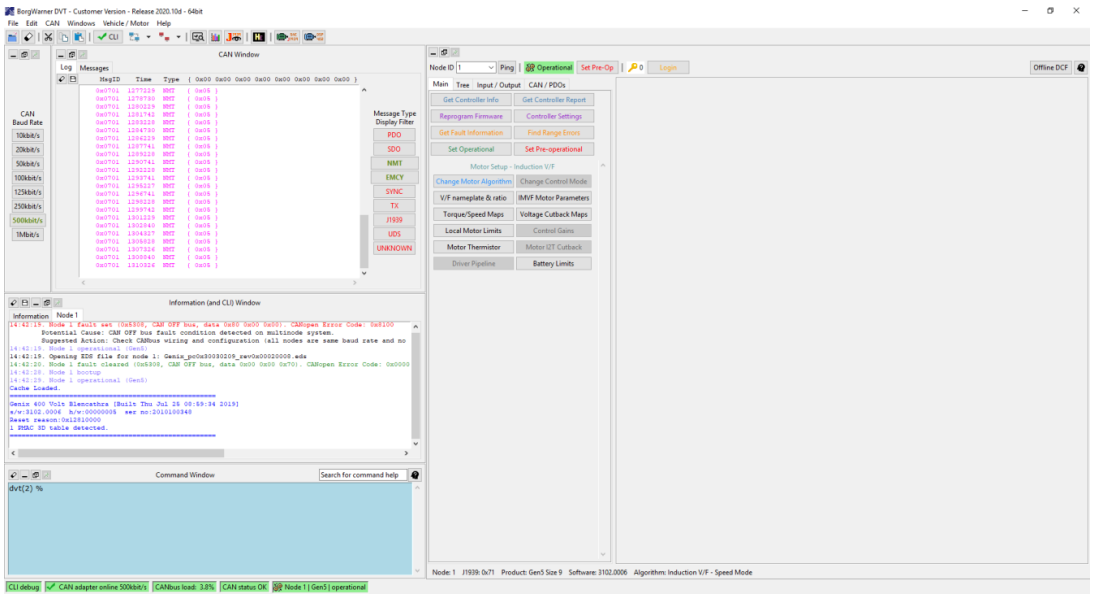


Explore our Technologies

Hybrid Electric

DVT Reference Manual, V1.4

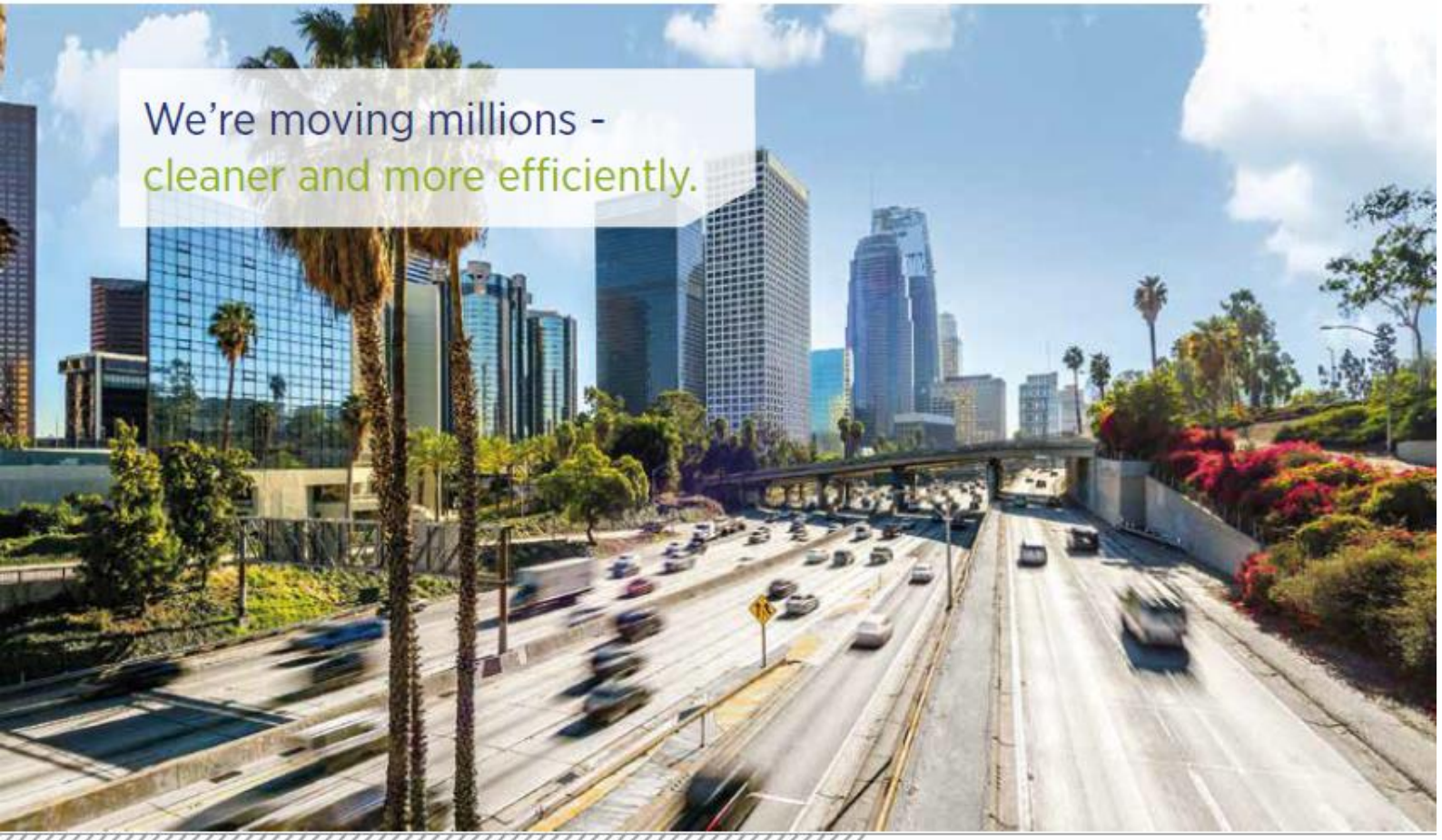
Document no: 177/52505

www.borgwarner.com

BorgWarner

Hybrid

Electric



BorgWarner

Table of Contents

Chapter 1: Legal Disclaimer

Chapter 1 - Legal Disclaimer

Copyright

Trademarks

No warranties and pre-presentations

This information is provided by BorgWarner and without warranty of any kind, expressed or implied, including (but not limited to) any implied warranties of merchantability, fitness for any particular purpose, or non-infringement of third-party rights. While the information provided is believed to be accurate, it may include errors or inaccuracies. In no event shall BorgWarner be liable to any person for any special, indirect or consequential damages relating to this material.

Licenses

No license to the BorgWarner’s intellectual property or the intellectual property of third parties has been granted by this manual.

Important Safety Information

Electric vehicles (and their component parts such as motors, controllers and batteries) can be dangerous and cause severe damage to property and individuals if not handled correctly. All testing, fault-finding and parameter adjustment should be carried out by competent personnel. High voltages, currents and mechanical forces are all present and have the ability to cause harm.

Using BorgWarner DVT to modify motor controller parameters can lead to an unsafe or dangerous system. DVT also allows for direct manual control of motor torque which should be never used on vehicle system and is only intended for dynamometer test bench use by sufficiently trained and competent persons where the DC electrical power can be easily and quickly disconnected.

When setting up a new vehicle configuration, the vehicle should be immobilized until the basic driver controls have been configured and the driver is able to stop the vehicle safely. Before this point, it is possible for full torque to be output from the motor, regardless of the driver demands. The vehicle manufacturer's manual should be consulted before any operation is attempted. Recommended methods for immobilizing a vehicle is by either

disconnecting the line contactor coil supply (only suitable for low voltage vehicles), or raising the drive wheels off the ground. Raised vehicles should be secured with blocks or axle stands. Do not rely on a jack or crane.

Throughout this manual please take extreme caution when the following warnings are shown.

A DANGER/WARNING indicates a hazard with a high level of risk, which if not avoided, could result in death or serious injury.

A CAUTION indicates a hazard with a low level of risk, which if not avoided, could result in a minor or moderate injury, or damage to the controller, motor or battery.

Chapter 2: DVT Overview

Chapter 2 - DVT Overview

2.1 Introduction

DVT is the main interface program used to communicate with the BorgWarner motor controllers, such as Gen4, HVLP, Dragon8 and Gen5 controllers. Over the course of this manual, you will be instructed on how to effectively use the DVT and the user interface known as the DVT configuration helper.

2.2 Technical support

BorgWarner is a major OEM focused business; however, we have an extensive authorized distributor network who can provide you with technical or commercial support. Please find the details of your nearest distributor through the following link http://www.sevcon.com/contact-us/

For direct customers of BorgWarner please contact one of the following BorgWarner offices for assistance:

- European Office (+Rest of World):
  - BorgWarner Systems Lugo S.r.l. (drives.sales@borgwarner.com)
- North America Office:
  - BorgWarner Southborough Inc. (US.drives.sales@borgwarner.com)

2.3 Installing

From the following customer portal link, it is possible to download the latest version of DVT. An internet access is required to download the installer but then it can be transferred to an “offline” computer for installation if required.

https://borgwarnerlugo.sharefile.com

Using the following credentials to sign in:

Username: dvt@sevcon.com
Password: Installer100!

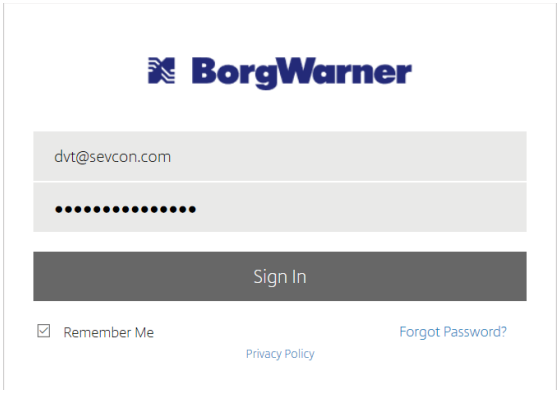


Figure 1 customer portal login

Once logged in, enter the “DVT installer” folder:

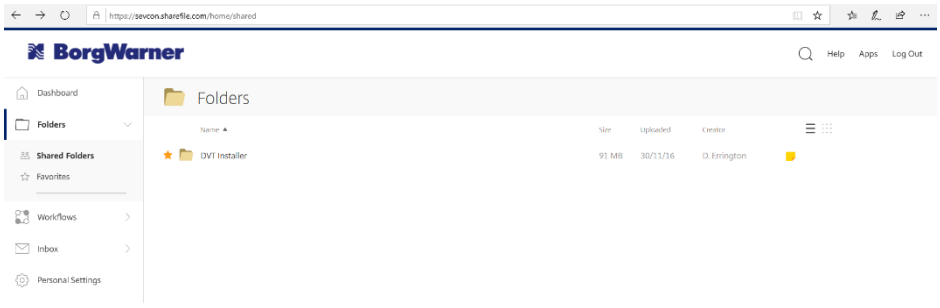


Figure 2 DVT installer folder

NOTE: you may see two versions of the installer, if you already have a recent version of the IXXAT drivers (VCI4) installed, you will only need the smaller “update” version.

Now download the required “.exe” installation file inside.

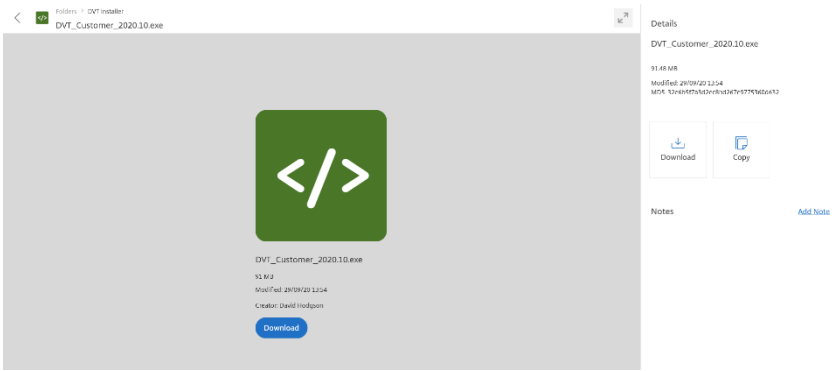


Figure 3 DVT installer file

Proceed with the installation process. Please ensure that your Windows session has administration rights to avoid any installation/activation issues.

NOTE: At present the install file is not digitally signed so you may get a warning from your antivirus or windows. Please ensure the installer you are using was obtained from a reputable source if not from BorgWarner Sharefile site.

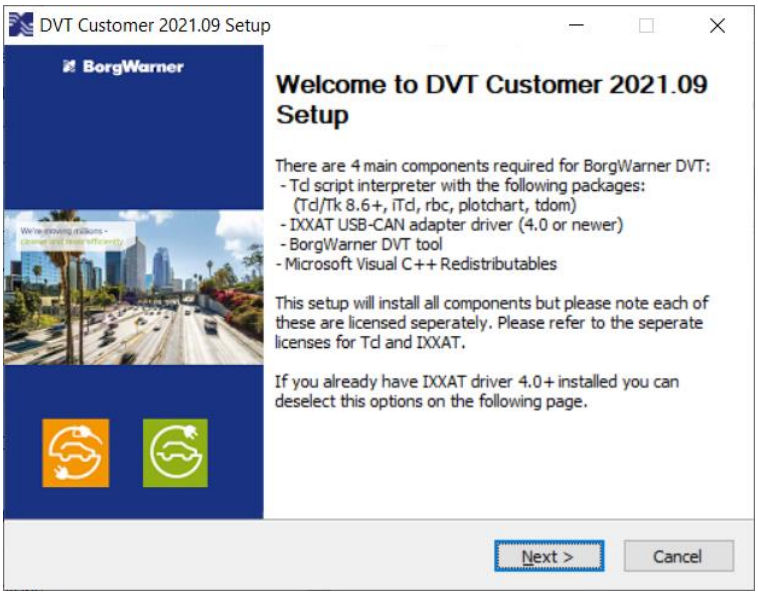


Figure 4 First page of DVT installer

Figure 5 Second page installer: DVT license

The next step is to select the components you wish to install. There are a number of additional components required for DVT that can be selected on the page shown in Figure 6. If using the installer update version some items may not be shown.

- CAN adapter (IXXAT) driver
  - If you already have a recent version 4+ you can deselect this
- Tcl interpreter
  - Since DVT version 2021.08 this is included as part of DVT rather than installed separately
- Microsoft Visual C++ Redistributable
  - links here as not included in older DVT installer (from 2021.10 onwards)
  - https://aka.ms/vs/16/release/vc_redist.x86.exe
  - https://aka.ms/vs/16/release/vc_redist.x64.exe

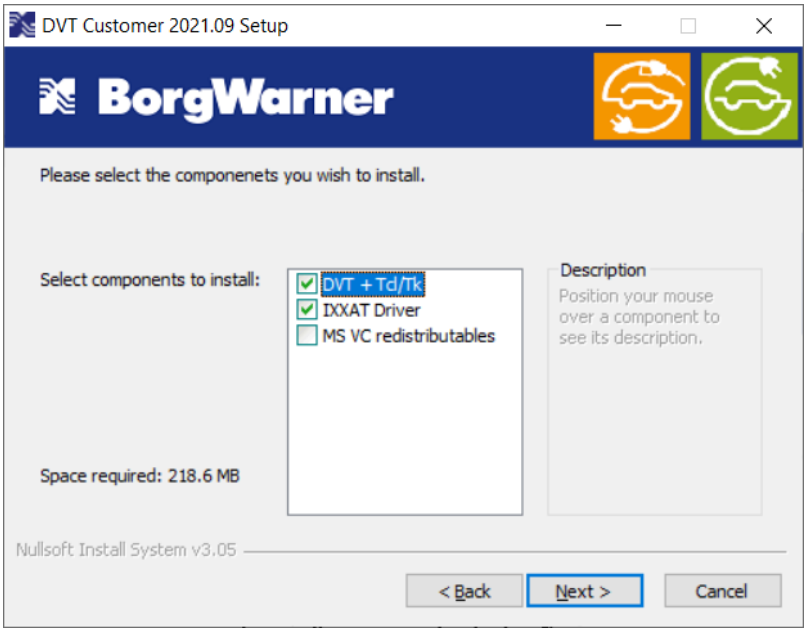


Figure 6 component selection

Select the destination folder for the DVT installation (by default a new folder is created for each new version, so multiple versions can be installed on a PC simultaneously without corruption, please note that the previous version will not be uninstalled automatically);

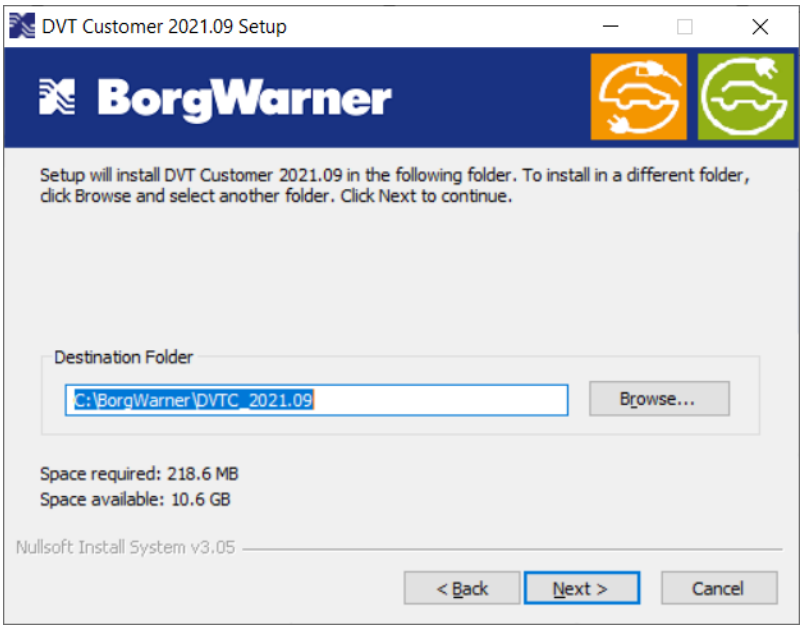


Figure 7 DVT install folder

Shortcuts will be created automatically. On this page there is also the option to associate .dcf (controller configuration files) to open with the DVT Helper. One shortcuts are selected click Install and the DVT installation will then complete automatically.

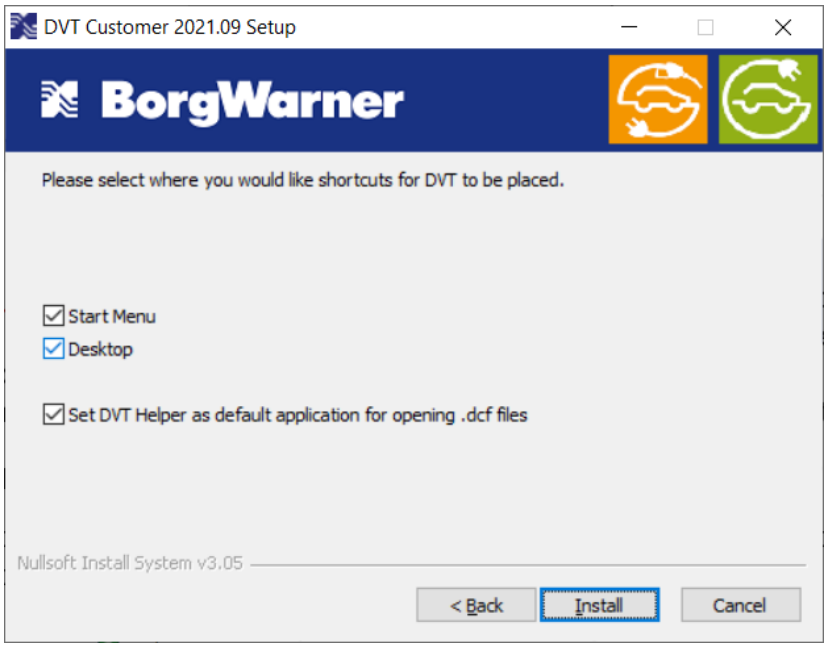


Figure 8 DVT shortcuts

The next step (if selected earlier) will open the installer for Microsoft Visual C++ Redistributables required for executing software compiled using Microsoft Visual Studio tools.

For the final step it launches the Ixxat driver installer. You may need to restart your PC for this to complete the install. You can leave all default options for this install.

Figure 9 IXXAT driver installation

2.4 Licensing

BorgWarner does not charge its direct customers for DVT. However, a licensing mechanism is used to restrict unauthorized access.

Licenses must be requested by email using information in XML tags and if accepted a license file is returned to activate the program.

If you are installing a newer version of DVT typically you can use the same license file as long as it hasn't expired. Recent versions of DVT when re-installed or updated will automatically find the previous license file and activate automatically, as it is stored locally on your machine in the Windows 'AppData' folder.

When running DVT for the first time you are presented with this options for activation. If you already have a file to use you can skip to step 2 on page 17.

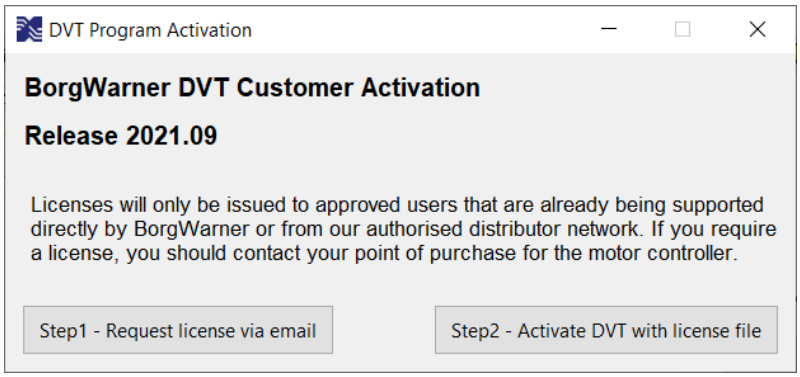


Figure 10 – DVT License Window

2.4.1 Step1 – License Request

The licensing process requires DVT to generate a license string to link the license to your computer hardware (a hash is used so it cannot be reverse calculated to identify the machine). Although we also ask for the "point of purchase" to speed up the license approval process and for the name of the company that will be using DVT to link the license to that company.

There are three options in order to activate DVT depending on the purchase channel of the motor controller:

- Purchased direct from BorgWarner
- Purchased through authorized Distributor / Reseller
- Other Source

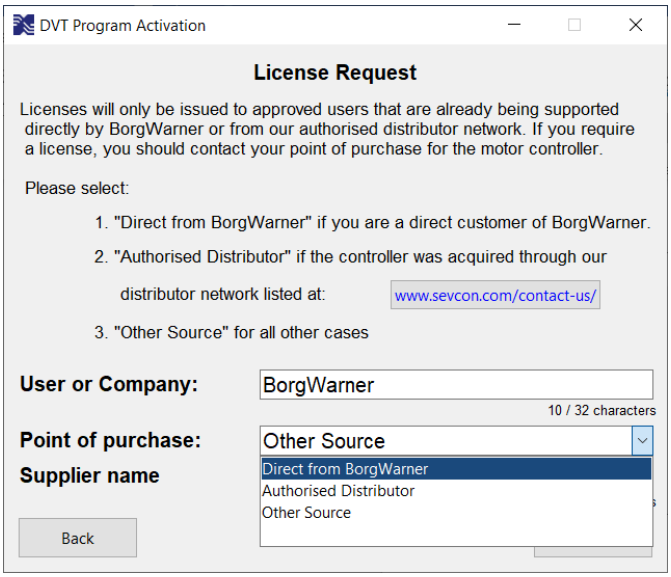


Figure 11 DVT License Request window

Selecting “Direct from BorgWarner” indicates the controller was directly shipped and invoiced from BorgWarner (formerly Sevcon) and not purchased through any 3rd party. The license request details should then be sent to the following email address ITAdvtlicense@borgwarner.com. This email address is not monitored and applies an automated algorithm to respond. If you are a new direct customer of BorgWarner you may 1st need to contact your assigned applications engineering or sales contact to have your company added to the list of approved DVT licenses.

If the motor controller has been purchased from a BorgWarner distributor or reseller, then the license request should be sent directly to the distributor as it is shown in the following figure.

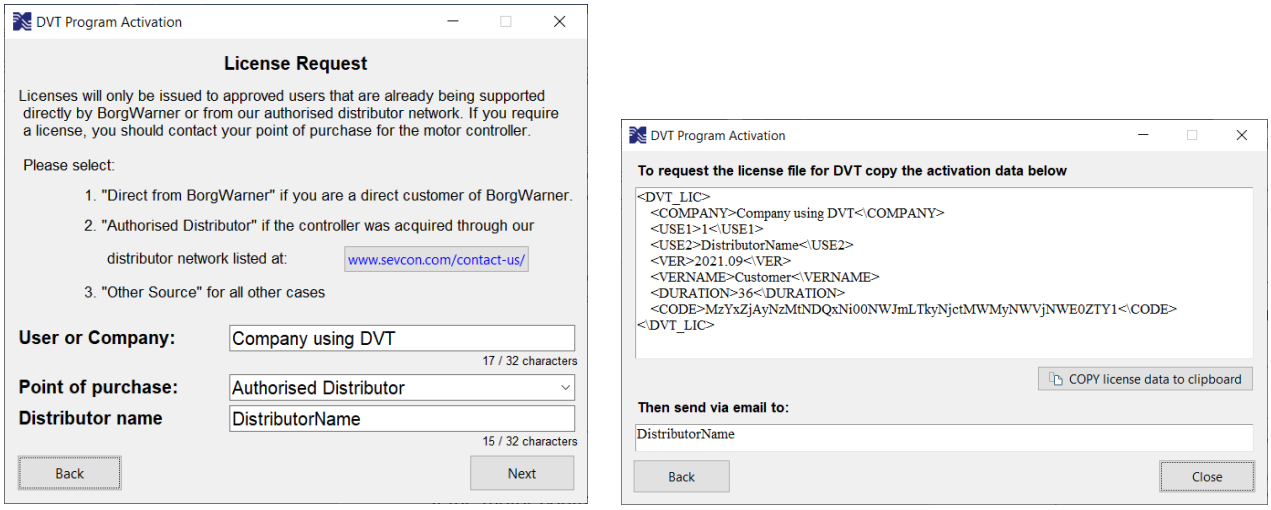


Figure 12 The motor controller has been purchased from an authorized distributor

If the motor controller has been purchased from other sources, then the process is the same as for a distributor and the request must be sent to the contact details of the point of purchase.

2.4.2 Step2 – DVT Activation

After contacting using the correct email address according to the type of purchase, the user will receive a license via email as soon as possible. Applying through the correct channel will reduce the time taken to issue the license.

The license can then be activated in DVT is as follows, first by selecting the “browse for license file” button to open the local computer’s file directory. The file can be found wherever the user saves it.

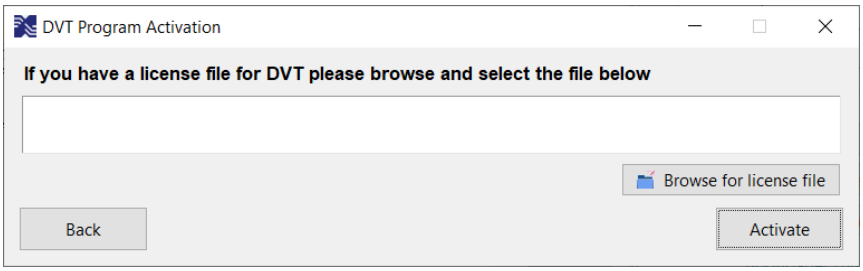


Figure 13 DVT license file selection

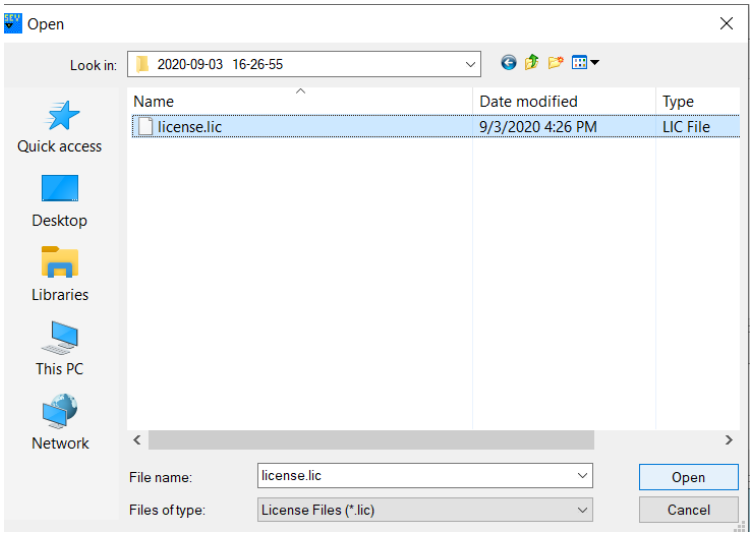


Figure 14 selecting the license file to activate DVT

After selecting the file, its pathway will show in the activation window. Finally select the “Activate” button.

2.5 DVT Main Page

This is the main page of DVT. From here all the functions and settings of the BorgWarner motor controller can be accessed:

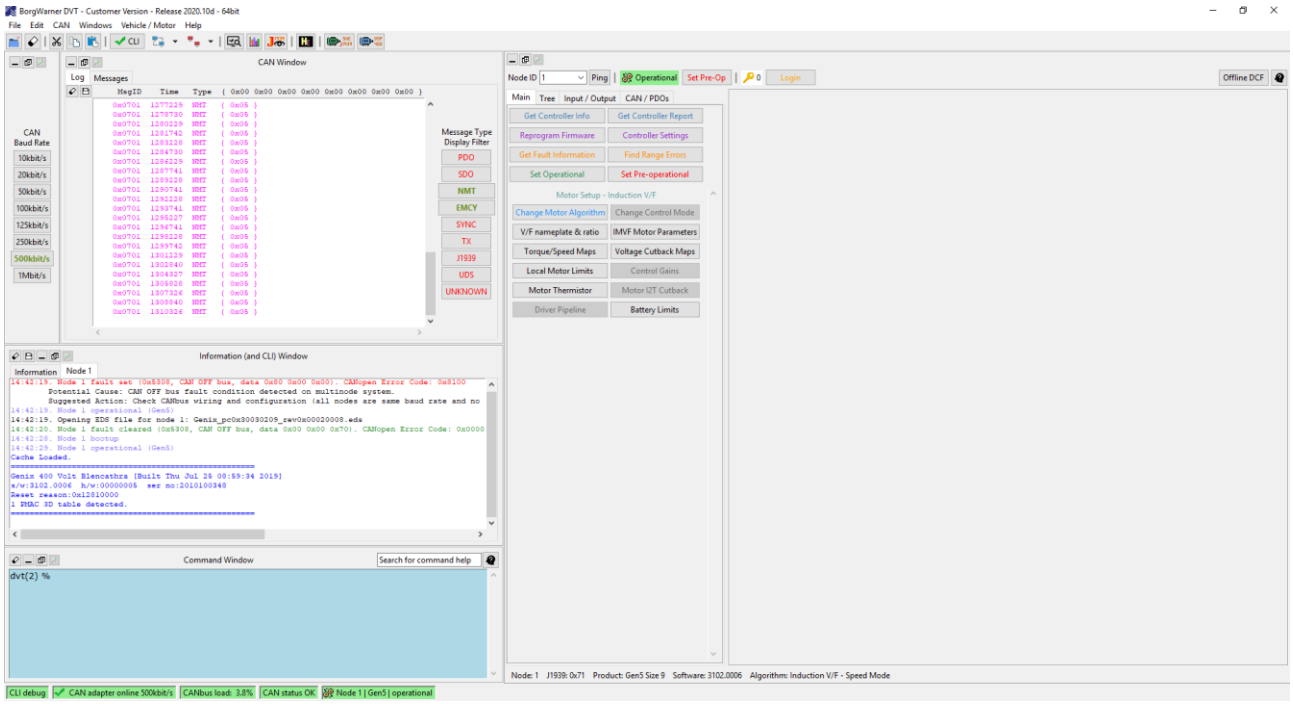


Figure 15 DVT main page

2.6 CAN Window

When there is an active connection between DVT and the BorgWarner motor controller. The CAN window, found in the upper left corner of the DVT, will show the traffic being transmitted. Unless being actively used for debug it is advised to disable high rate CAN message types (such as unknown, J1939, sync, PDO and Tx) using the filter options to reduce the PC resources used and potential CAN data loss.

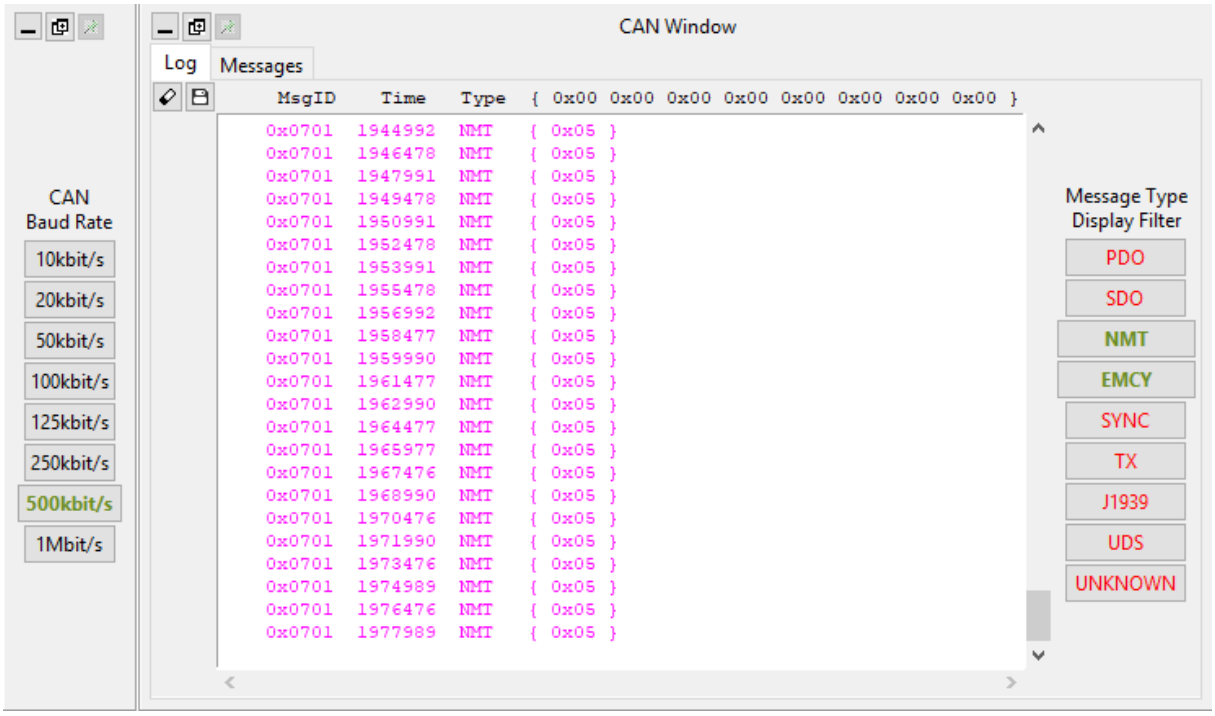


Figure 16 CAN window

2.7 CAN Baud

The different baud options can be seen inside the red box in Figure 17. The baud rate is the speed of data transmission to communicate with the configured BorgWarner motor controller.

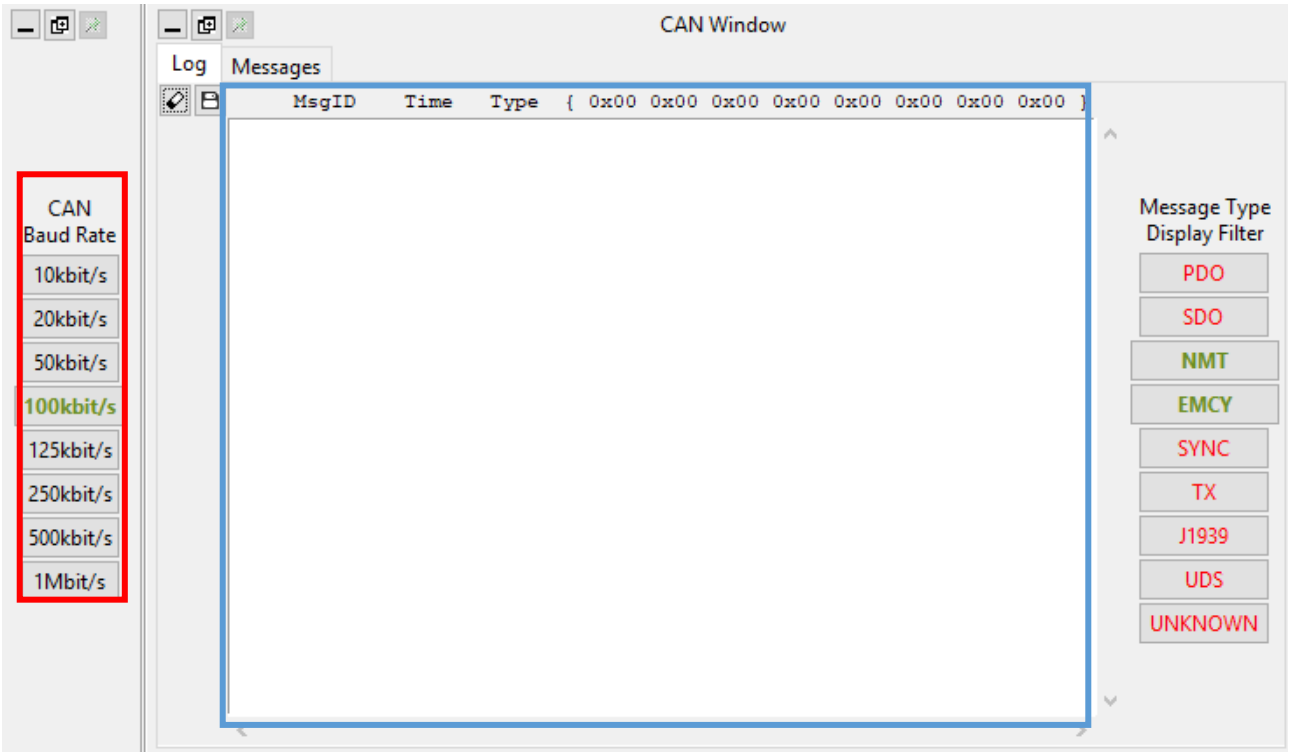


Figure 17 Blank CAN window due to selected wrong baud rate

In Figure 17 for the CAN network connected there is currently an incorrect baud of 100kbit rate selected. This is indicated because the CAN window (seen in the blue box) is empty even though an active CAN node is connected and the NMT message types are enabled. If an incorrect baud rate is selected, then the CAN window remains blank. If correct baud is selected, then CAN bus transmissions will be seen scrolling in the CAN window. The DVT is now ready to perform operations.

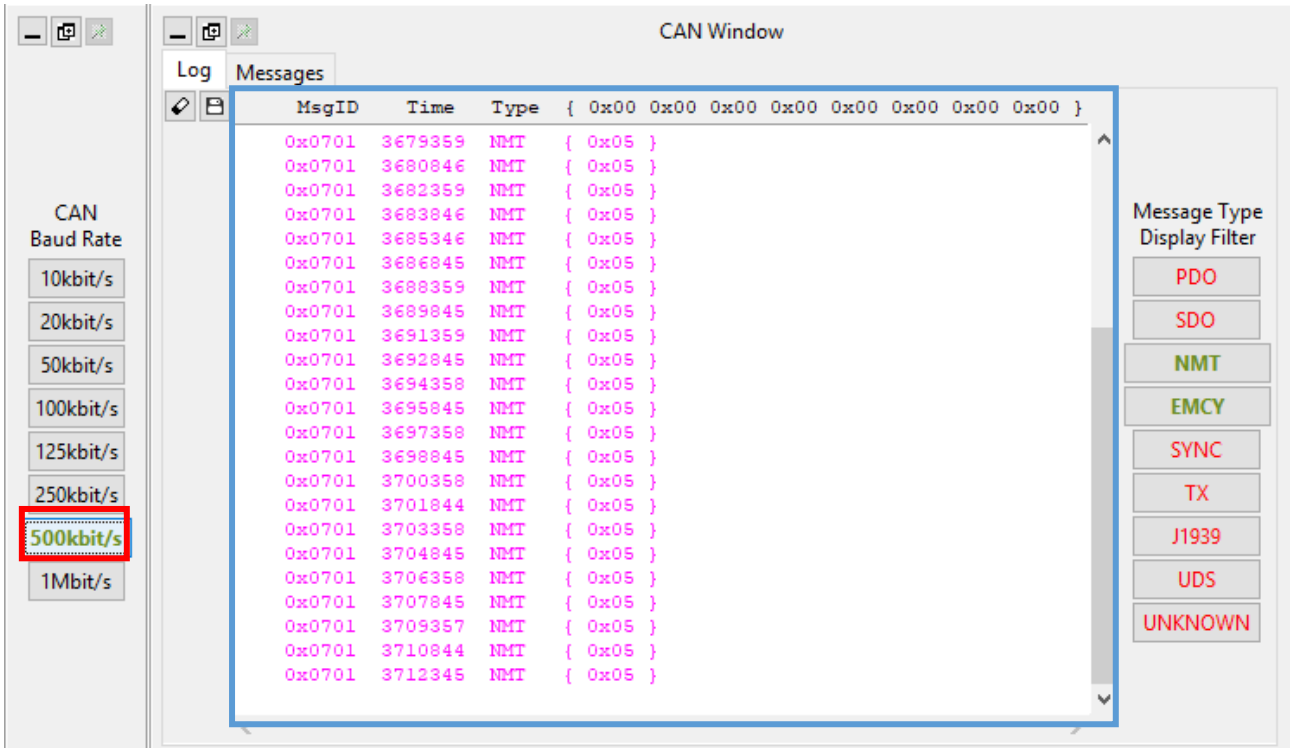


Figure 18 CAN window with baud rate selected properly

2.8 Vehicle interface

The DVT comes with a feature that will allow the user to view a variety of information on the motor, such as the current, voltage, temperatures etc. in real time. This is the vehicle interface and it can be accessed by selecting the button highlighted in red in Figure 19:

Figure 19 Vehicle Interface Button

Selecting the button will open a window separate to the DVT that looks like this:

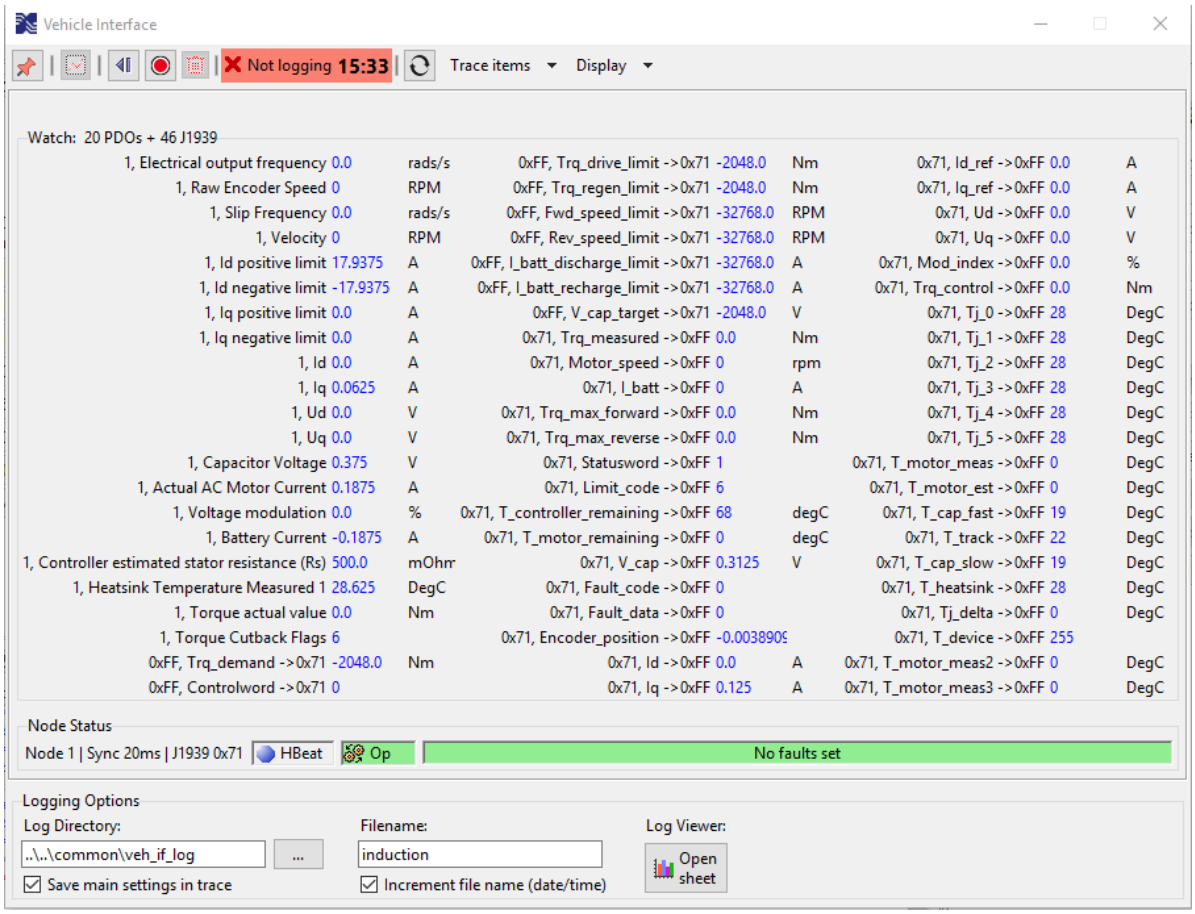


Figure 20 Vehicle Interface Window

This window will update in real-time with measurements and information about the motor controller setup. Information displayed depends on the setup of TPDO, H- and I-protocols of the motor controller.

2.9 Information Window

The window found in the center of the DVT homepage is known as the “Information Window”.

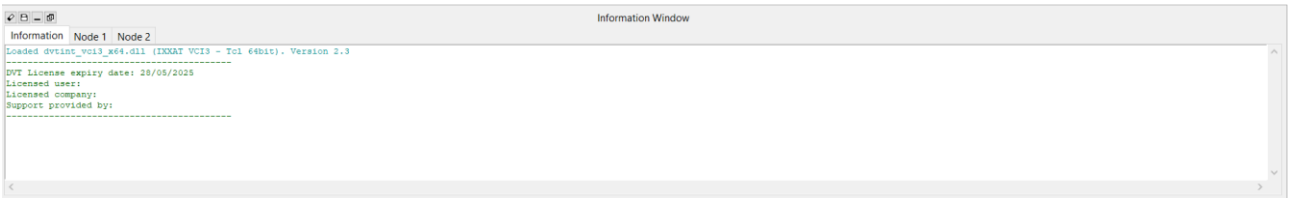


Figure 21 Information Window

This window can give a variety of information to the user such as faults being set inside the controller or the CLI debug information.

CAN CLI messages will cause the controller to send text-based debug to the DVT window. Such as the bootup message shown in Figure 22. It also lists any parameter range errors in the configuration. You can enable and disable CLI message using CLI button in the DVT main window.

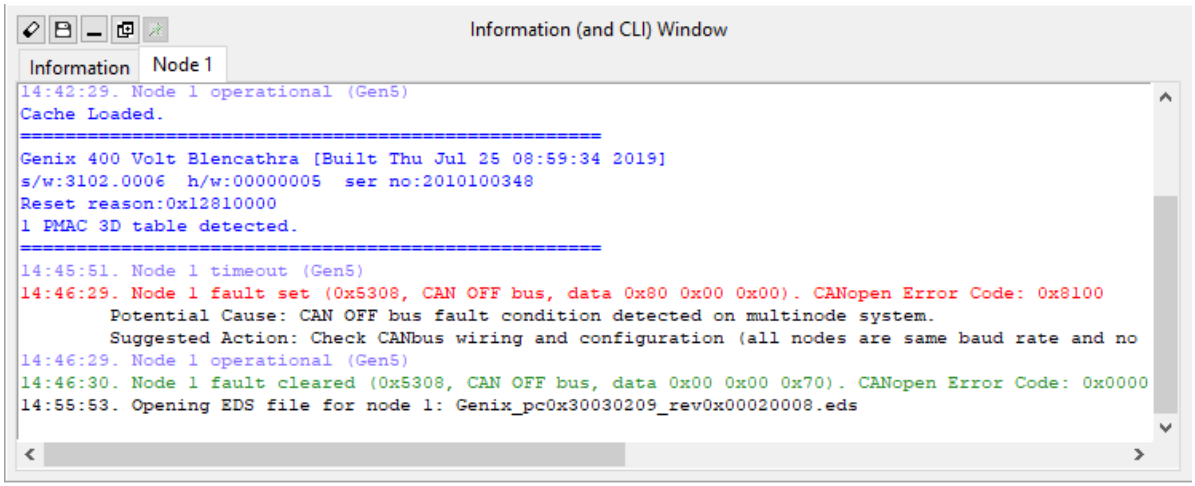


Figure 22 CLI bootup message on Node 1

Also faults information of each node is reflected in Information window under its dedicated node tab. For example, here the window shows a “low battery” fault in the controller configured as Node 2:

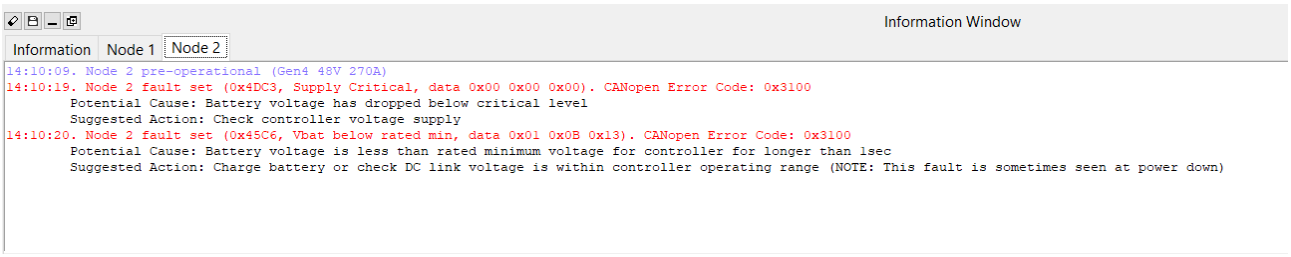


Figure 23 Information Window with set fault message on Node 2

After clearing the fault, the DVT will report to the user that the fault has been cleared by showing the error message in green.

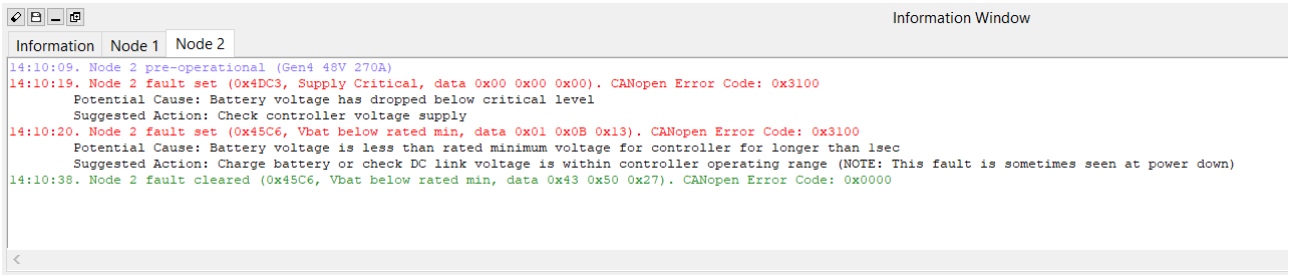


Figure 24 Information Window with cleared fault message on Node 2

2.10 Command Window

The command window allows direct modification of all parameters. Incorrect configuration can lead to dangerous system operation.

The DVT comes with a low-level input window for giving commands manually to the BorgWarner motor controller, you can find this window at the bottom part of the DVT:

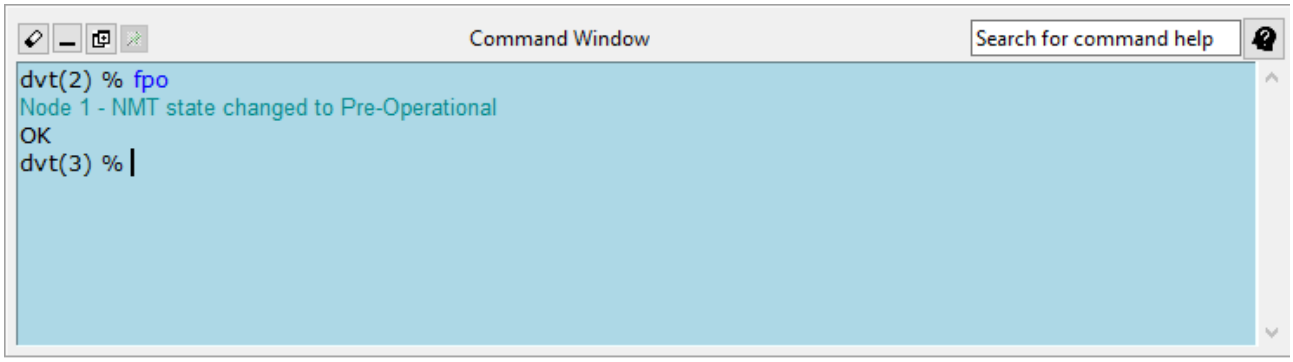


Figure 25 Command Window

This tool is recommended for more experienced users of DVT only and can be minimized unless required, for more information please contact BorgWarner.

2.11 Accessing the DVT Configuration Helper

The DVT configuration helper is the main user interface found in the DVT. Its function is to make viewing/changing settings inside the controller easier, creating TPDO/RPDO's and managing Input/output connections with a user-friendly interface. The DVT configuration helper can be accessed through selecting the button  . On the latest versions of DVT the helper is launched automatically in the main window.

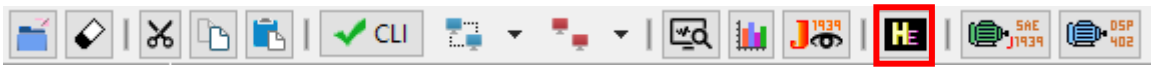


Figure 26 DVT configuration helper

This is the DVT configuration helper, its features will be detailed in the following chapter. It is recommended to save the existing configuration in a dcf file before changing any parameters.

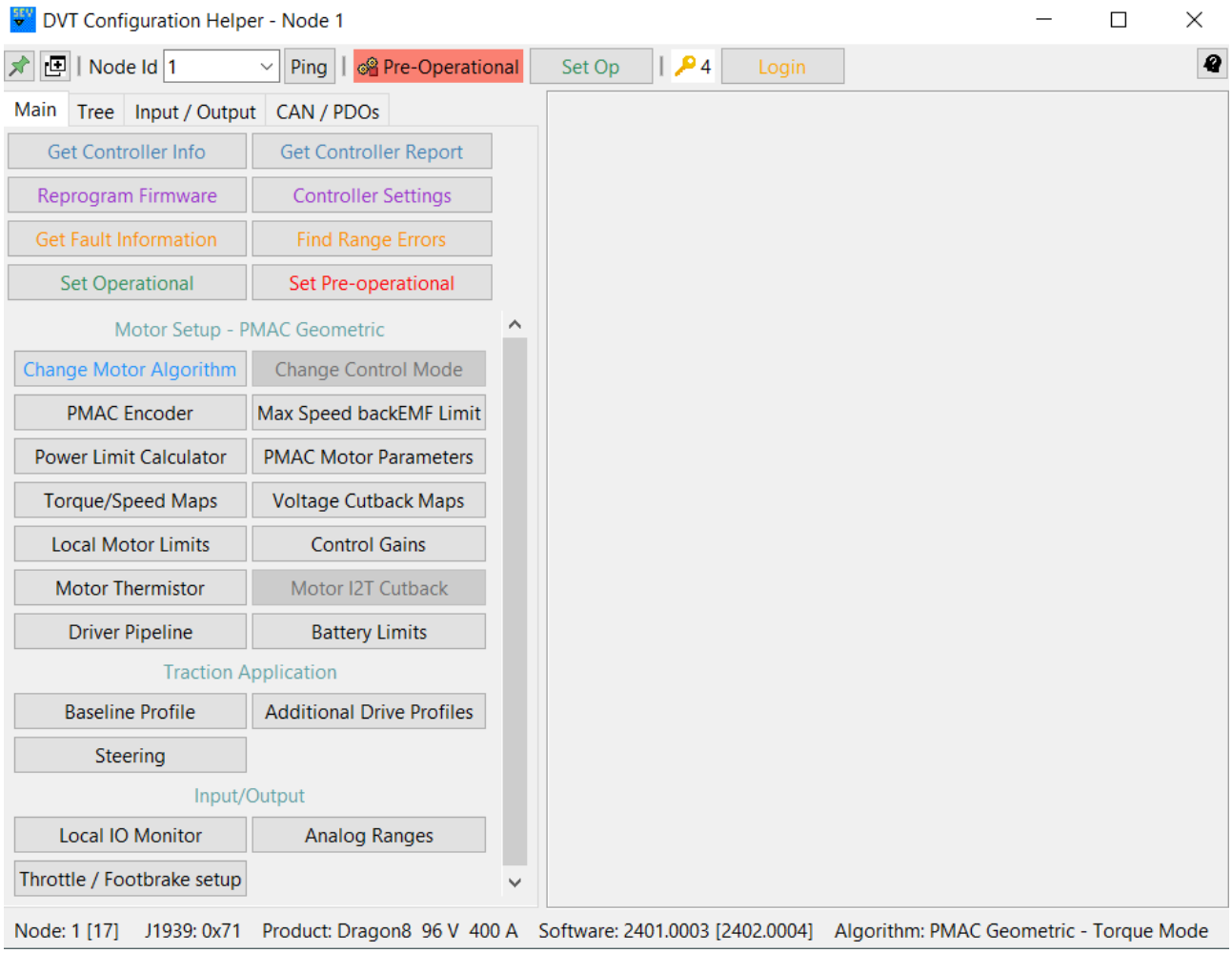


Figure 27 DVT configuration helper

2.12 Help Section

Using help option in the DVT main window you can find fault codes list which gives you useful information once you face a fault in settings.

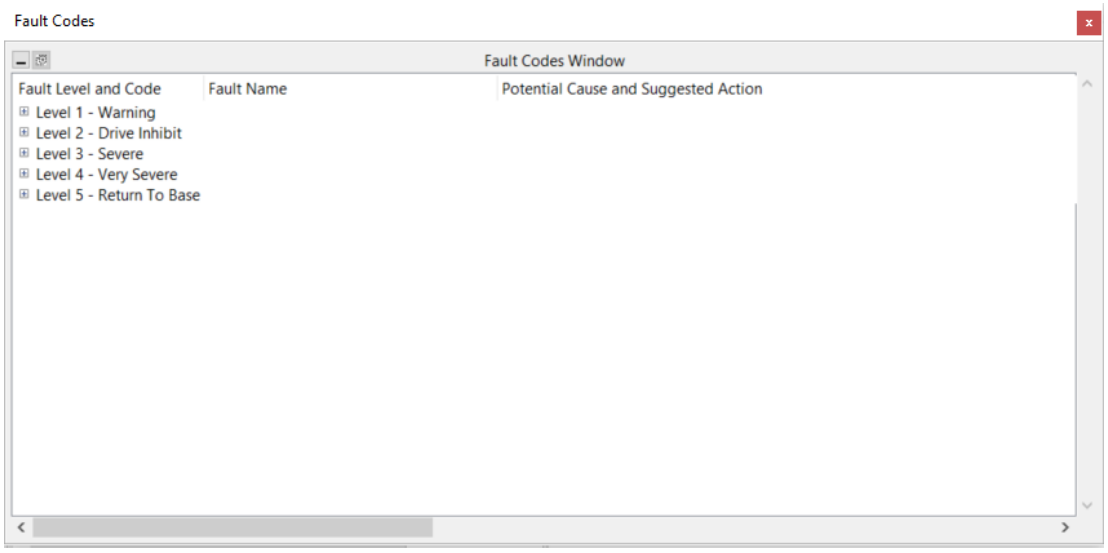


Figure 28 Fault codes list

Chapter 3: DVT Configuration Helper

Chapter 3 - DVT Configuration Helper

3.1 Accessing Different Nodes

If there are multiple nodes connected to the CAN network, DVT can be used to access each node's configuration via the DVT helper. This is done through the CANopen node ID switch found here:

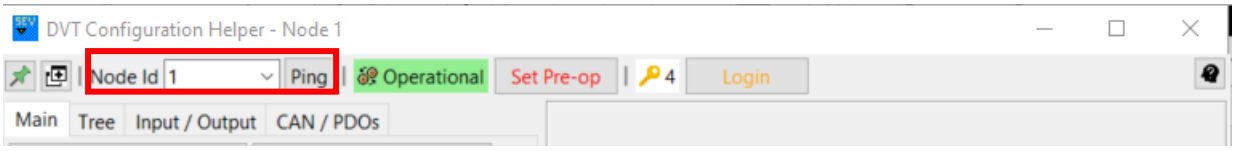


Figure 29 Node ID selection in DVT Configuration Helper

By clicking the small arrow seen above, you can cycle through different node ID numbers.

3.2 Operational and Pre-Operational

Two of the most important buttons on the DVT configuration helper are the "Set Op" and "Set Pre-op" buttons. These buttons are used to activate critical functions within the motor controllers. Only one button will be shown depending upon the existing state.

3.2.1 Set Operational (Set Op)

Selecting the "Set Op" button will essentially set the controller to "ready to drive". While in this mode, the many of the motor controllers' settings cannot be changed.

3.2.2 Set Preoperational (Set Pre-op)

Many of the controllers' objects can only be changed while in pre-operational mode. When in pre-operational mode, CAN PDO messages will not be transmitted from the controller.

3.3 Main Tab General Buttons

3.3.1 Getting Controller Information

Basic hardware and software information about the BorgWarner controllers can be found by selecting the “ Get Controller Info ” button. The first button found on the main page of the DVT configuration helper.

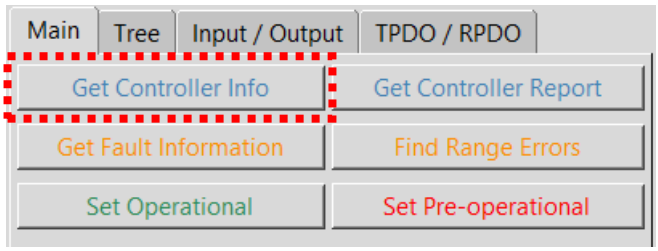


Figure 30 Get Controller Info button

Selecting this button will cause a new window to open, which will fill with information on the controller similar to Figure 31.

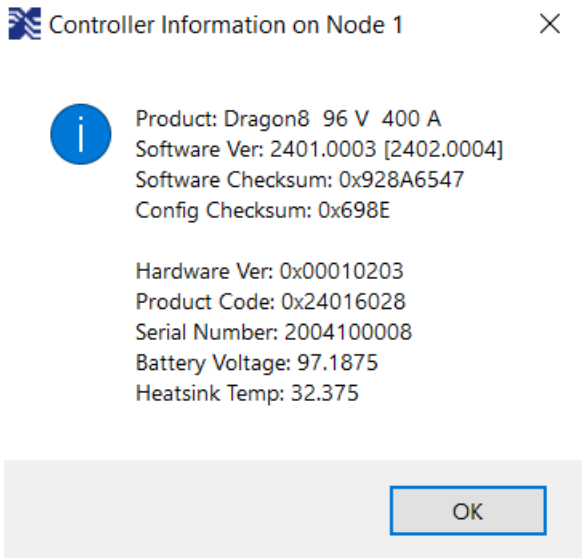


Figure 31 Controller information

This information can be refreshed at any time by selecting the Get Controller Info button again.

3.3.2 Fault information and report

BorgWarner motor controllers are designed to detect a range of operational faults and warning conditions. Selecting the Get Fault Information button will open a window which displays the Fault ID code and simply description of any active faults at that time.

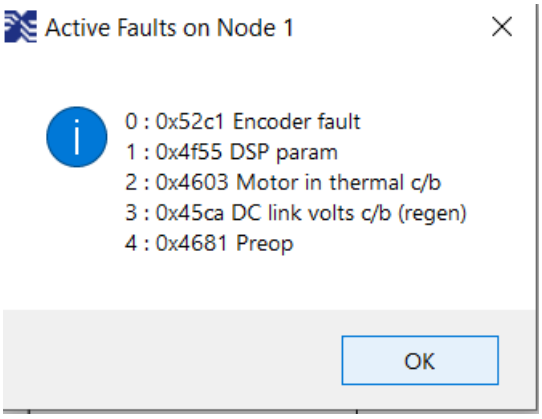


Figure 32 Active Faults

Using Find Range Errors button will show range of existing errors.

3.4 Motor Setup Buttons

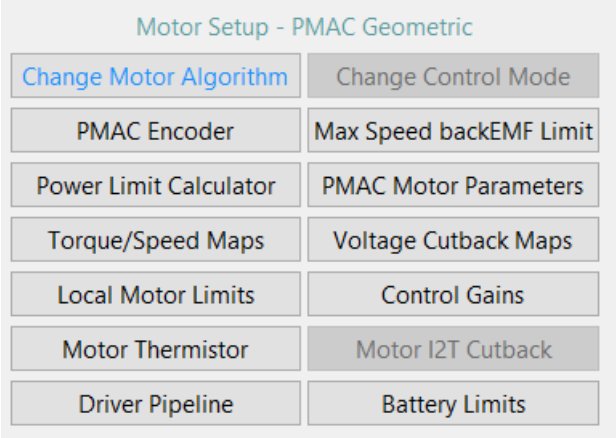


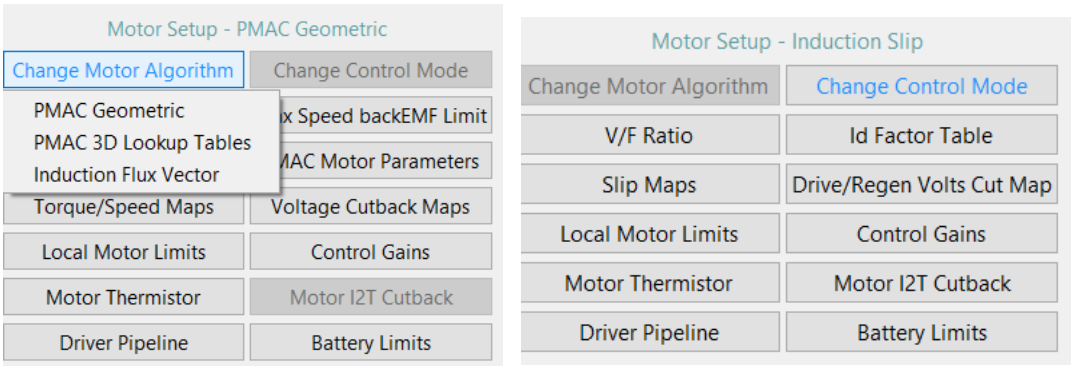
Figure 33 Motor Setup Buttons

3.4.1 Change Motor Algorithm

Changing the motor algorithm requires a significant number of parameters to be updated for the new algorithm. The system should be put into a safe state before changing algorithm

In order to change the motor control algorithm, you need to use the Change Motor Algorithm button. Depending upon the BorgWarner motor controller variant and the installed firmware, you may be able to switch between different control algorithms. As an example Dragon 8

motor controller gives the flexibility to switch between three different algorithms as it is depicted in Figure 34 (a), while the Gen 4 motor controller with induction slip control firmware does not give the flexibility to change the algorithm as the button is disabled in Figure 34 (b). The controller must be reprogrammed to change the motor algorithm.



(a) (b)

Figure 34 (a) change motor algorithm in Dragon 8 (b) No algorithm change possible in Gen4 with induction slip firmware

3.4.2 Change Control Mode

Changing the control mode requires a significant number of parameters to be updated. The system should be put into a safe state before changing mode

In some firmware versions, the BorgWarner motor controller can be configured to operate in torque, or speed control mode. Other versions only support torque mode. If available DVT can be used to switch between the two modes, by using the "Change Control Mode" button. Once this button is selected, a small drop-down menu will come from the button:

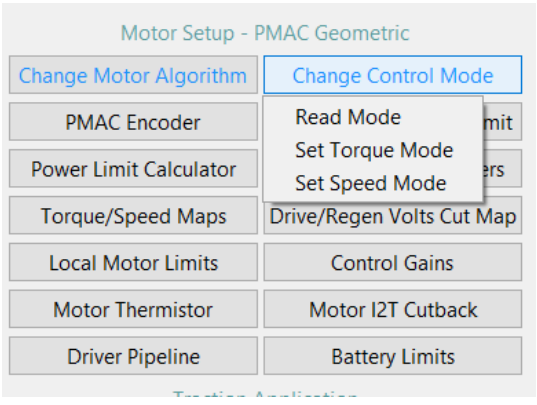


Figure 35 Change Control Mode

When switching the control mode, DVT will first be automatically put into pre-op.

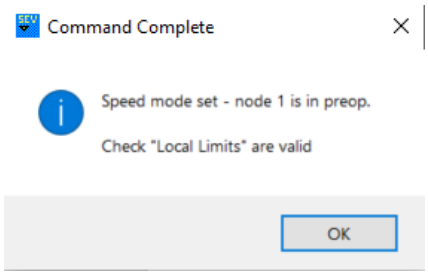


Figure 36 mode change confirmation

The DVT will then confirm whether you wish to set the defaults of the new mode. It is recommended to only apply these default settings if the default torque or speed mode configuration requires configuration. Please ensure you have already saved your existing configuration into a DCF file as instructed in the section on page 57.

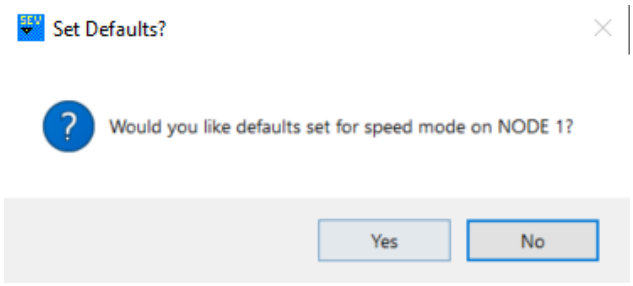


Figure 37 mode change additional settings

3.4.3 PMAC Encoder

Incorrect sensor angle offset or wiring can lead to torque being applied in the opposite direction as expected

The DVT can be used to manually align the Permanent Magnet AC encoder signals with the mechanical position of the rotor. With this, the controller will know the correct angle of the flux to produce the desired torque from the machine. A misalignment of the encoder will cause reduction of torque per amps available, or potentially incorrect torque direction. The allowable range to configure the offset angle is between 180 and -180 degrees (if you see two offsets, then adjust the second one leaving the first one set to zero, since the first one is limited to smaller adjustable range). From this window the offset angle can be changed in steps of 1 degree.

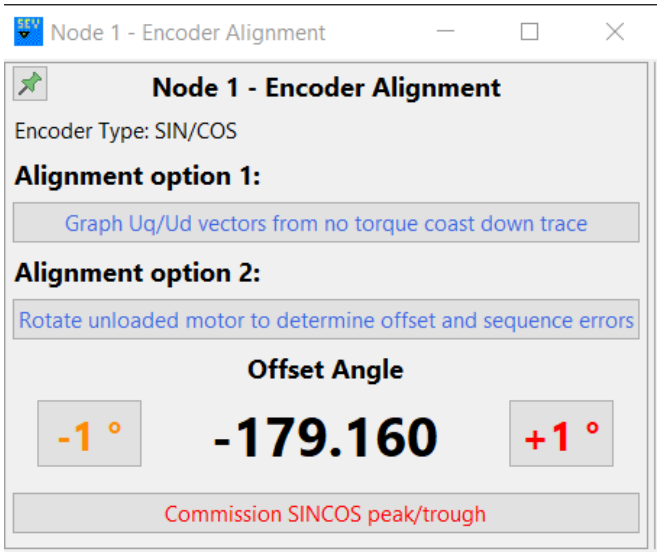


Figure 38 PMAC Encoder Window

If you are using a sin/cos encoder type, you will see the option to commission the peak and trough of the connected sensor. Please ensure you have already rotated the motor at least one mechanical revolution before activating this option.

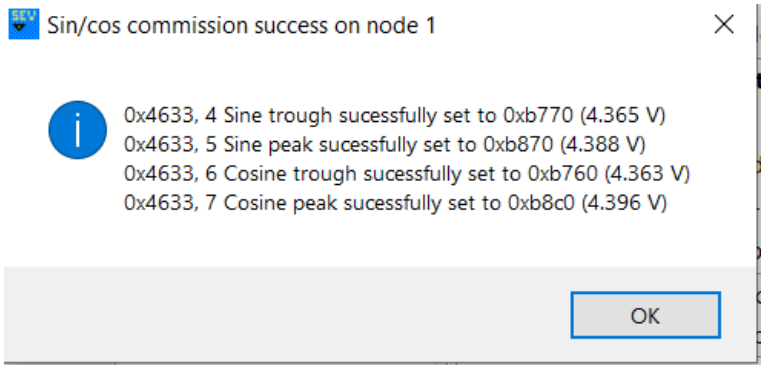


Figure 39 sin/cos commission result (NOTE in this example the rotor hasn't been turned before commissioning as the peak and trough values are almost the same)

3.4.4 PMAC Max Speed Voltage

While connected to a Permanent Magnet AC motor, the DVT can perform some simple calculations to check on the allowed BEMF (Back EMF voltage) for the configured motor.

The results of these checks can be viewed through the "Max Speed backEMF Limit" button found here:

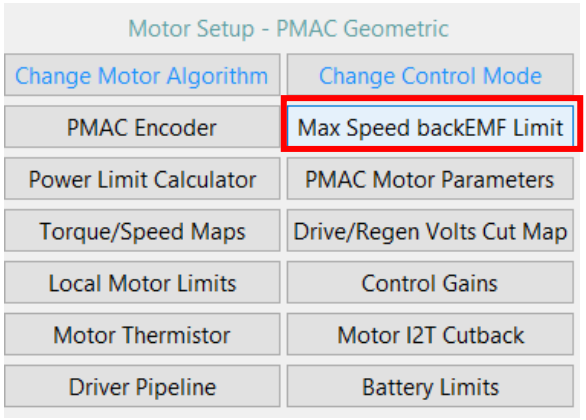


Figure 40 PMAC max speed calculation button

Selecting this button will open a screen containing the voltage data calculated based upon the motor parameters already configured:

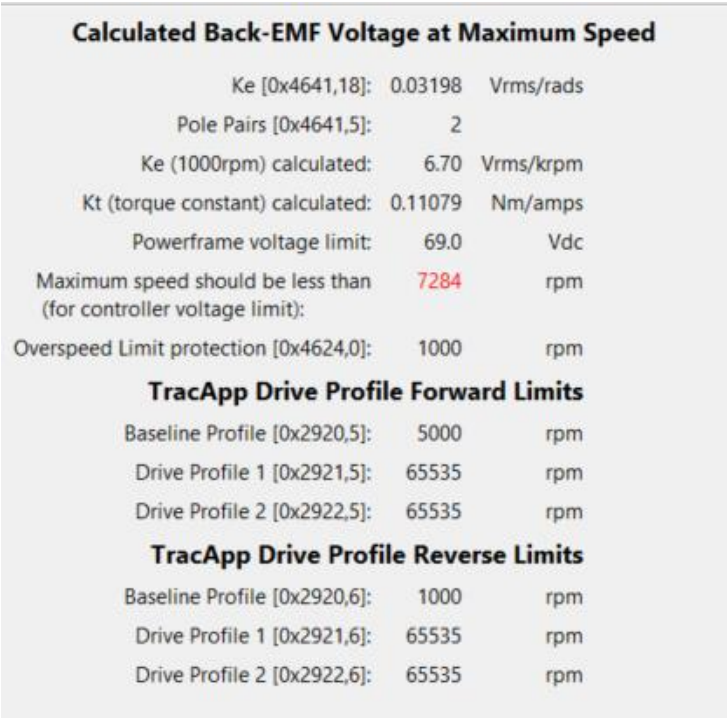


Figure 41 PMAC motor voltage calculations

3.4.5 Torque/Speed Maps (Motor Power Limit Map)

The DVT can be used to configure the entire torque/speed relationship of a motor through the use of the "Torque/Speed Maps" button. Selecting this button will create a dropdown from the button that looks like this:

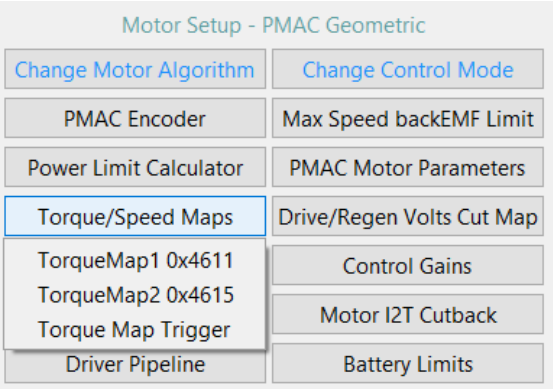


Figure 42 Power Limit map selection

Selecting a map will open a table and graph like this:

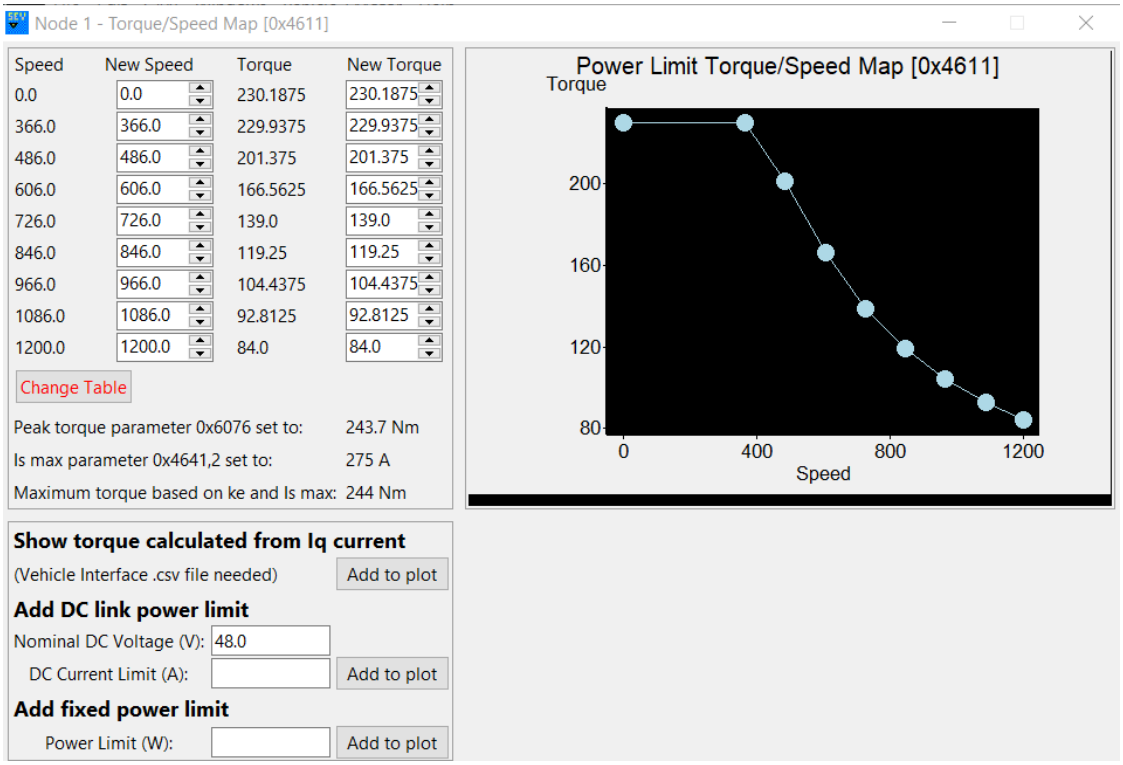


Figure 43 Power Limit Map

The main function of the power limit table is to configure the maximum torque allowed across the speed range of the motor, which then limits the power: speed*torque = power

Depending upon the motor type and algorithm being used different options to help set the correct power limit map will be shown in the power limit helper window.

3.4.6 DC link Voltage Cutback Map

The DVT will allow control over the voltage cutbacks for the controller. This can be accessed through the “Drive/Regen Volts Cut Map” button.

In the table below, it is shown that the voltage for the connected controller is between 43V and 70V. Inside this range, the torque request to the motor won’t be restricted. Above or below these limits; however, the torque will decrease as configured in the voltage cutback gain.

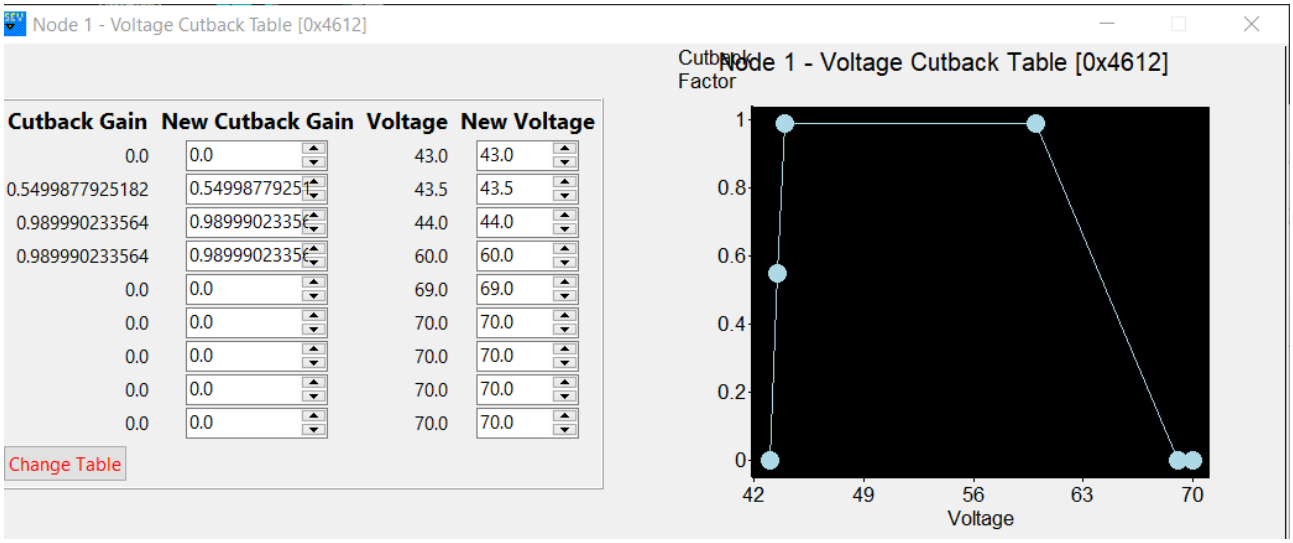


Figure 44 voltage cutback map

These limits are customizable and should be set according to the voltage rating of the controller and system. Each value has two arrows shown here:

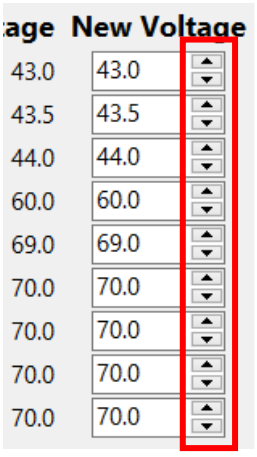


Figure 45 voltage cutback adjustment

Each click of one of these arrows will increase/decrease the value in the corresponding box by a value of 1 volt.

Alternatively, new values can be entered into the boxes manually through the keyboard.

The same customization can be applied to the level of torque that is cut back in the same way. This is seen under the “New cutback” gain.

3.4.7 Local Motor Limits

DVT allows configuration of the main limits in both current, torque and speed of a motor.

The easiest way to access these functions is the local limits “ Local Motor Limits ” button found here:

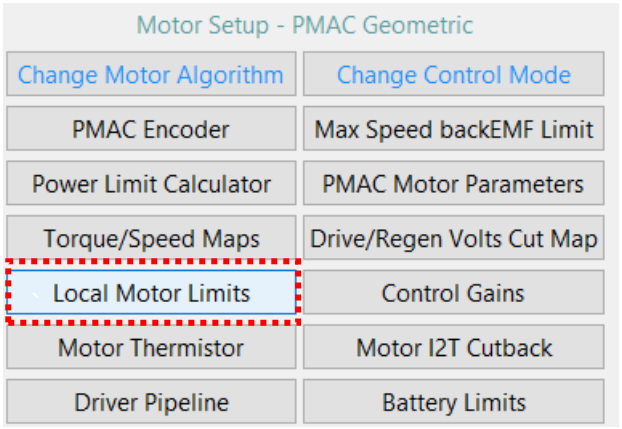


Figure 46 Selecting Local Motor Limits

Selecting this button will open the local limits window:

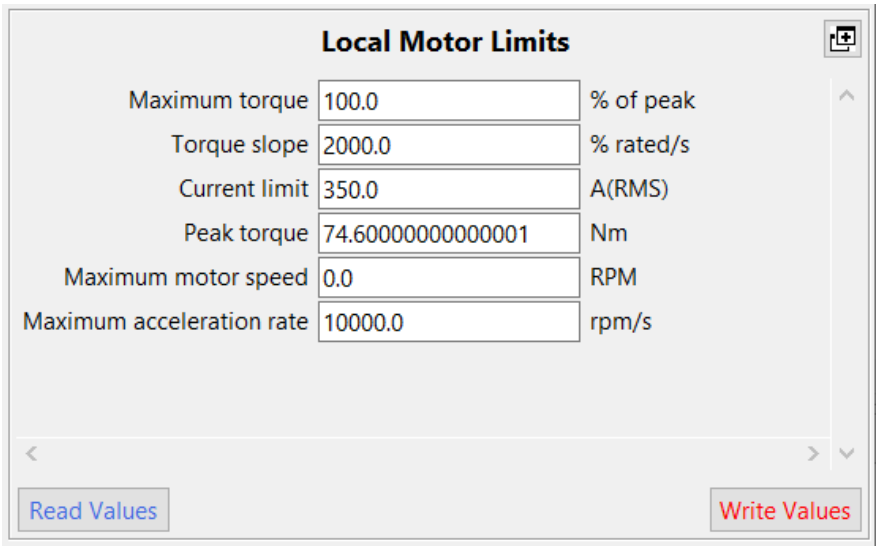
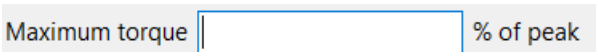


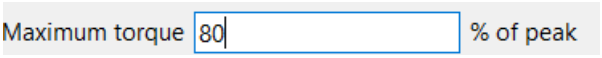
Figure 47 Local Motor Limits

For example, to change the Maximum torque from 100% to 80% of the peak, the process is as follows:

First, clear the text box of the torque limit:



And now enter the desired value:

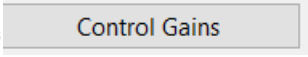


To save the change to the controller, select the 

button in the bottom right of the window.

3.4.8 Control Gains

Incorrect gains can cause unstable motor operation, or a requested limit not being applied.

DVT allows adjustment of various motor control loop configuration, proportional and integral gains. These functions allow tuning of the motor control gains to smoothly accelerate or decelerate and maintain the requested speed. The “ 

” button gives access to these settings and can be found as follows:

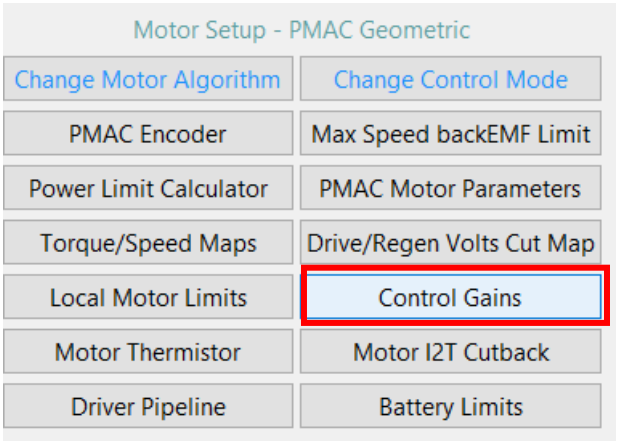


Figure 48 Selecting Control Gains

Selecting this button will open the gains configuration window.

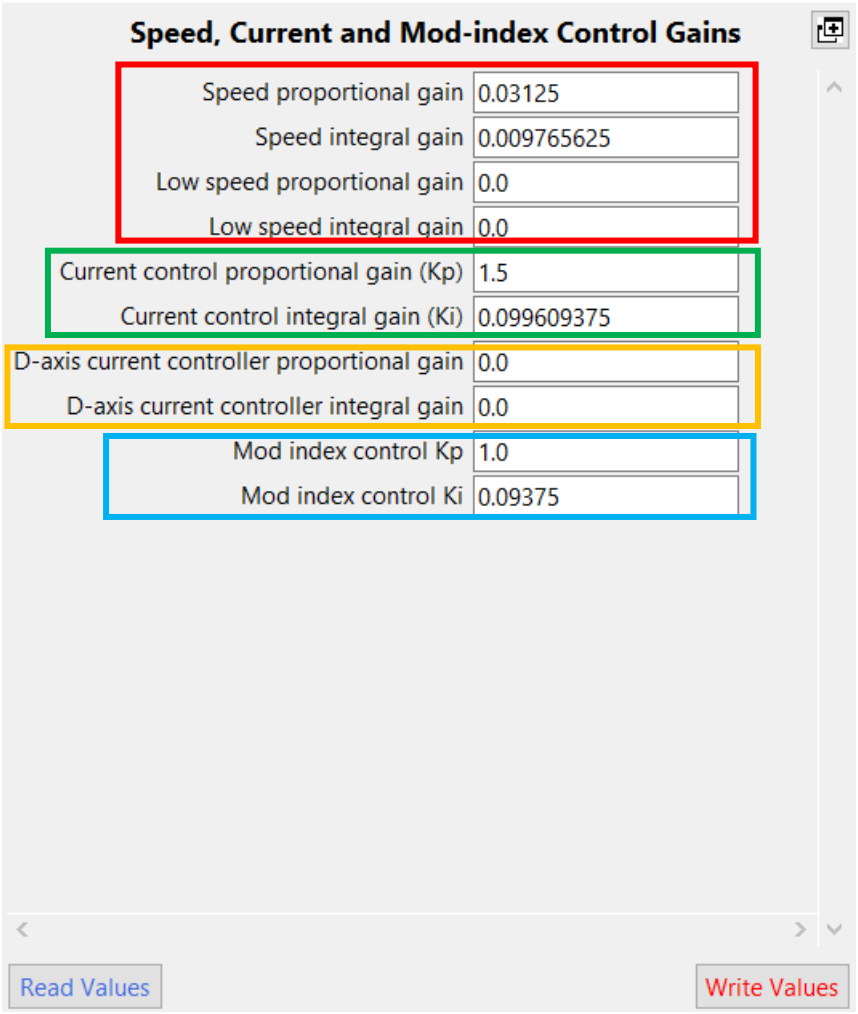


Figure 49 Control Gains window

Depending upon the controller connected different gains are shown. In the example in Figure 49 the gains in red are used for configuring the speed control/limit gains in the motor torque conditioner. The green gains are for the current control loop, setting different gains in yellow are applied for the D-axis control only, then the gains in green are for Q-axis only. In most cases the D-axis gains can be left at zero, so the green gains are used for both axes.

In order to get a smooth response from the controller perform slight changes on these values until obtain the right desired response. For more information about tuning techniques please contact BorgWarner.

3.4.9 Motor Thermistor

⚠ Incorrect thermistor configuration can cause the motor temperature to exceed the upper limit and the motor to be damaged.

It is recommended to connect the motor thermistor to the controller so that the motor temperature can be monitored and to protect against high motor temperatures. The easiest

way to configure this is using the thermistor configuration window opened from the Helper main page: “ Motor Thermistor ”.

This window shows a summary of all the different thermistor parameters with links to open them directly for editing:

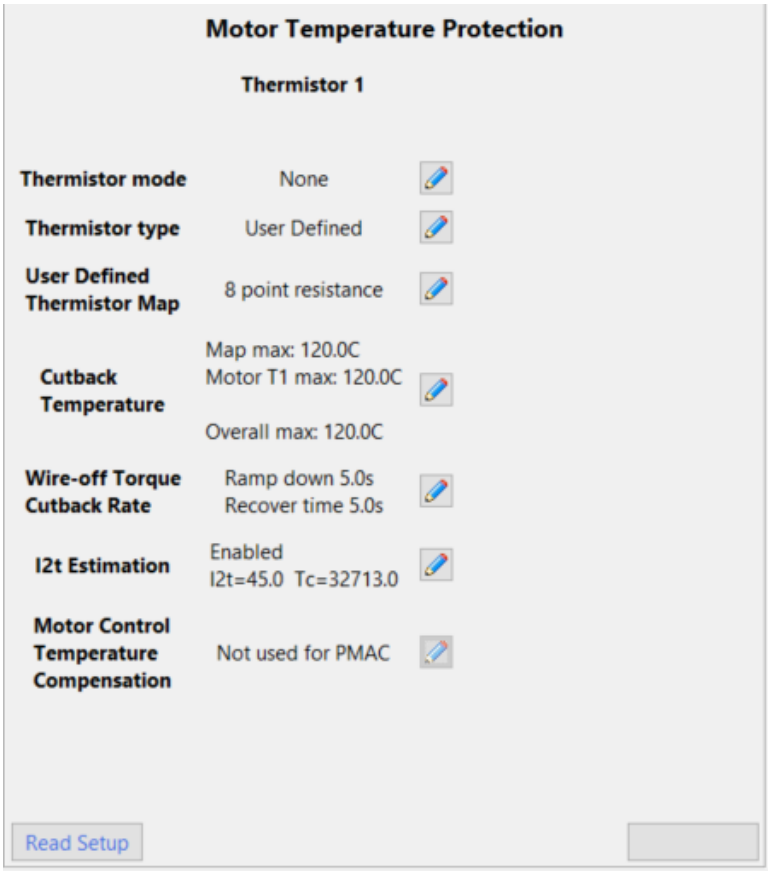


Figure 50 Motor Thermistor window

Depending upon the controller connected different thermistor mode options may be shown. Typically, either “None” or “Thermistor” options are used. Although some motors contain an overtemperature thermal switch rather than a thermistor.

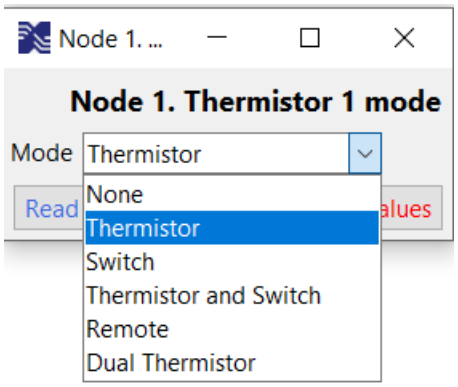


Figure 51 Thermistor mode

Due to the large number of thermistor variants available, a map is provided to configure motor temperature feedback against resistance measured. The most common thermistor types can be quickly configured by setting the option to set the user defined thermistor map to for example KTY84.

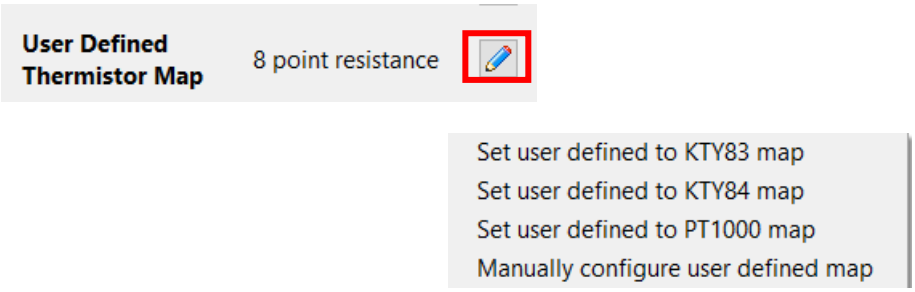


Figure 52 User Defined Thermistor Map shortcuts

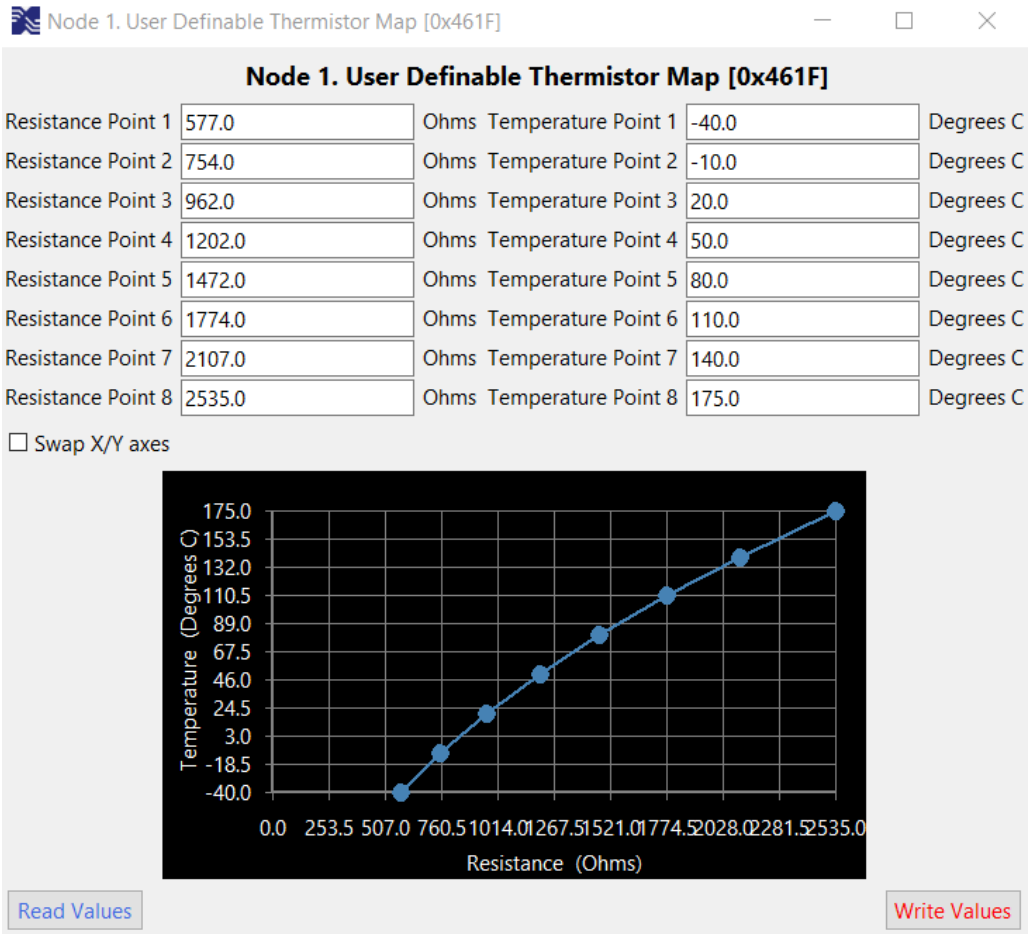


Figure 53 User Defined Thermistor Map

To give full configuration of allowed motor torque with changing motor temperature, a map is provided so that the desired de-rating profile of the motor can be set.

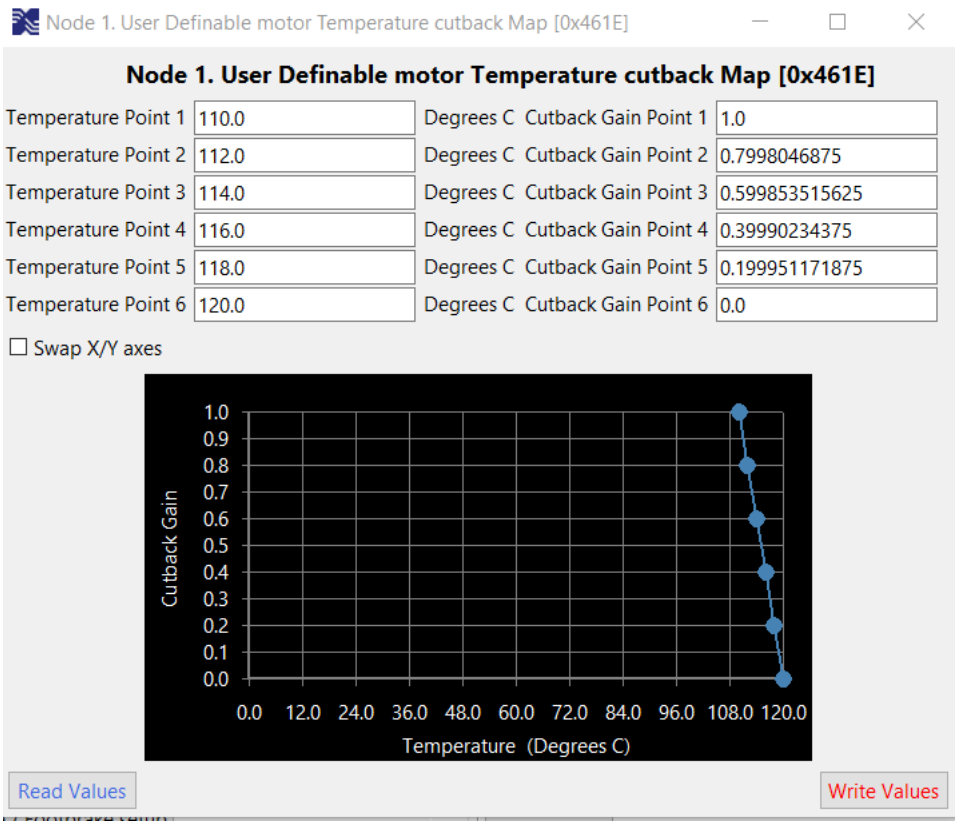


Figure 54 Manually configured cutback

If a failure occurs in the thermistor or its wiring during motor operation, this could lead to the torque being rapidly removed during the vehicle operation, as the thermistor feedback resistance makes the motor either seem to be very hot or very cold.

To avoid this, the thermistor wire-off cutback rate can be set to allow sufficient time for the vehicle operator to react to the thermistor wire-off warning being set. The required recovery time if a fault in the thermistor wiring resolves during vehicle operation.

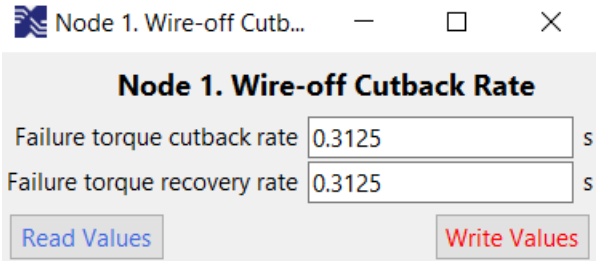


Figure 55 wire-off cutback back rate

3.4.10 Driver Pipeline

The “ Driver Pipeline ” button opens a window in the DVT configuration helper that can be used to easily access some useful debugging objects found inside the controller. The button can be found here:

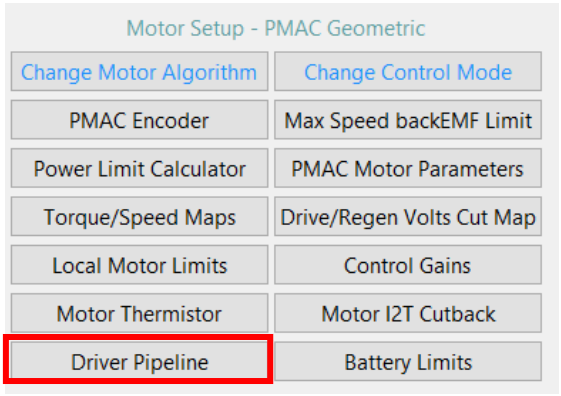


Figure 56 Drive Pipeline button

This will open up the driver pipeline window for monitoring the controller:

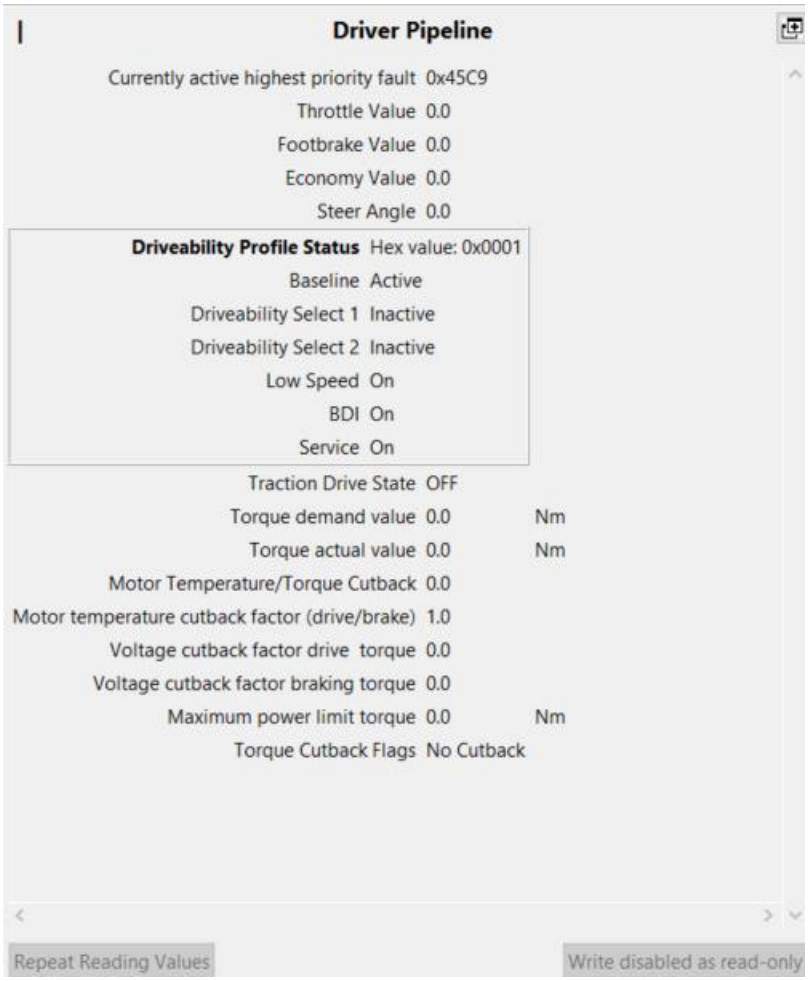


Figure 57 Driver Pipeline

3.4.11 Battery Limits

Incorrect DC link voltage configuration can lead to damage to other components connected to the DC link

Protection for both the maximum and minimum DC link voltages that are applied to the controller are configurable in the DVT. These settings can be changed using the window opened with the “Battery Limits” button:

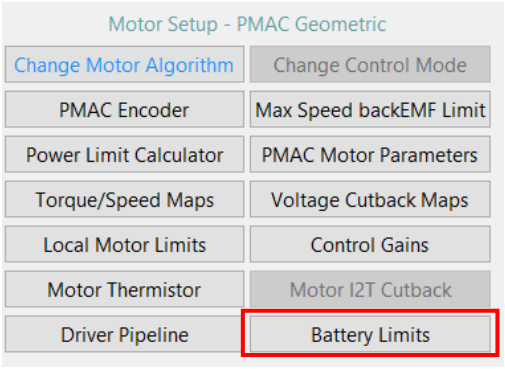


Figure 58 Battery limit window selection

The battery limits / voltage cutback button displays the following window:

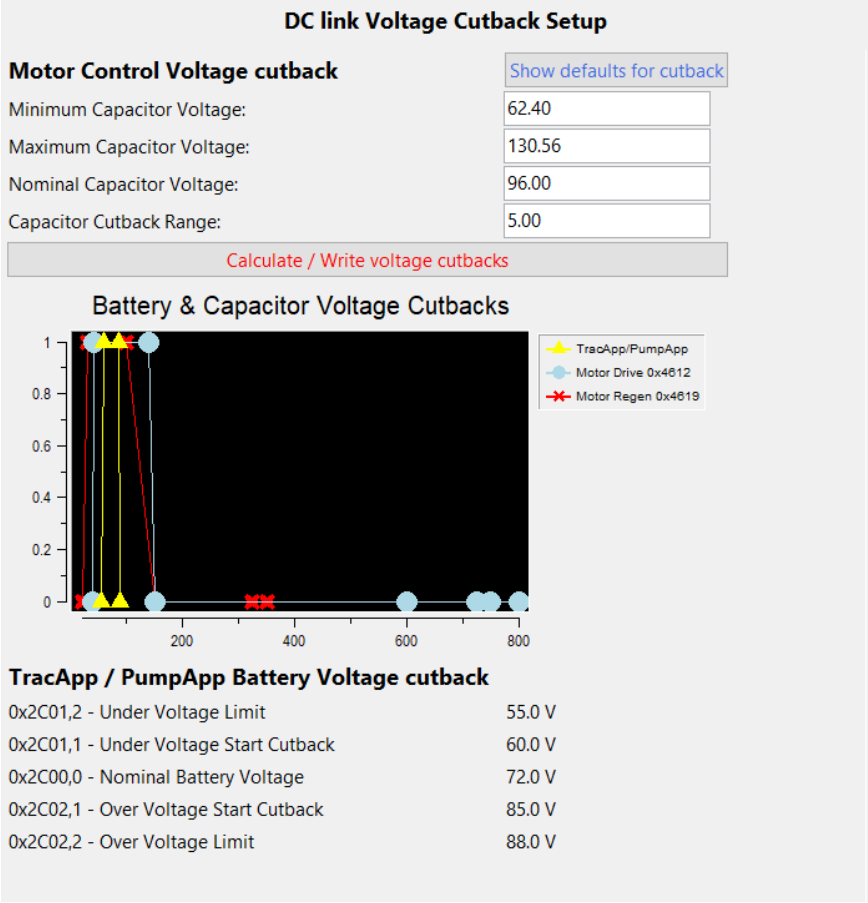


Figure 59 Battery Limits Setup for Dragon8 96V Motor Controller

In a typical vehicle system with Traction Application enabled and a single local motor controller used. There are 2 DC link voltage cutbacks available, one for the battery carried out by TracApp (which is also applied to remote nodes driven over CAN) and one for the local controller's DC link capacitors calculated within the motor control "Torque Conditioner".

Clicking on " Show defaults for cutback " will set values appropriate for the motor controller connected, however these may not be suitable for the system and should be adjusted accordingly.

Clicking on " Calculate / Write voltage cutbacks " the motor control voltage map is configured as entered. The TracApp voltage cutback is set "out of the way" to the minimum and maximum for the controller as in most application using the motor control DC capacitor cutback is most appropriate. As it is calculated and applied at a faster rate to give more precise DC link control and protection.

Alternatively, to manually change the under-voltage limit (the minimum voltage that can be set without the line contactor opening) from 55V to 48V, the steps are as follows in Figure 60:

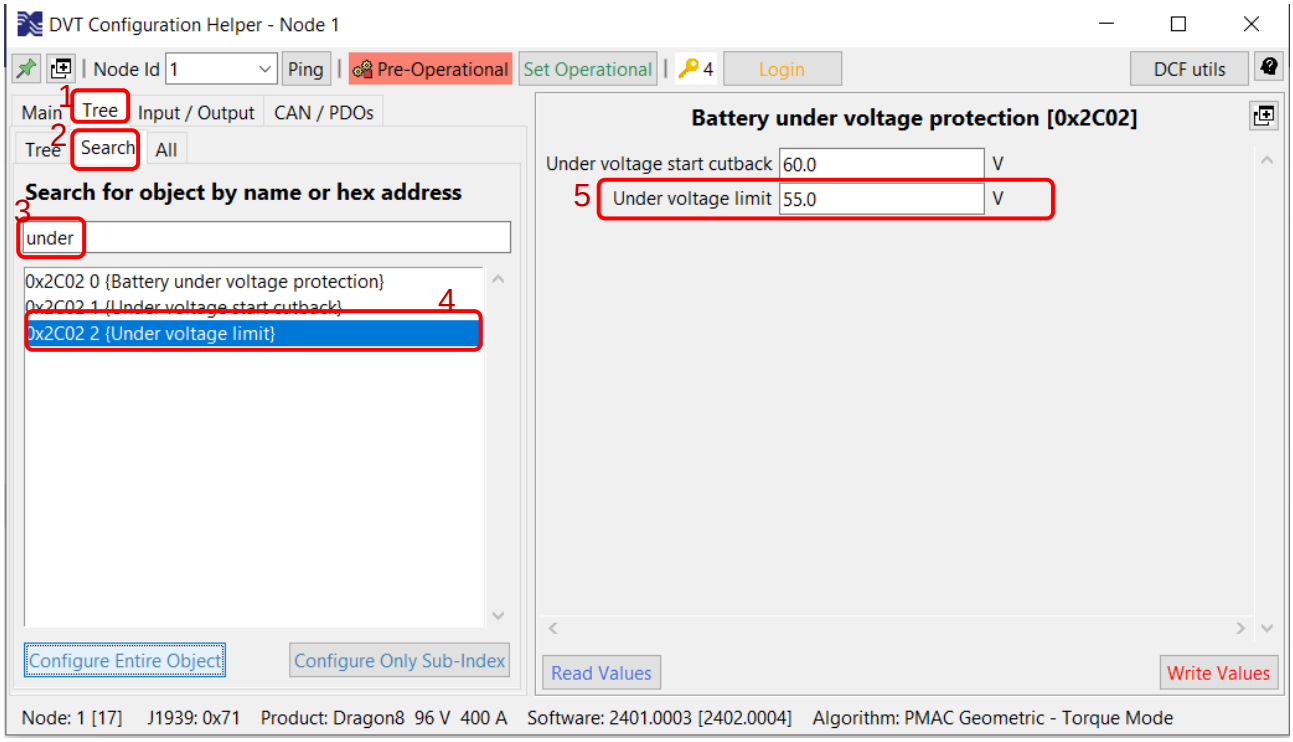


Figure 60 using the DVT helper tree to search and configure an object

First, clear the text box of the actual limit.

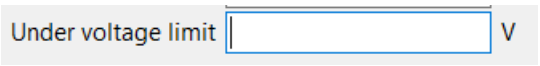


Figure 61 Under voltage limit parameter

And then enter the desired under voltage limit (in this case, 48v)

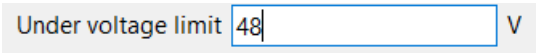


Figure 62 Under voltage parameter set to 48V

To save the change to the controller, select the 

button in the bottom right of the window.

Alternatively, you can configure the same parameter through:

DVT Configuration Helper ➔ Tree➔ Tree➔ Vehicle Master Applications➔ Battery Application (Protection & Contactor) ➔ Batt Under-volt Protection

Now reopening the Battery Limits window, it will be modified according to the change we have applied:

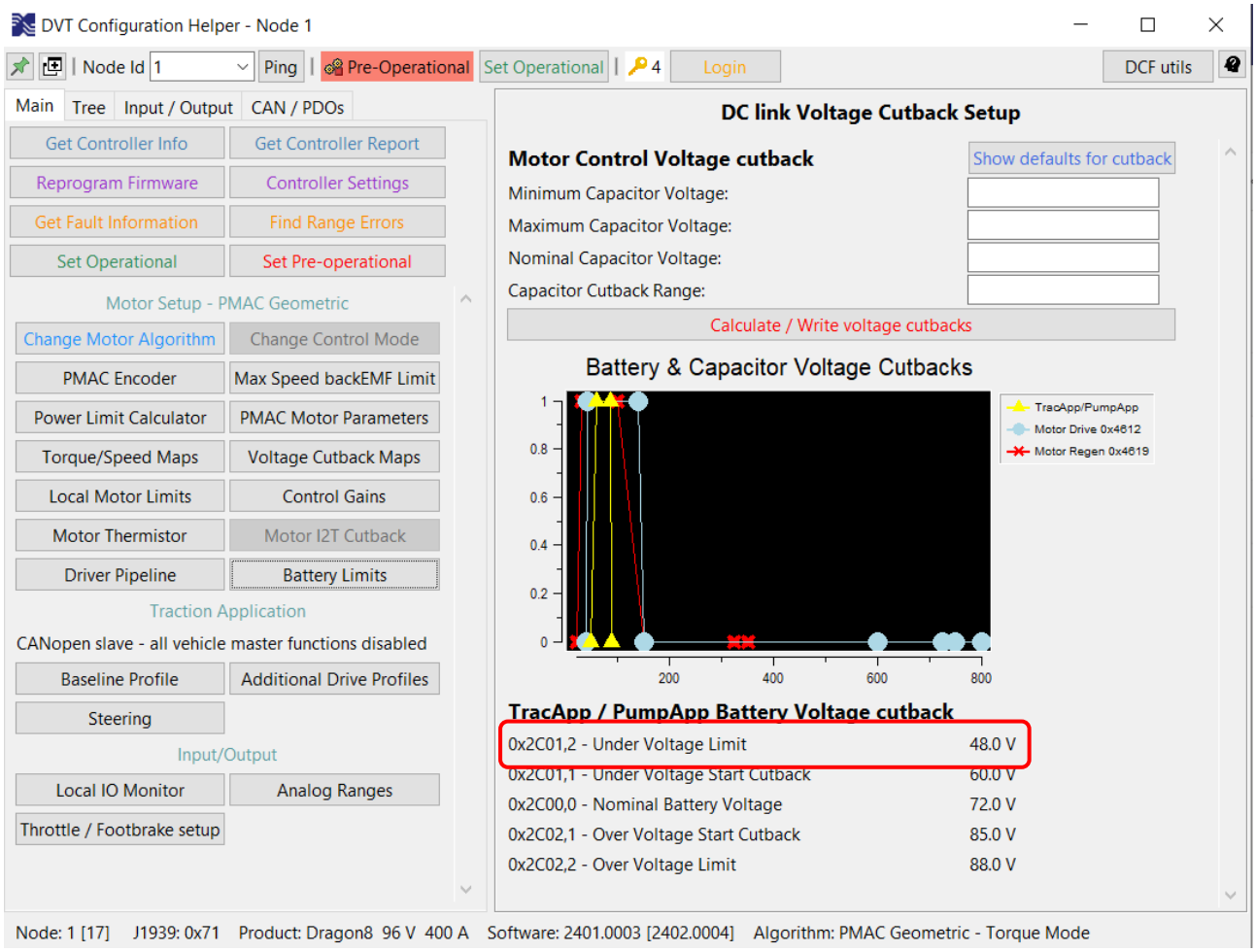


Figure 63 Battery Voltage configuration

3.4.12 V/F Ratio (Only for V/F Induction Motor on HVLP and Slip Control Mode on Gen4 LV)

DVT can be used to configure the voltage/frequency ratio for induction motor control through the “ V/F Ratio ” button found here:

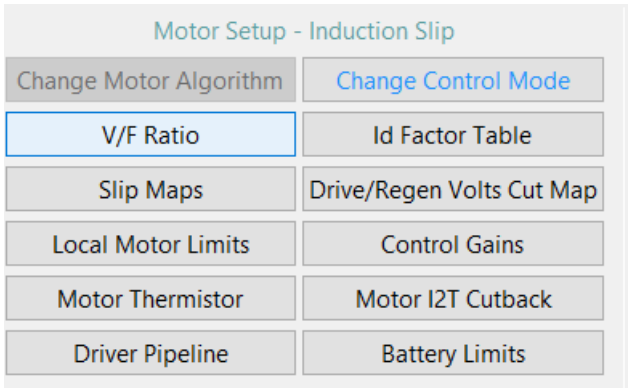


Figure 64 V/f ratio configuration

Selecting this button will open the induction motor Nameplate and V/f ratio calculation window. Most induction motors have the key motor parameters supplied on a plate fixed to the motor. Using these parameters some key control values can be automatically calculated. If the plate is not present on the motor please contact the motor manufacturer or refer to the motor datasheet for more information.

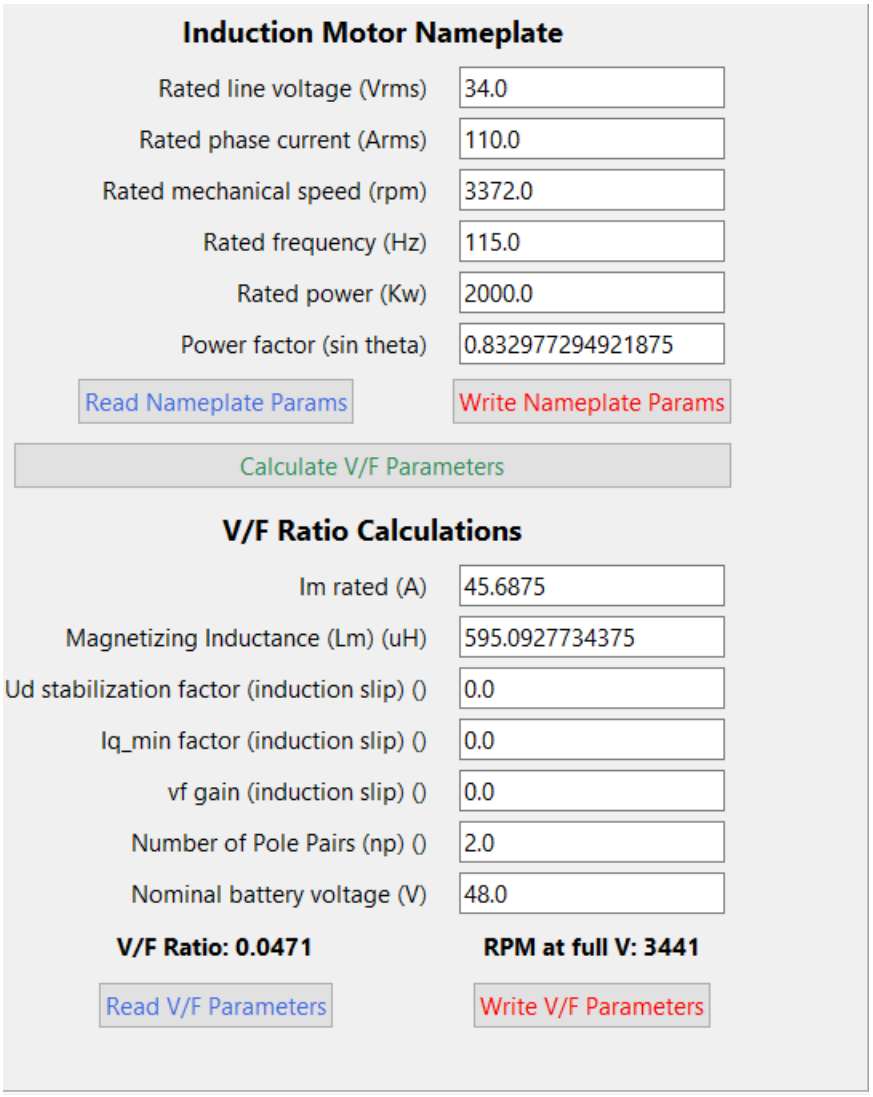


Figure 65 V/f parameter configuration

3.5 Traction Application Buttons

3.5.1 Baseline Profile

The Baseline profile is the default settings applied within the Traction Application in BorgWarner's motor controllers. You can find its configuration button under Traction Application section inside DVT Configuration Helper main tab.

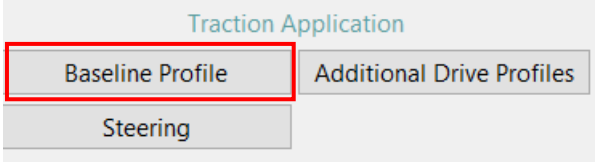


Figure 66 TracApp Baseline Profile

Once you select "Baseline Profile" button it will bring up this window full of objects on the right side of the DVT configuration helper:

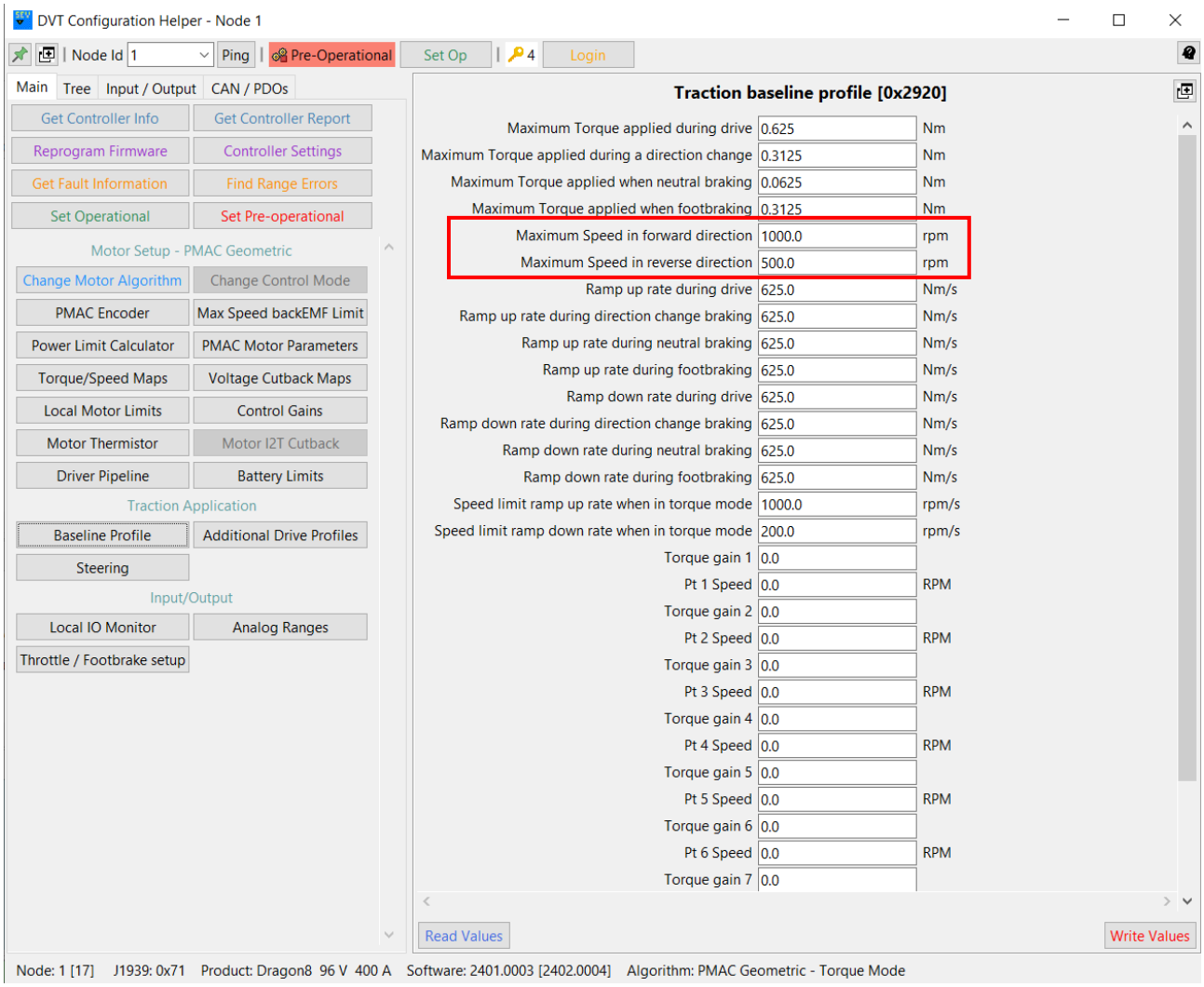


Figure 67 Traction baseline profile configuration

As an example, let's change the maximum forward and reverse speeds to be requested for the motor. First click inside of the appropriate text boxes and delete the contents as shown.

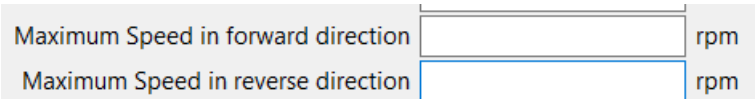


Figure 68 TracApp profile speed limits

Then, enter the desired figures into the boxes:

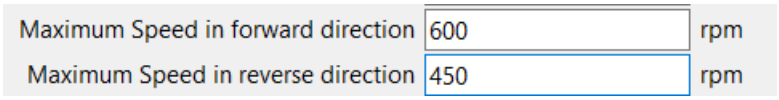


Figure 69 TracApp profile speed limits

Finally select the 

button found in the bottom right of the window to finalize the values. The successful write should be indicated with a temporary change of the write button.

Note: In order to write **a single** value, you can use CTRL+Enter keys. Also, by using CTRL+Up or CTRL+Down keys you can write the 'double of' or 'half of' the current value.

3.5.2 Driveability Profiles

Multiple drivability profiles allow vehicle operation to be tuned under different speed, torque, acceleration and deceleration profiles. The buttons to access them are shown below:

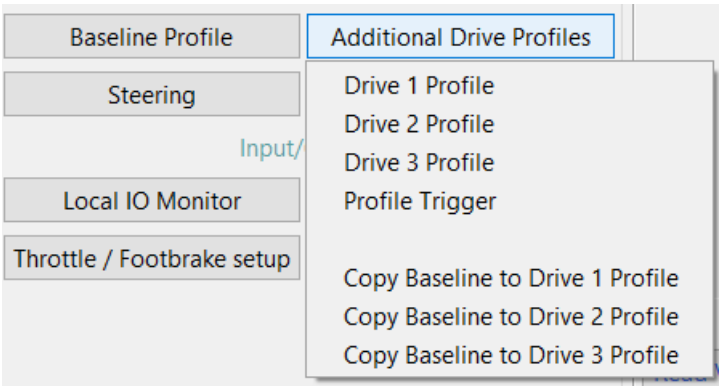


Figure 70 Additional Drive Profile

Selecting either of these buttons will open the appropriate profile configuration window. The available parameters are identical to the window from "Baseline Profile" and can be edited in the same way.

The different profiles can be activated using external switches, over CAN or during configurable vehicle operating conditions.

3.5.3 Steering

Dual motor vehicles with left and right motors, which use the drive motors for turning, require some means of determining the angle of the steering wheel. If the vehicle steering wheel is fitted with an angle sensor, configuration of this vehicle functionality can be accessed with the “ Steering ” button.

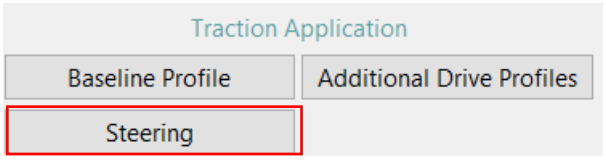


Figure 71 Steering configuration button

This will open a window to the right of the DVT helper:

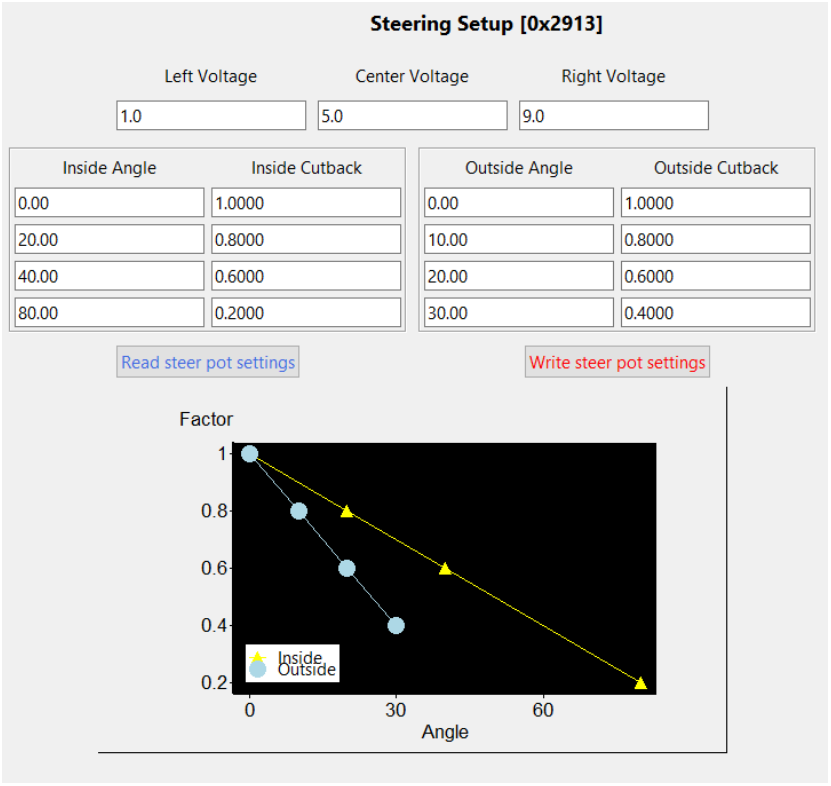


Figure 72 Steering Setup window

From this window, the steer angle voltages corresponding to fully left (-90 degrees), straight ahead (0 degrees) and fully right (90 degrees) are accessible. The corresponding values are used by the controller to calculate the steering angle based on the analogue voltages from the steering potentiometer.

The steering map defines the relationship between the inner and the outer wheel speeds and the steering angle. Each map (inside table and outside table) has 4 definable points; this can be seen on the graph.

The steer map can be defined by 4 points relating the steering angle between 0 and 90 degrees and the torque/speed demand (per unit) between -1 and 1. Where a demand of -1 is shown at 90 degrees, this means the inner wheel demand will be equal and opposite of the outer wheel.

In speed mode, the outer wheel speed target and maximum torque are scaled according to the outer wheel map, while the inner wheel speed target and maximum torque is scaled to the outer wheel demands according to the inner wheel map.

In torque mode, both inner and outer wheel maximum speeds are scaled according the outer wheel map. The outer wheel target torque comes from the throttle. The inner wheel target torque is scaled to the outer wheel actual torque according the inner wheel map.

3.6 Input / Output Buttons

3.6.1 Local IO Monitor

DVT can be used to monitor the digital and analog inputs wired to the controller, and also the mapped VPDO inputs/outputs to the motor controller using the “ Local IO Monitor ” button found here:

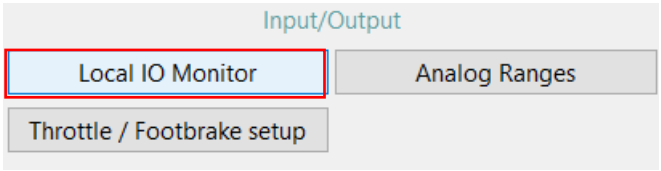


Figure 73 Local IO monitor button

This will open a window showing the raw analogue inputs/outputs and also VPDO mapping if available:

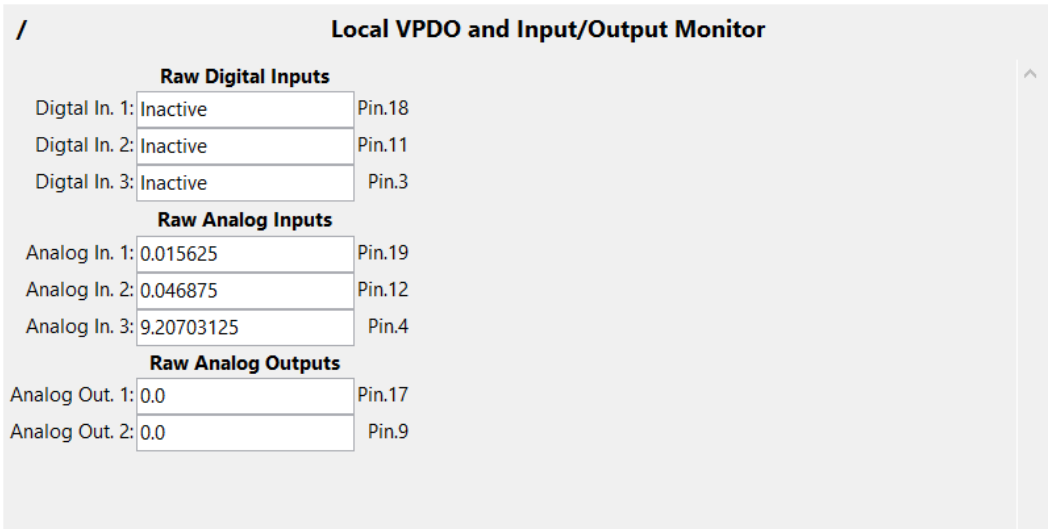


Figure 74 Local VPDO and IO monitoring

3.6.2 Analogue Ranges

DVT allows the user to adjust the minimum and maximum allowed voltages on the analog inputs attached with the motor controller for wire-off detection. These functions can be accessed through the “ Analog Ranges ” button found here:

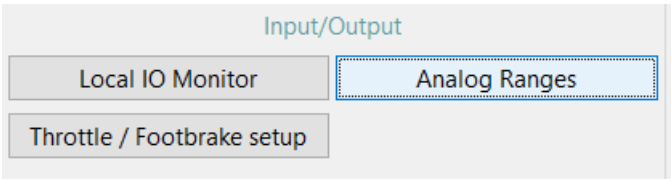


Figure 75 Analog ranges button

This will open the following window:

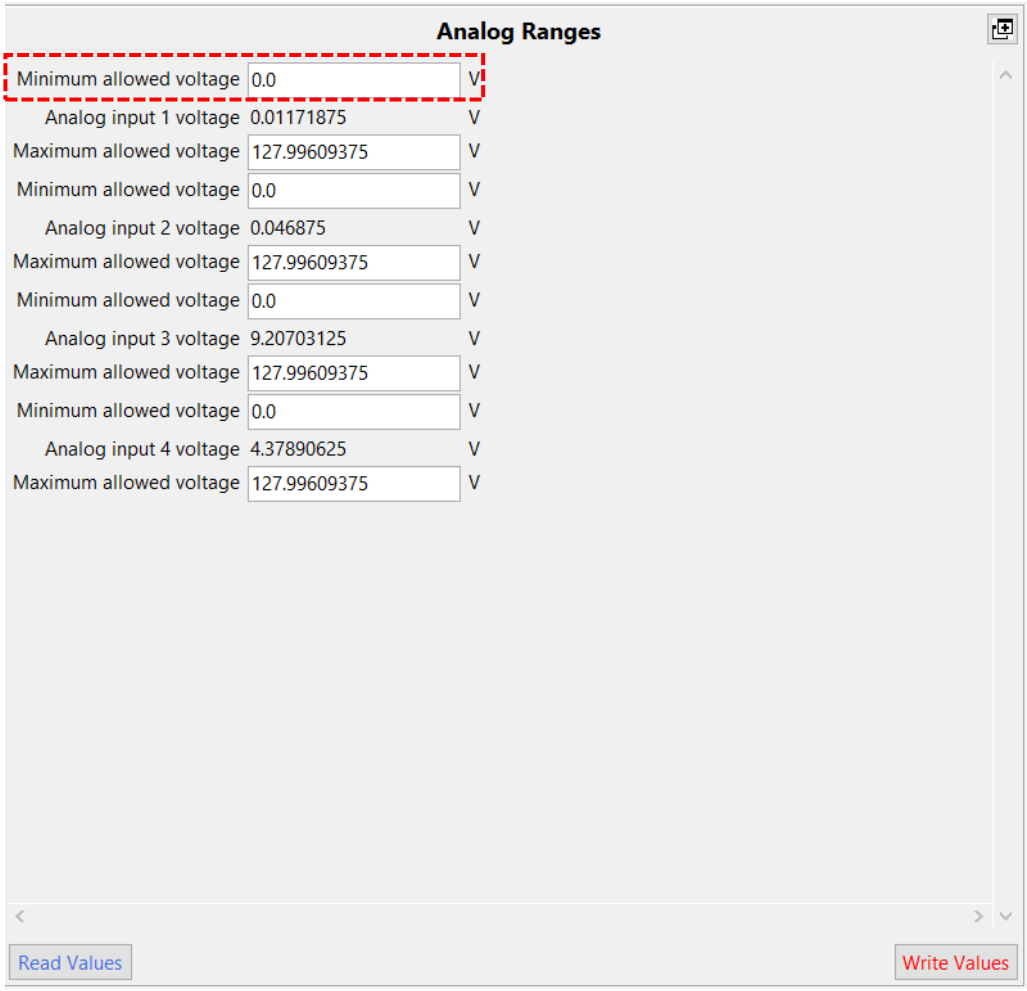


Figure 76 analog input ranges

The setting highlighted above is going to be changed from 0 to 5V. To do this, first click inside of the appropriate text box, and delete the contents.

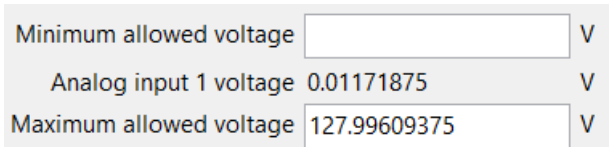


Figure 77 Analogue input 1 minimum

Then, enter the desired figures into the boxes like so:

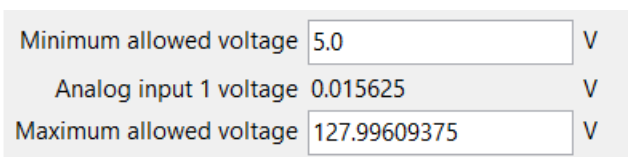


Figure 78 Analogue input 1 minimum

Finally select the Write Values button found in the bottom right of the window to finalize the values. Alternative CTRL+ENTER shortcut can be used to write a single modified value.

3.6.3 Throttle/Footbrake setup

Although the throttle measurement is performed in pre-operational state to prevent vehicle drive, ensure the vehicle is in a safe test condition, for example wheels raised with axle stands.

DVT allows the user to configure automatically throttle and/or footbrake analog inputs through" Throttle / Footbrake setup " button. Clicking on this button shows you two options:

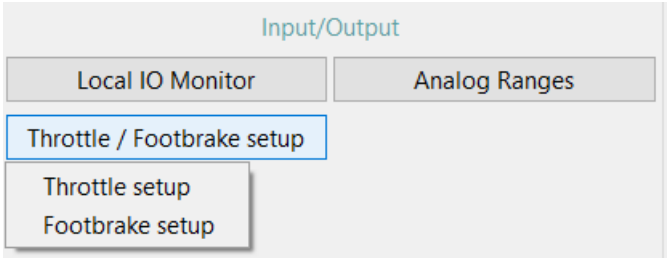


Figure 79 Throttle/Footbrake setup

Selecting throttle setup, DVT asks you to go full throttle:

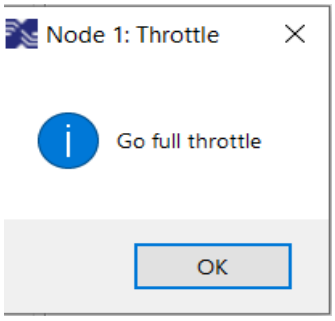


Figure 80 Throttle auto setup

Once you apply the full throttle, click on OK and the DVT will configure the throttle automatically.

Using similar approach, you will be able to automatically configure footbrake too.

3.7 Advanced settings

3.7.1 Controller Access Level / Passwords

Changing the stored passwords within the controller, can permanently prevent access to the controller configuration which can only be resolved returning the controller to BorgWarner. This is not covered by warranty, so this section only explains changing the passwords stored in DVT used to login to the controller.

The password configuration is launched from the Edit menu:

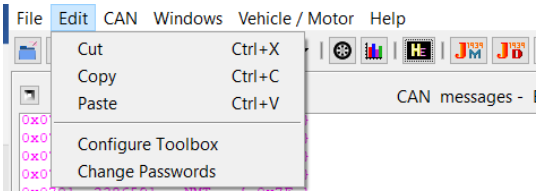


Figure 81 Login password configuration

The password window allows custom passwords to be used for Gen4 size 2,4,6 login and also separately for Gen4 DC, HVLP, Dragon8 and Gen5 size 9.

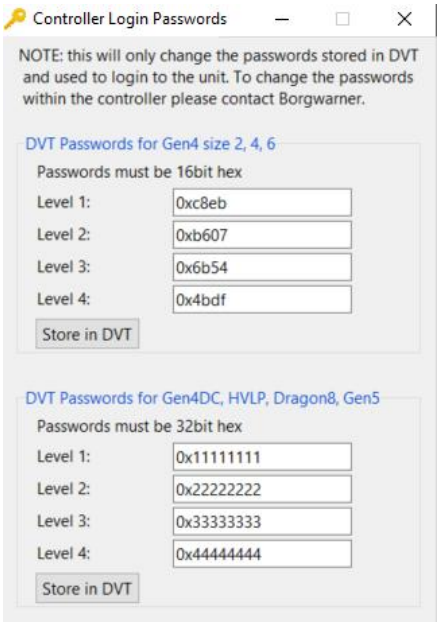


Figure 82 Default login passwords

3.7.2 Firmware Installation

Incorrect firmware can cause unexpected vehicle operation. If loading firmware for a different algorithm a significant number of parameters need to be reconfigured.

You should ensure the firmware you are loading is a released version.

The firmware of the controller uses a .dld or .dldx file extension and is an integral part of making the BorgWarner motor controller function correctly. On some products (Gen4) the firmware must be changed to use different motor algorithms.

BorgWarner controllers will come with firmware already installed that in most cases should be suitable, but sometimes downloading a different or updated firmware is required.

Click on 

buttons found in DVT configuration helper;

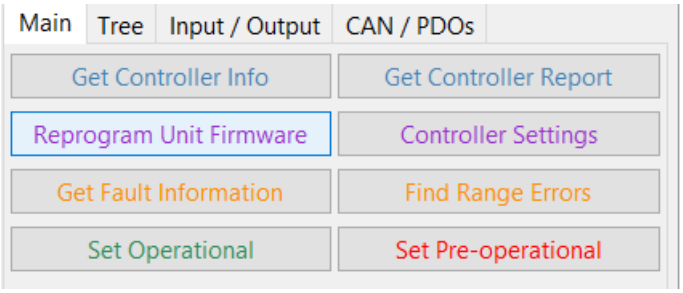
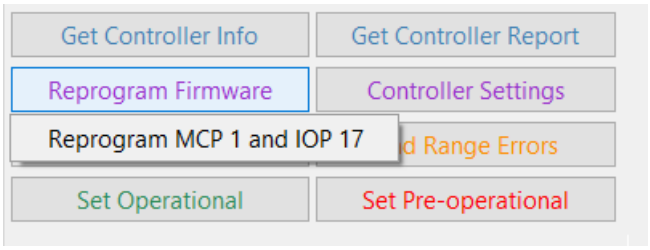
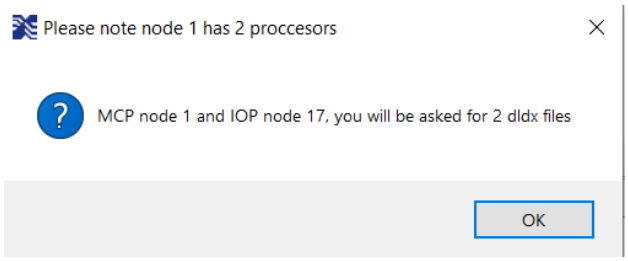


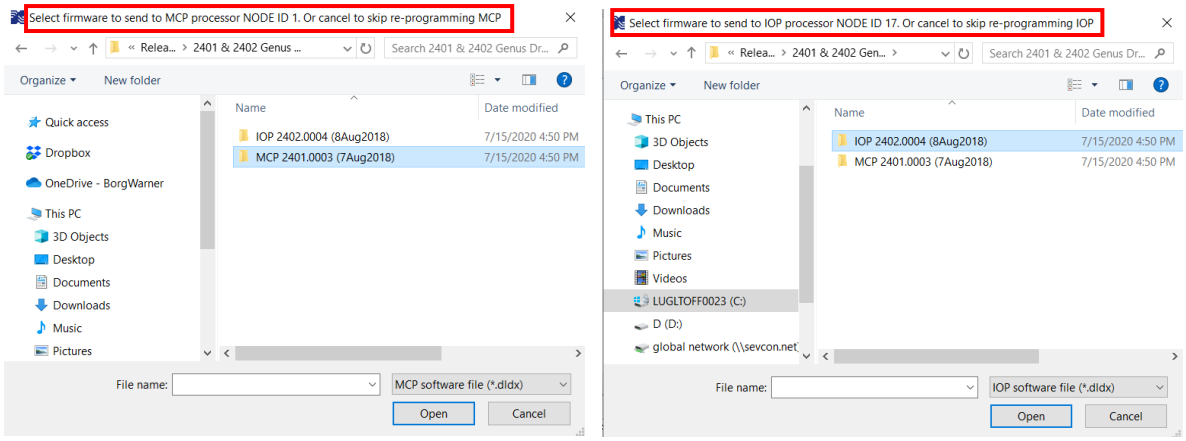
Figure 83 Firmware programming button

Selecting this will ask you to select the new firmware file to begin the process of installing new firmware. Please note that this process is slightly different for different BorgWarner motor controllers. While for Gen4 size products you need to select one dldx file, for Dragon 8 and HVLP you need to select **first** the dldx file for MCP (motor controller processor) and then dldx file for IOP (input/output processor).



(a)





(b)

Figure 84 Dragon 8 Motor Controller Reprogramming with 2 dld files (a) Reprogramming Firmware button in DVT Configuration Helper (b) Sequence of dld files selection

Selecting the desired DLD and opening it the DVT will then being automatically installing the DLD into the controller, its progress can be viewed for the DVT main window.

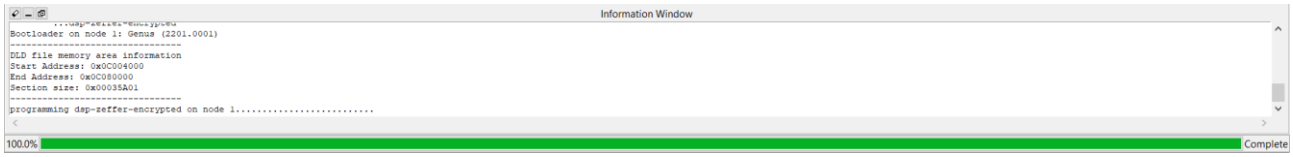


Figure 85 Firmware download progress

Take into account that during the reprogramming process the controller will be in bootloader mode where it will be unresponsive to commands and will display errors or timeout when changes are attempted to anything aside from software. Please wait for programming to complete.

3.7.3 Uploading and Downloading Settings (DCF)

Configuration files have the DCF extension and are the files in which the settings and parameters of the controller are stored. DCFs can both be uploaded and downloaded from the controller through the Controller Settings button located in DVT configuration helper main window.

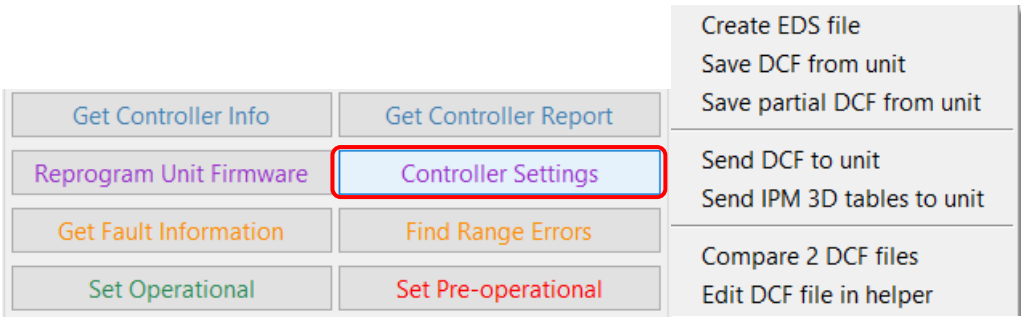


Figure 86 Controller settings menu

Selecting “Save DCF from unit” will save the current configuration inside the controller to wherever the user wants.

⚠ Loading a dcf typically overwrites all of the configuration in a controller. This cannot be undone. It is recommended to create a backup of the existing configuration first. Incorrect configuration can cause unexpected system operation.

Changing DCF however is done through the “Send DCF to unit” option. Selecting this option will notify the user about new settings which cannot be undone.

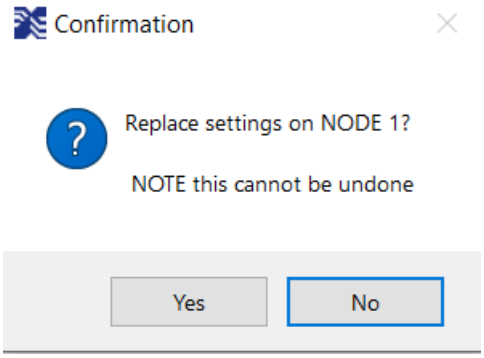


Figure 87 DCF download confirmation

Selecting a DCF will result in an upload bar opening over the DVT main screen showing the progress of the DCF installation.

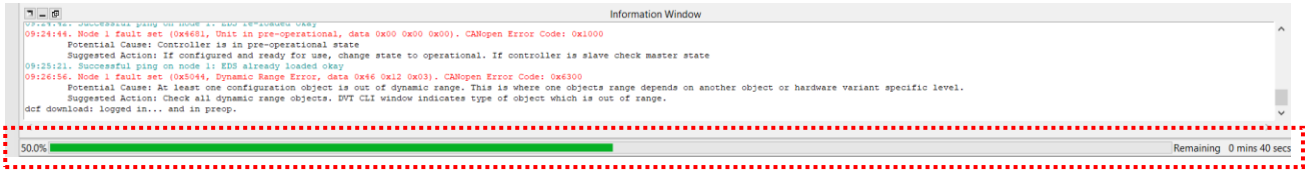


Figure 88 DCF download progress

When the progress bar has filled, a message should appear at the bottom of the Information Window confirming the successful installation.

```
Software version name in dcf matches unit: 2401.0003 [2402.0004]
Configuration checksum in dcf matches unit: 0x3f68
10:13:17. Successful ping on node 1: EDS already loaded okay
```

Figure 89 DCF download check

3.7.4 Changing Node ID Number

DVT can be used to change the node ID of a unit through the DVT configuration helper's tree, CAN Setup as it is depicted in Figure 90.

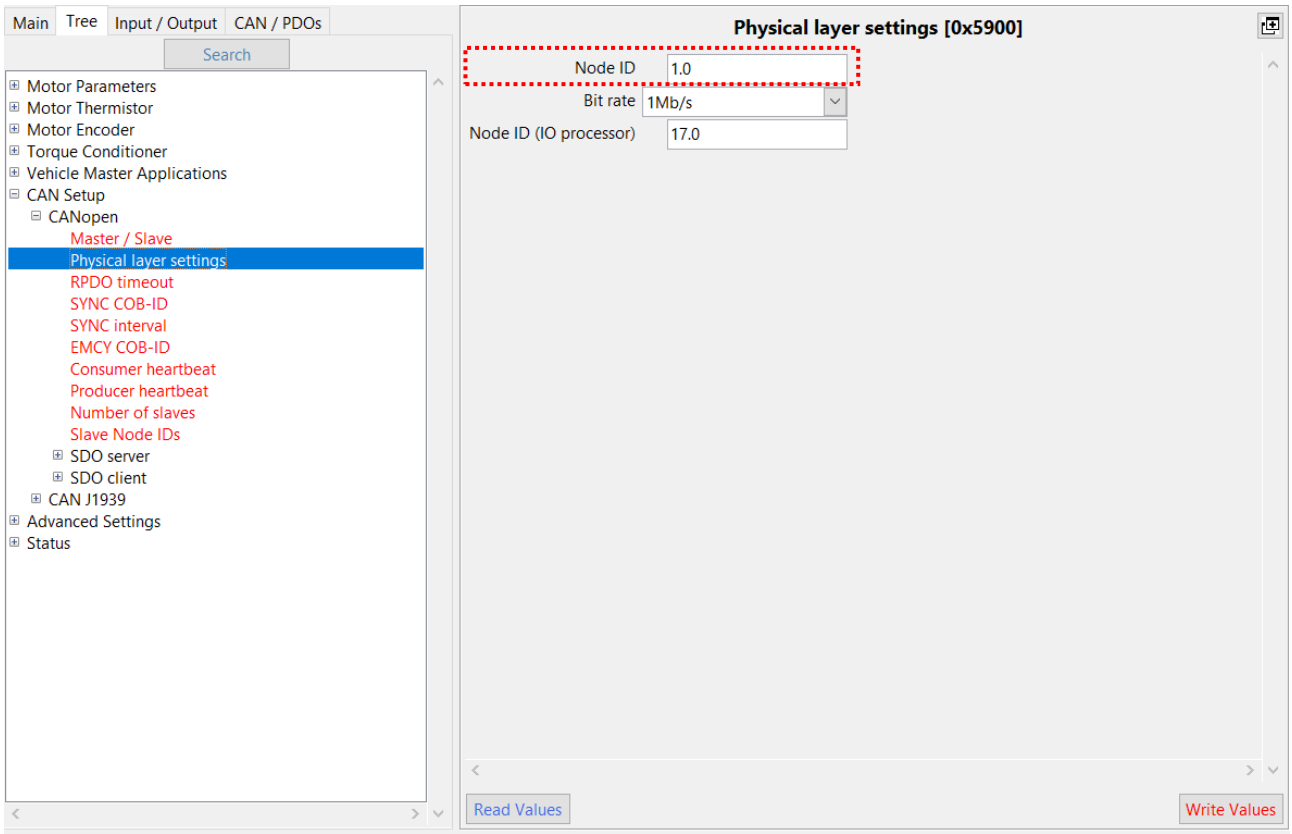


Figure 90 Node ID configuration

To change the node ID of a unit, using the "Node ID" option shown in Figure 90 the user can change the ID to the desired one and then using the Write Values button write the new value. The DVT will prompt the user to recycle power on the system. After the power has been recycled, the new node ID will be set. This can be checked by looking at the numbers in the CAN traffic as shown below:

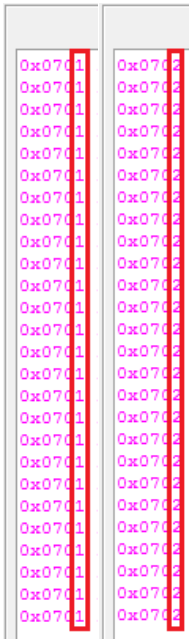


Figure 91 (a) Before (Node ID1) (b) After (Node ID2)

Chapter 4: Configuration Tree

Chapter 4 - Configuration Tree

4.1 Tree

The easiest way to navigate the settings and features of the BorgWarner motor controller is the Tree menu. Selecting this tab will open the Tree menu:

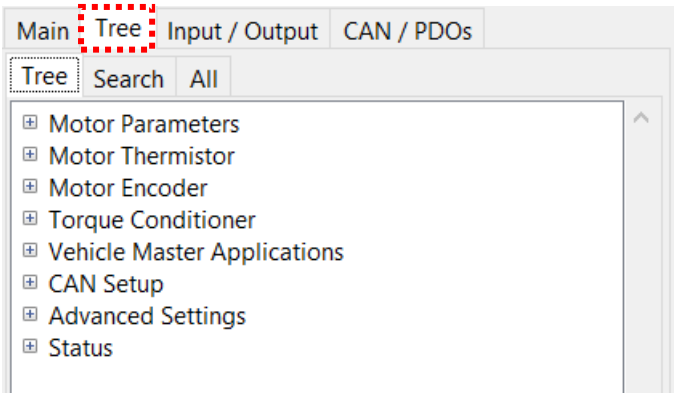


Figure 92 Tree menu

From this menu, there are a couple of different methods that can be used in searching for specific variables or objects. For example, the most intensive of these is the "Search" tab. Selecting it so will open a window that looks like so:

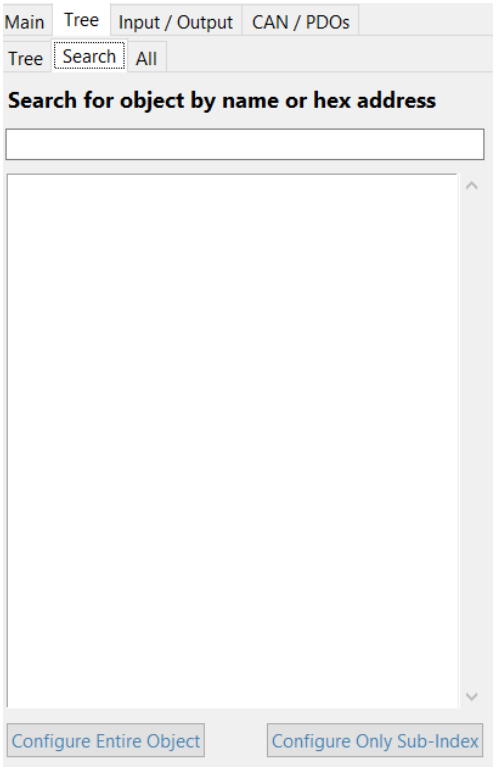


Figure 93 Tree search tab

In this scenario, a search is going to be performed for the “Maximum Battery Voltage”. To do this, enter the term into the search bar found at the top of the object search window.

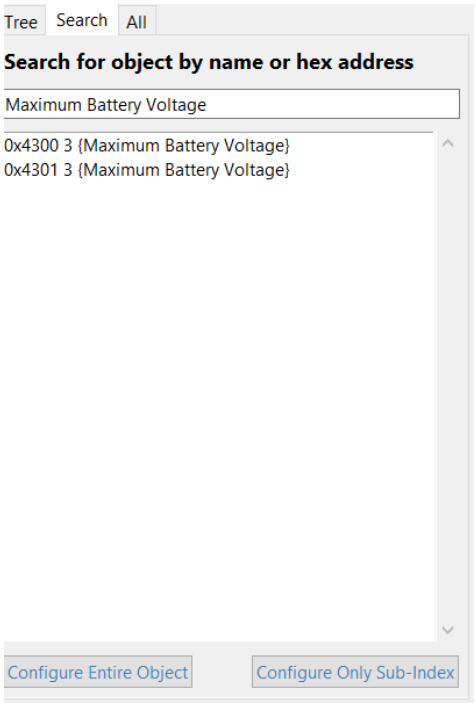
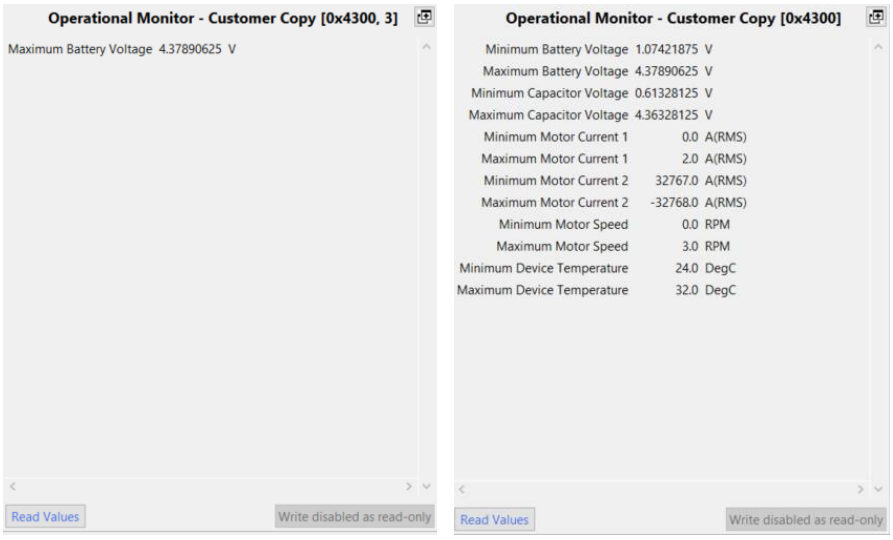


Figure 94 Tree search for battery voltage

There is then a choice between viewing the single sub-index that has been searched for or the entire object the sub-index is contained in. Selecting either will present the selected object/index here:



(a) (b)

Figure 95 (a) Single index (b) Full Object

Alternatively, the objects can be browsed through a series of drop-down menus. For example, to find the under-voltage cutback in the tree; first open drop-down menus by

selecting the “+” icon until finding the relevant heading. In this case the Batt Under-volt Protection.

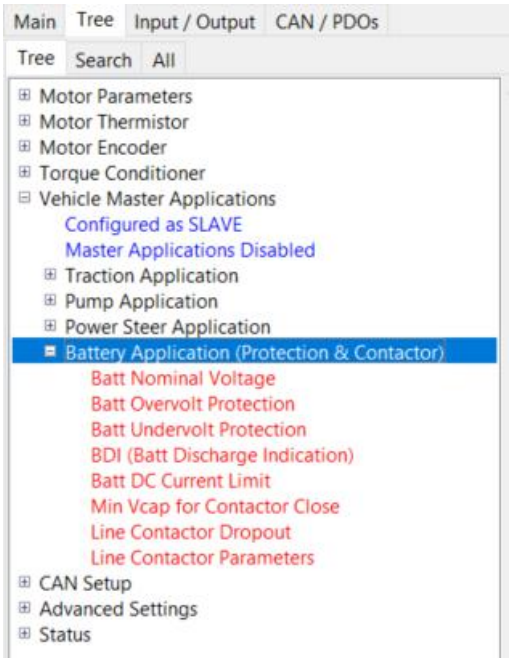


Figure 96 tree – battery application

Selecting this will create a window to the right of the tree. The settings can then be read/changed using the same method as any other tab in the DVT configuration helper.

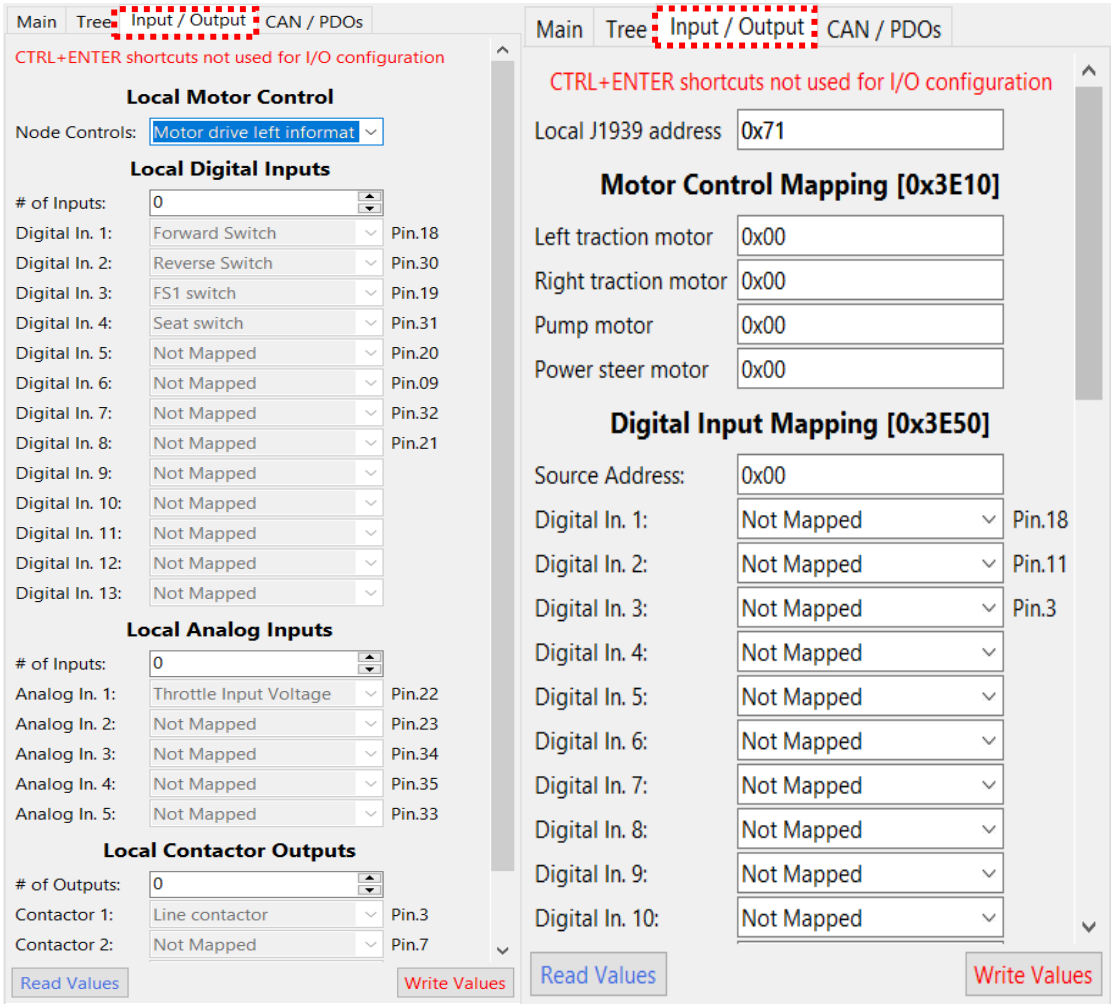
Chapter 5: Input/Output Configuration

Chapter 5 - Input/Output - Configuration

Modifying the IO setup on a vehicle will change the functionality behind the driver controls. Including those related to vehicle safety. Make sure the drive wheels are raised on axle stands.

5.1 I/O Configuration

BorgWarner motor controllers can be configured to work with a variety of input/output components of both analog and digital nature. These features can be accessed through the "Input / Output" tab found in DVT configuration helper. Depending on the motor controller variant you might see either of windows depicted in Figure 97.



(a) (b)

Figure 97 Input/Output section in (a) CANopen based motor controllers, (b) J1939 compatible motor controllers

5.2 Local Motor Control

In CANopen the default setting is as shown in Figure 98. By default, the node control will be set to “Motor drive left information”. This is the default setting when a single traction motor system is being configured, if you would like information on the other settings however, contact BorgWarner.

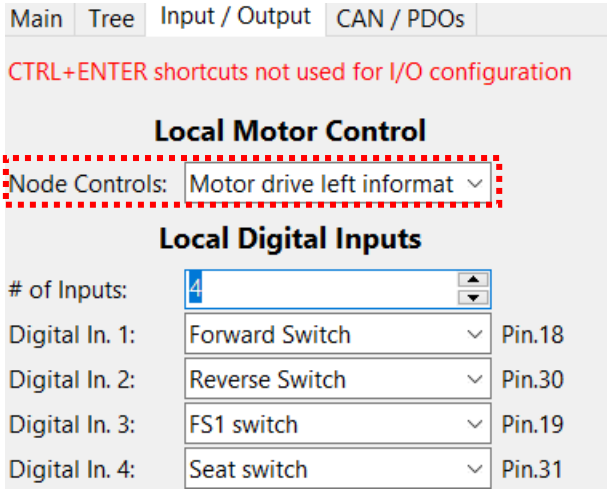


Figure 98 Default settings in Input/Output window in CANopen based motor controller

In J1939 the default is as shown in Figure 99

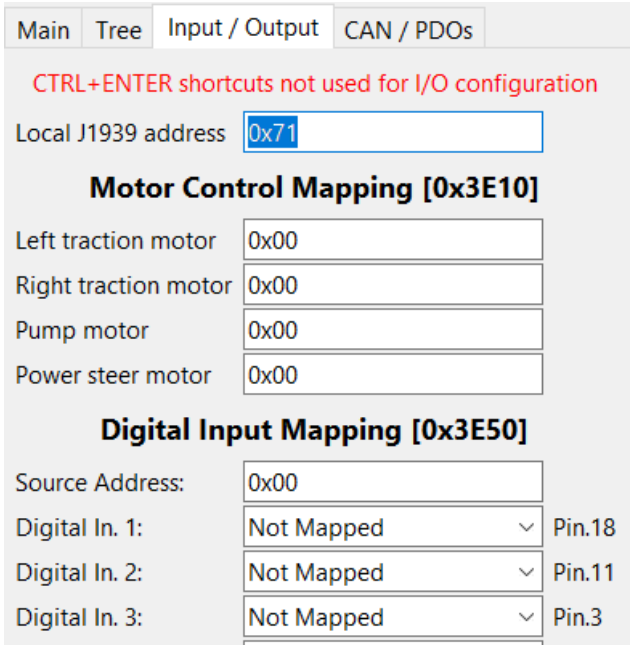
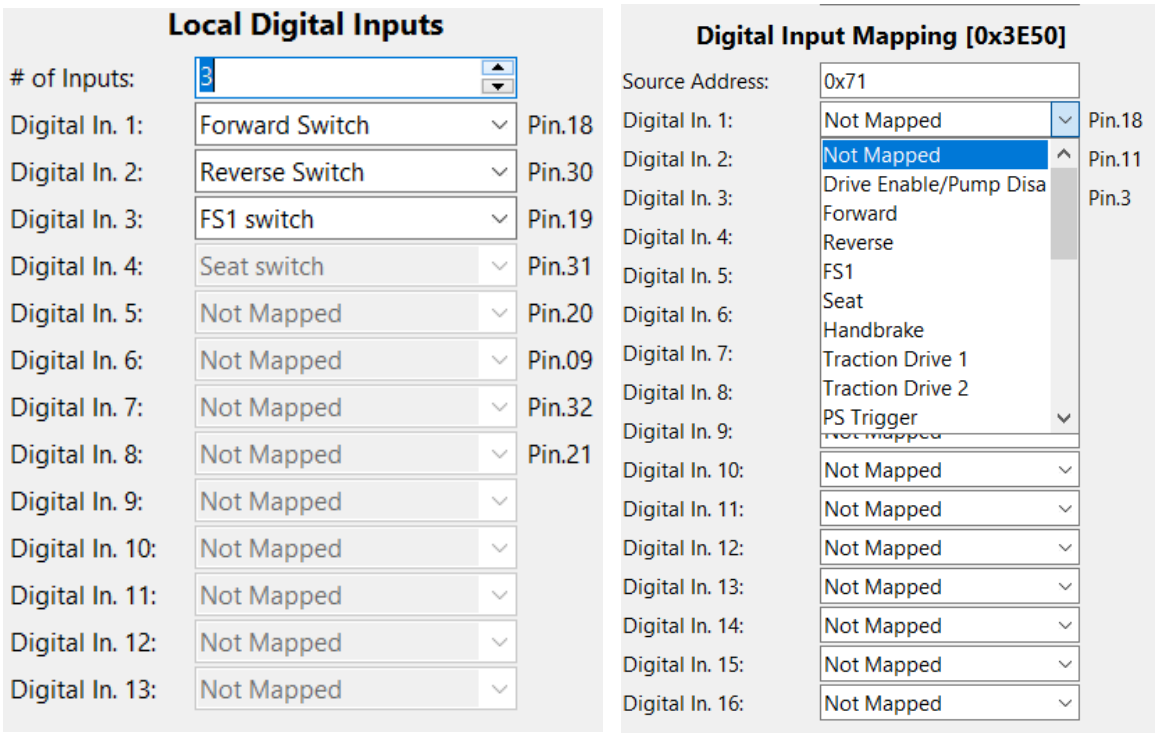


Figure 99 Default settings in Input/Output window in J1939 based motor controller

5.3 Digital Inputs

Both digital and analog inputs are governed by the pins in the control unit harness. The settings for the digital inputs can be found here:



(a) (b)

Figure 100 Digital Input mapping (a) in CANopen based motor controller (b) in J1939 compatible motor controllers

In Gen 4 the "'# of inputs" setting has to be set exactly. For example, if the number is set to four, but there are five inputs configured; the DVT configuration helper and also the Gen4 controller will ignore the input configured in number five.

The # of inputs can be changed by the small arrows which will raise the number by one in each direction as it is depicted Figure 100 (a). Alternatively, the number can be entered manually in the white box beside the arrows. Setting the number to anything above thirteen will result in the # of inputs back to its default.

To change a digital input; selecting the arrow of the input that will be changed will open a drop-down menu.

In J1939 compatible motor controllers, you do not need to select the number of active digital inputs, instead you need to select the J1939 source address.

Select the new inputs and select the Write Values button to finalize the changes.

Chapter 6: TPDOs/RPDOs

Chapter 6 - TPDOs/RPDOs

On a multi-node CAN system modifying the CAN configuration can cause unexpected vehicle behavior

6.1 TPDOs/RPDOs

The BorgWarner motor controller can be configured to transmit and/or receive PDOs information packets, known as TPDOs and RPDOs respectively. The configured message structures can be viewed and edited through the CAN / PDOs tab. Selecting the tab will open the PDO configuration window.

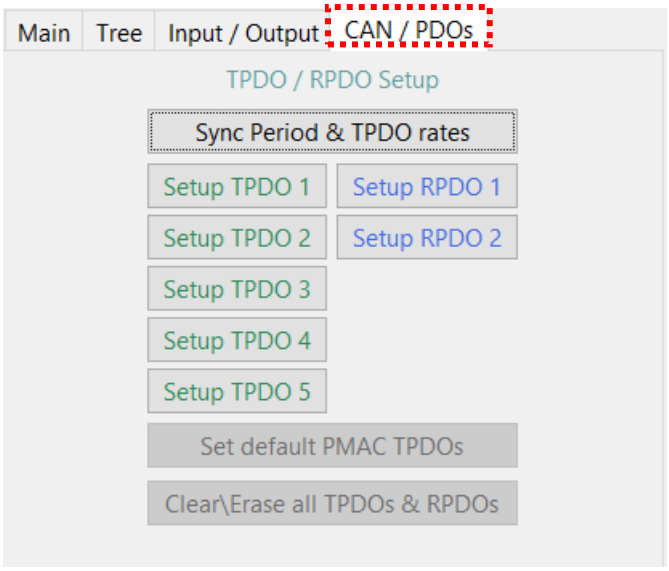


Figure 101 PDO configuration

Up to five RPDOs and TPDOs can be configured at any one time, per BorgWarner controller. The creation/editing window looks like this:

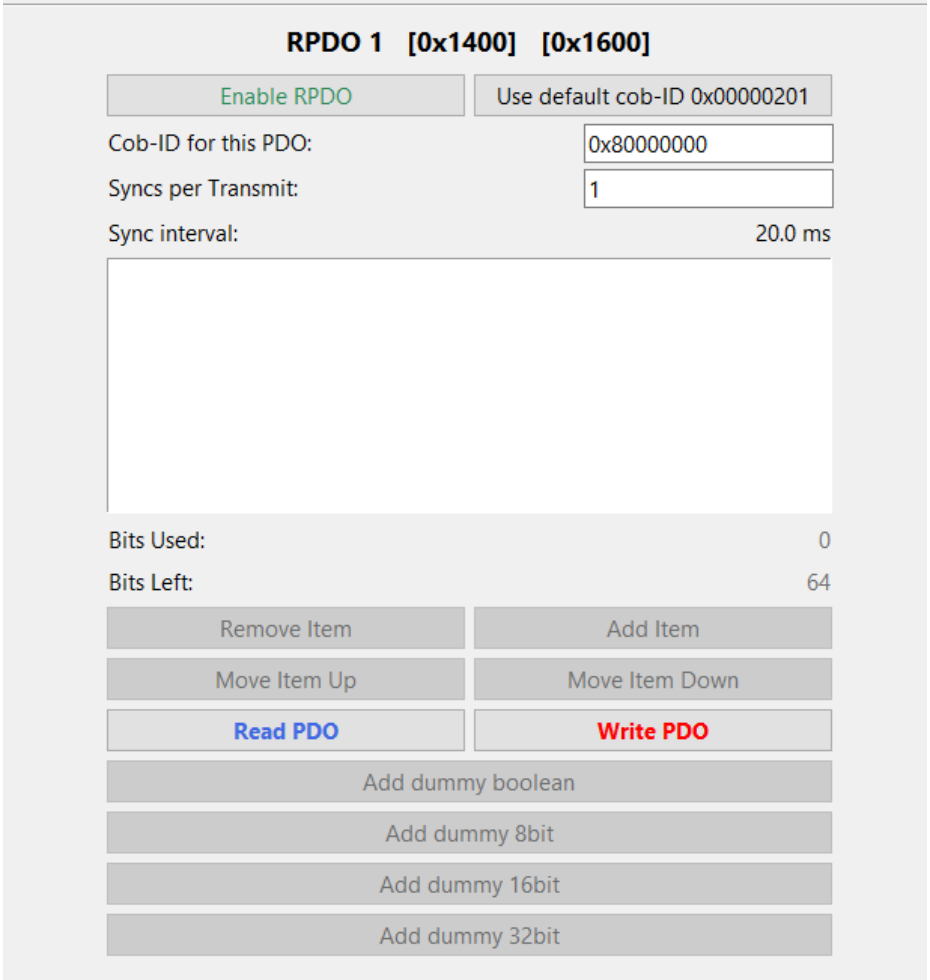
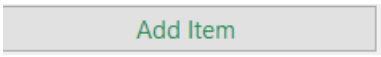


Figure 102 PDO configuration

Each PDO must have a unique Cob-ID which denotes the priority of the associated PDO, the lower the number; the higher the priority of the PDO.

The PDOs have a data size limit of 64 bits (8 bytes), meaning that the TPDO and RPDO can only contain a certain number of objects.

6.2 TPDOs

Begin by selecting the 

button; this will open a window in front of the DVT configuration helper:

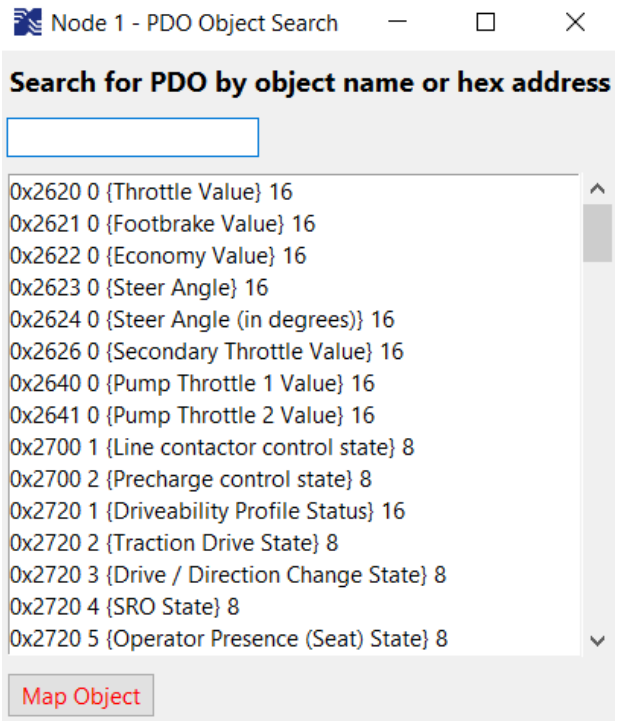


Figure 103 mapping PDO items

Selecting the search button or pressing any key will cause the window to fill with objects.

TPDO 1 in this scenario is going to be given the “Heatsink temp” object. To do this, enter the terms into the search bar found at the top of the add object window, and then select the search button.

Selecting the map objects button will add the object to the TPDO.

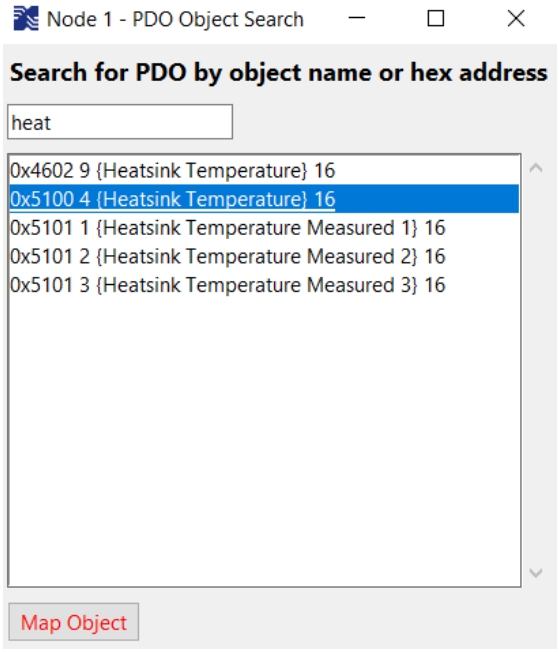


Figure 104 mapping PDO items

Finally, select the Write PDO button to save the changes to the controller.

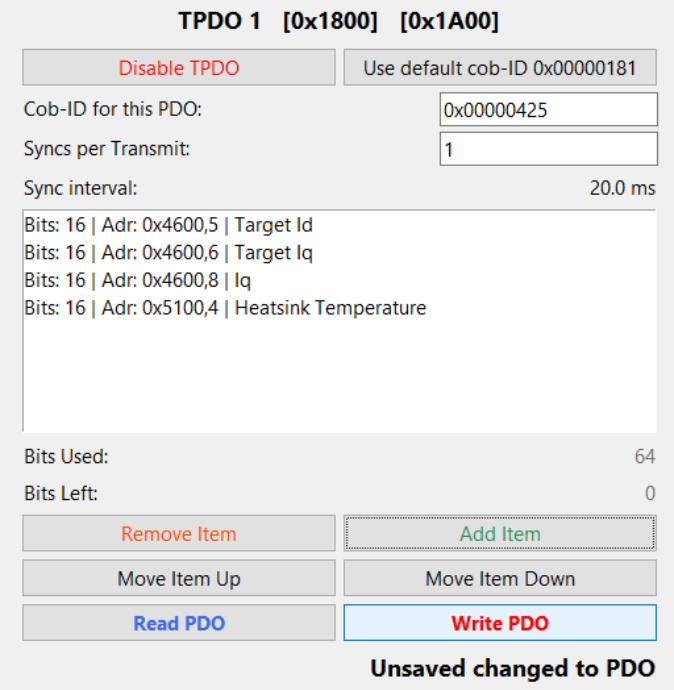


Figure 105 TPDO configuration

Note: When adding objects into a PDO, ensure that there are adequate bits left for the desired objects.

6.3 RPDOs

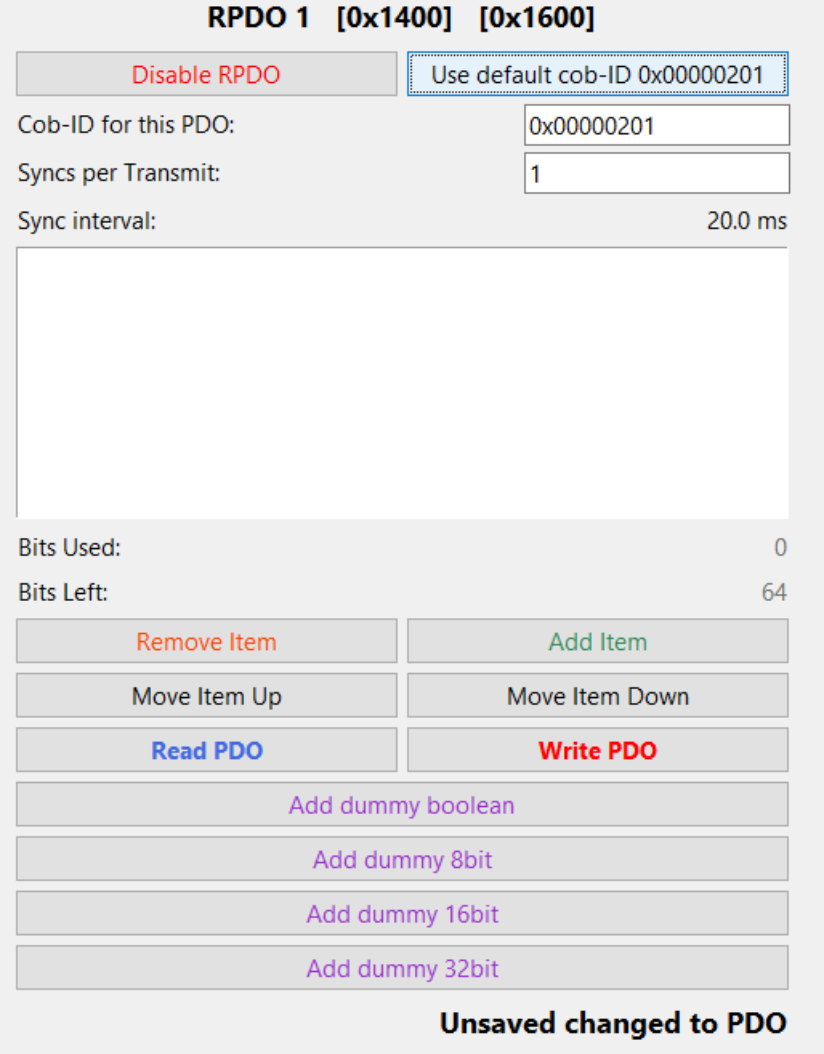


Figure 106 RPDO configuration

Begin by selecting the 

button; this will open a window in front of the DVT configuration helper:

Selecting the search button or pressing any key will cause the window to fill with objects:

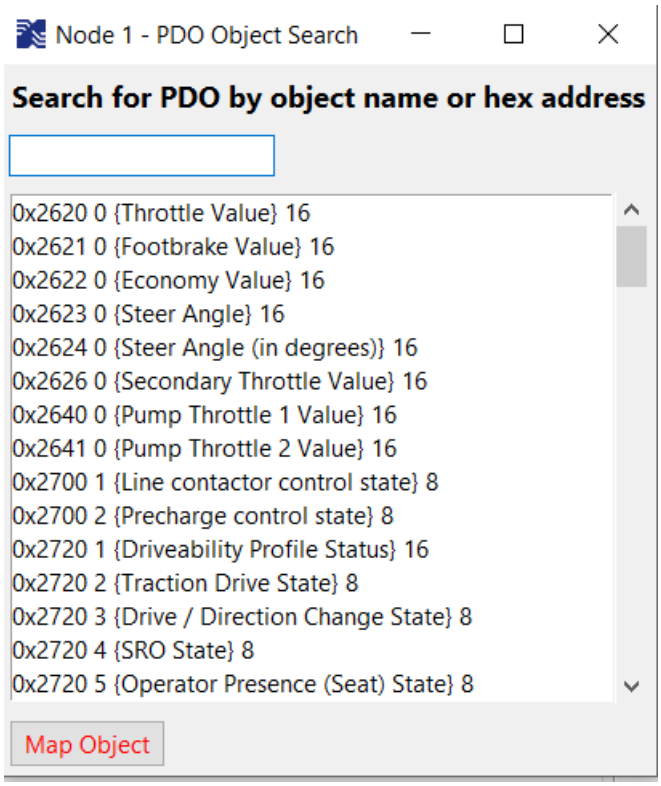


Figure 107 mapping PDO items

RPDO1 in this scenario is going to be given the “Battery Voltage” and “Vehicle Speed”. To do this, the procedure is the same as seen in the TPDO section of this guide:

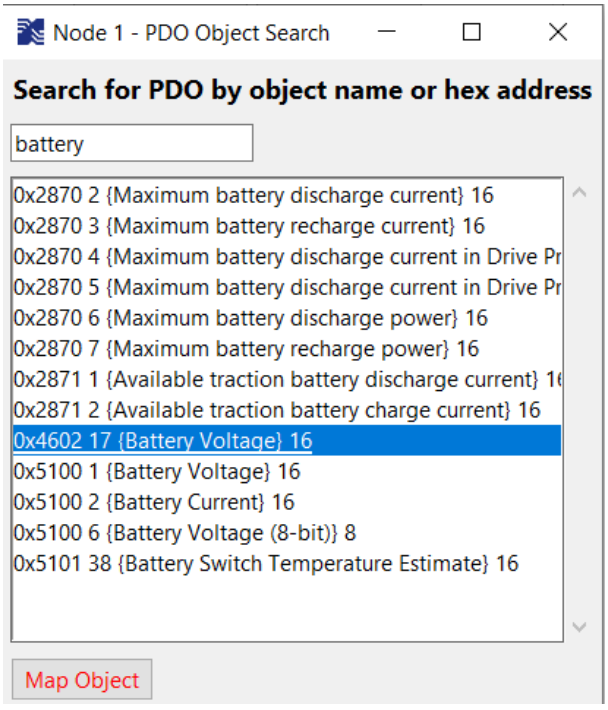


Figure 108 mapping PDO items

Selecting the map objects button will add the object to the RPDO.

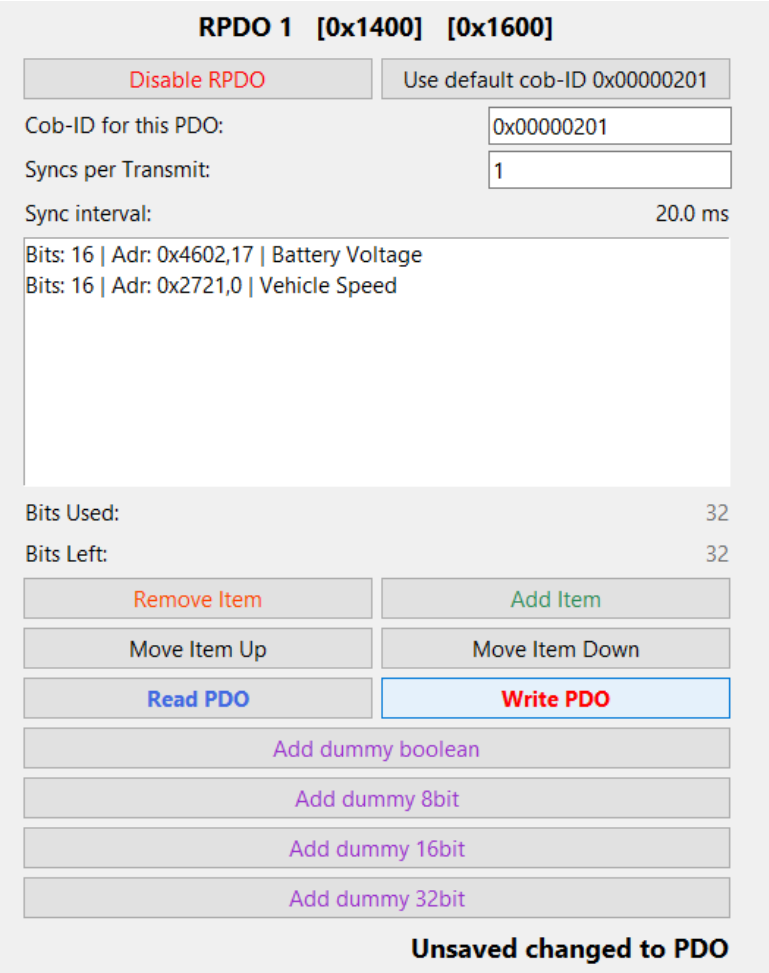


Figure 109 RPDO configuration

Finally, select the 

button to save the changes to the controller.

Chapter 7: Motor Demand Control

Chapter 7 - Motor Demand Control

7.1 Introduction

Controlling a motor direct from a laptop should only be performed on a motor dynamometer test bench by suitably trained and competent personnel, where the high-power supply to the controller can be quickly disconnected safely.

If the motor controller has been set up as a slave unit in the IO configuration, using the DVT environment you will be able to send demands to the motor via the CAN communication. For this purpose and according to the type of motor controller you need to use either CANopen demand generator or J1939 transmission window as described in the following.

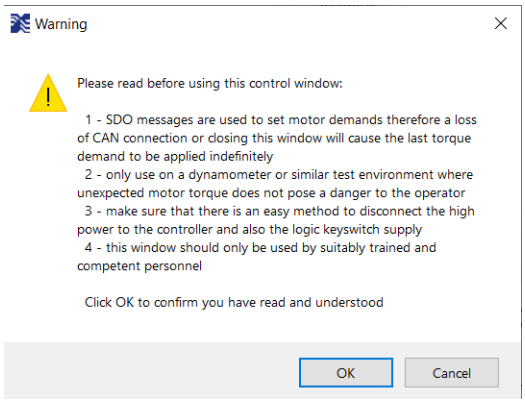
7.2 CANopen for Control

The CANopen motor demands window uses SDO commands. A failure in CAN communications leads to the last torque demand to be applied until the controller power is removed.

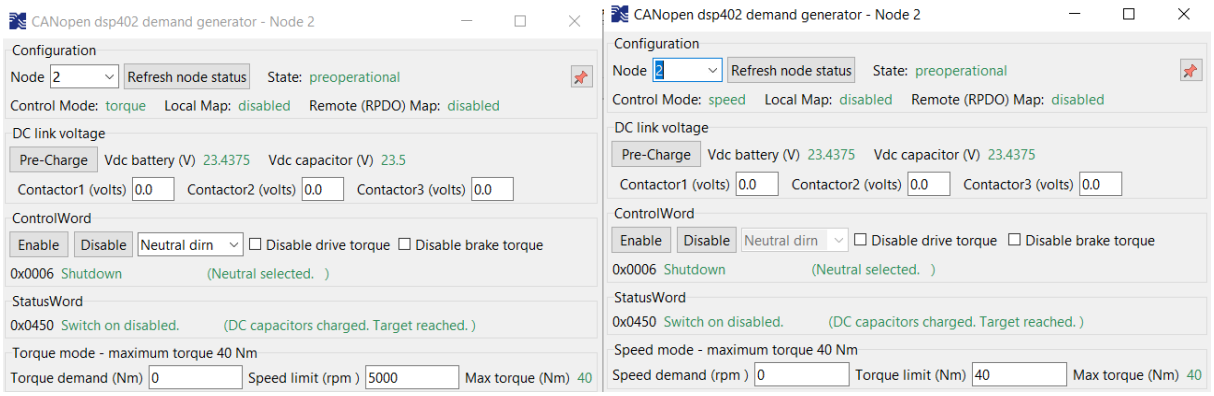
In DVT environment for all Gen4 LV family including size 2, 4 and 6 as well as CANopen software variants of Gen4 HV (size 8 and 10) you need to use the CANopen 402 demand generator window to spin the motor. This window is accessible via button  in the main DVT window.

Figure 110 CANopen 402 demand generator button

The first time you open then window you may see the warning window as it is depicted in the Figure 111 (a). You need to take into account that CANopen 402 demand generator uses SDO to command the motor controller. Due to the fact that SDOs go to object dictionary, facing a communication loss or closing the demand generator window will cause the last torque to be applied indefinitely. By clicking OK the CANopen demand generator window will open as is depicted in Figure 111 (b) or (c) according to the mode of operation.



(a)



(b) (c)

Figure 111 (a) Warning prior to opening demand window (b) CANopen demand window in torque mode (c) CANopen demand window in speed mode

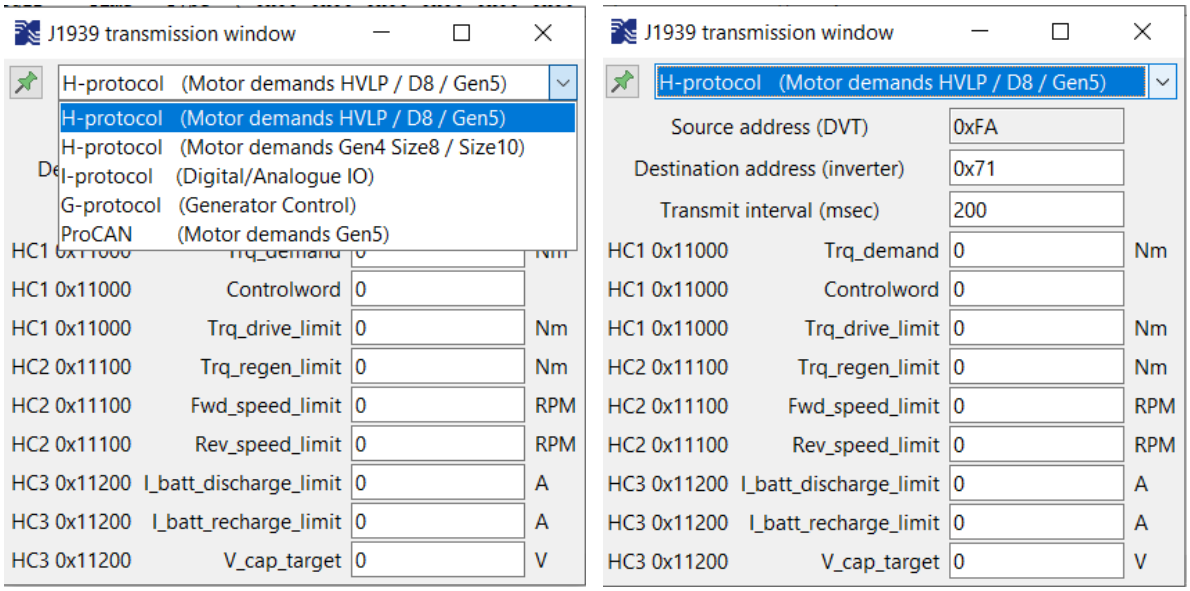
By selecting the correct node according to your hardware setup, you will be able to command contactors, change the control world and send the torque/speed demand and speed/torque limit.

7.3 J1939 (BorgWarner H-and I-protocols)

For HVLP, Dragon 8, Gen 5 size 9 motor controllers as well as J1939 software variants of Gen4 HV (size 8 and 10) you need to use J1939 Motor Demands panel to spin the motor in DVT environment. This window is accessible by clicking on "  " button in DVT main window as it is depicted in Figure 112.

Figure 112 J1939 Motor Demands button

In the opened J1939 transmission window, you first need to select the type of motor controller / CAN protocol you are working with from the drop down menu showed in Figure 113 (a). In addition to H-protocol and depending on the motor controller variant you can select I- and G-protocols too (for more information about H-, I- and G-protocols refer to the application notes from BorgWarner).



(a) (b)

Figure 113 J1939 transmission window (a) drop down menu (b) H-protocol parameters to send in torque mode

Once you select the H-protocol you need to set destination address (i.e. the inverter) and CAN message transmit interval according your application. Then you can start spinning the motor by sending HC1, HC2 and HC3 messages including torque demand, controlworld, as well as forward/regen torque and speed limits.

7.4 Debugging and Tracing

You may need to monitor in real time and save several parameters such as speed, currents, temperatures etc. during the operation. As it is mentioned earlier in chapter 1, for this purpose you can use Vehicle Interface. Inside this window you are able to observe enabled TPDOs and RPDOs as well as H-, I-, and G- protocols. To select what you want to observe you need to use Trace items drop down menu as it is reflected in Figure 114. In addition to, you can select the style of the of window through Display drop down menu. It is also possible to reduce the window update rate so that every CAN message is not displayed. Typical message rates of 20ms are difficult to read and lead to high CPU load on the DVT computer. Changing the display rate does not affect the rate that messages are logged to a file.

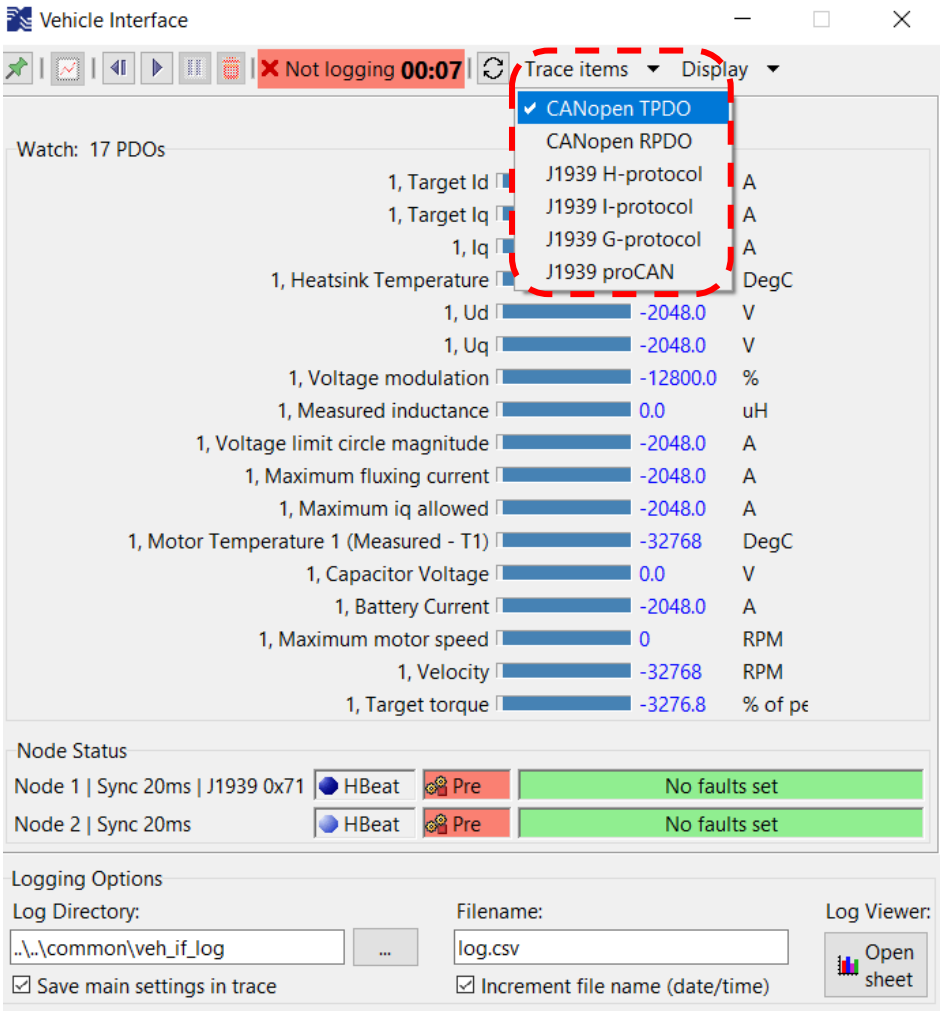
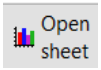


Figure 114 Trace Items

In order to plot a trace, first you need to record the data. To do that you need to decide about the log directory and file name. Following that, by pressing  button the DVT starts logging all the parameters shown inside the Vehicle Interface.

Once you stop recording, you can plot the recorded data using Log Viewer built-in spreadsheet. To do that use the  button.