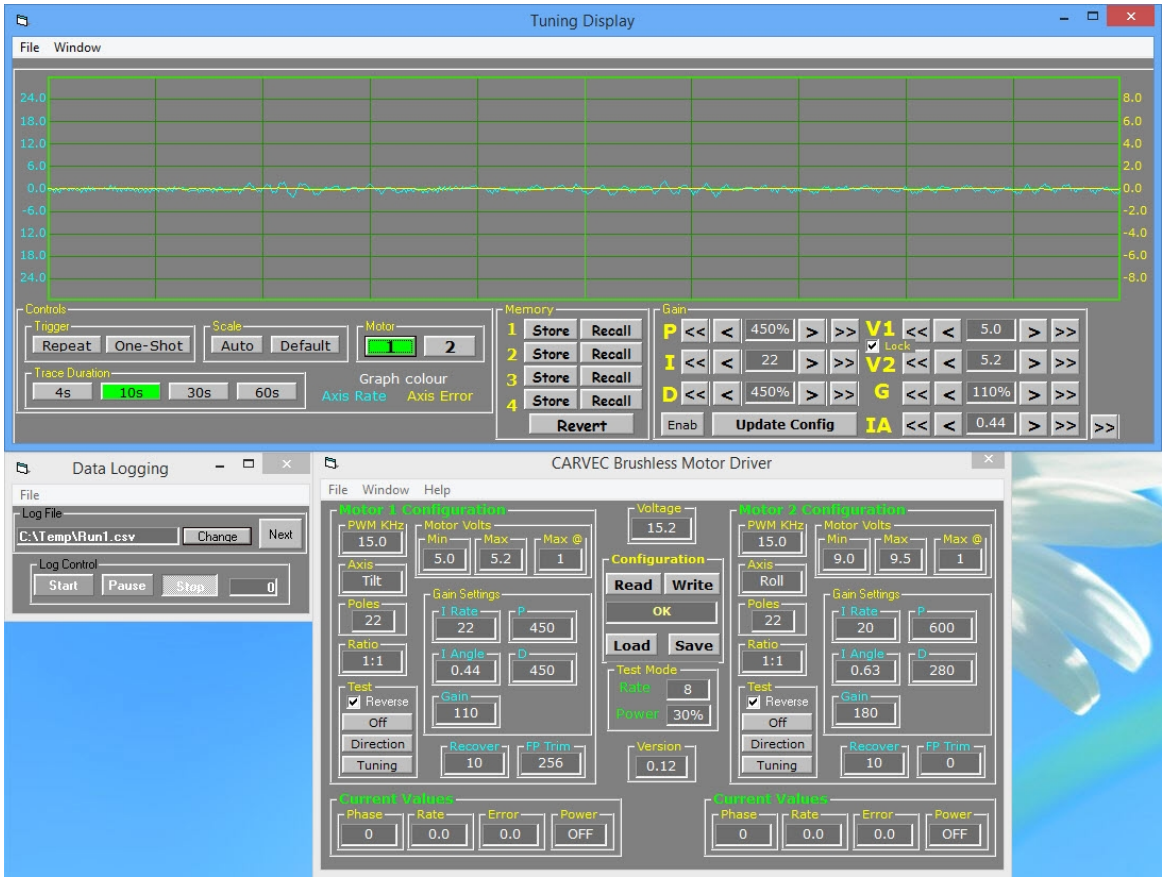
CARVEC Systems

CARVEC G-Lock 5A, Dual Channel Brushless Motor Driver Module

Software and Tuning Manual
Issue 1 Draft D

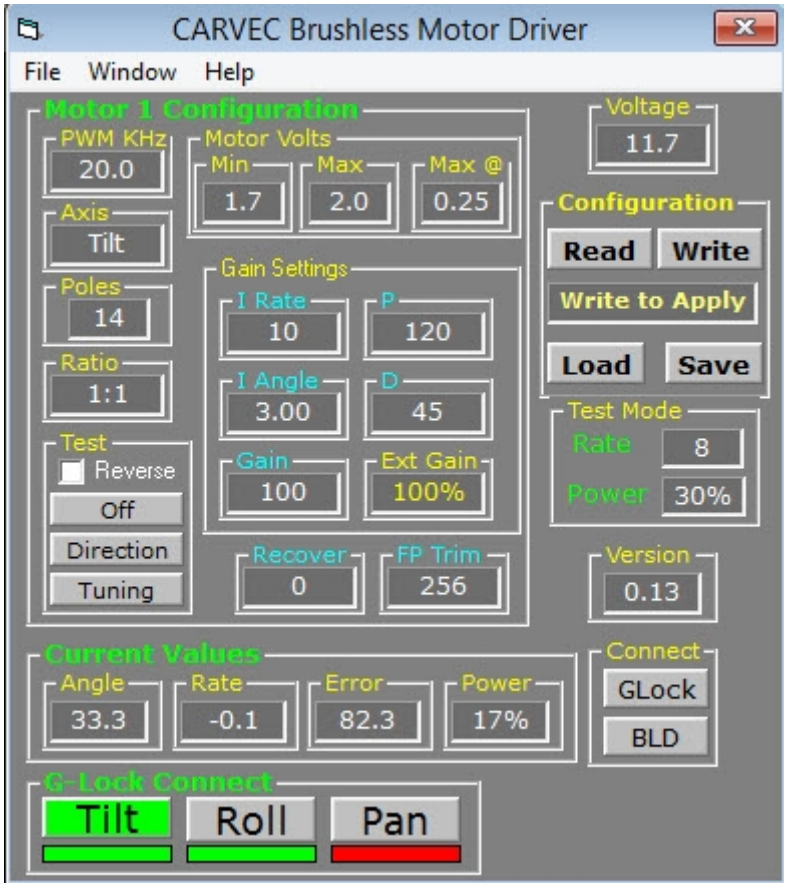
PC Software Overview

The PC software has 2 main windows : the lower configuration window and the larger tuning window.



Note that most controls have help text which is displayed if you hold the mouse pointer over it for a short time.

Note that the BLD software will also allow tuning of the motors when connected to the G-Lock module. In this case, the configuration display will automatically switch to the single axis mode which looks like this:



The desired axis is selected for tuning by clicking the Tilt/Roll/Pan button. The coloured status bars underneath the axis shows if the axis is available for tuning. If the status bars are red when you expect them to be green, check the HSL connections to the BLD modules.

Apart from the single display, the tuning is similar for either way of connecting.

Configuration Settings (Lower Window)

The configuration window has all the settings for the module. It will automatically read the configuration from an attached module when it is first connected. Note that the BLD software also supports tuning whilst connected through the G-Lock module. In this case, only one motor is tuned at a time.

The configuration parameters are:

PWM KHz : lower frequencies around 8KHz can be more efficient but can also be noisy. Somewhere around 10-15 works well. Click to enter a new value.

Axis : The G-Lock axis this motor is driving. If a channel is not being used, set it to ‘Off’ to prevent it clashing with another BLD on the same HSL bus.

Poles : Enter the number of magnetic poles for the motor here.

Ratio : Enter any gearing ratio here. Set to 1:1 for direct drive.

Motor Volts:

The power to the motor is calculated automatically using the volts specified here and the actual main battery voltage. The voltage is varied depending on the angle error of the stabilisation allowing lower power to be used when the gimbal is static.

The 'Min' voltage will be used when the stabilisation angle error is zero. It will ramp up to the 'Max' voltage when the stabilisation angle error reaches "Max@".

This function is useful to prevent a motor getting hot under static conditions, but gives more power when needed.

Direction: the direction of each motor must be set for proper operation. When the 'Test' button is clicked, a 'Tilt' motor should start tilting upwards, a 'Roll' motor should start rolling right-wing down and a 'Pan' motor should start rotating clockwise.

The speed and power used during the 'Test' function can be set in the 'Test Mode' section.

The 'Recover' angle is used to try and prevent the gimbal 'running away' if it gets knocked out of position. When the stabilisation error is greater than this angle, the gimbal 'locks' the motor drives and attempts to bring it back.

Tip: Set this angle to zero (disabled) during tuning.

'FP Trim': This is the 'Fixed Position Trim'. The G-Lock allows an option for the Pan axis called "Lock Pan in FP" which locks the brushless motor drive at the current angle. This is useful before takeoff where the landing gear is attached to the pan axis : if it is stabilised, it will try to spin the aircraft above it. If a brushless motor is turned completely off, it provides very little resistance to turning – so this feature provides a way of holding the pan axis in position.

The 'FP Trim' is the default angle drive to the motor if it has not yet been initialised into 'stabilised' mode immediately after power up. This can be adjusted so that the gimbal points straight ahead by default. The angle can be 0 to 360 degrees which represents one electrical cycle of the motor – but the actual angle on the pan axis depends on the number of motor poles.

Gain Settings : These are described in the 'Tuning Display' section.

Tuning Display (Upper Window)

The tuning display has 2 main functions :

1) To provide a real-time graphical display of the motor drive signals in order to be able to judge visually how well the motor is tuned and
2) To provide easy to adjust, real time gain parameter changes to aid tuning of the

motor.

When a capture is running:

The yellow line shows the stabilisation error for the axis (ie the error between the desired angle and the actual angle of the gimbal)

The blue line shows the rate-of-turn of the axis – ie how fast the IMU senses it is moving for this axis.

The ‘Trigger’ section controls when a new display trace will start. When ‘Repeat’ is selected, a new one will start immediately when the current one reaches the right-hand side. When ‘One-Shot’ is selected, a trace will start and then stop once it is finished. Another will not be started until ‘One-Shot’ is clicked again.

‘Trace Duration’ allows the time for a full trace to be changed to allow more data or more detail to be shown.

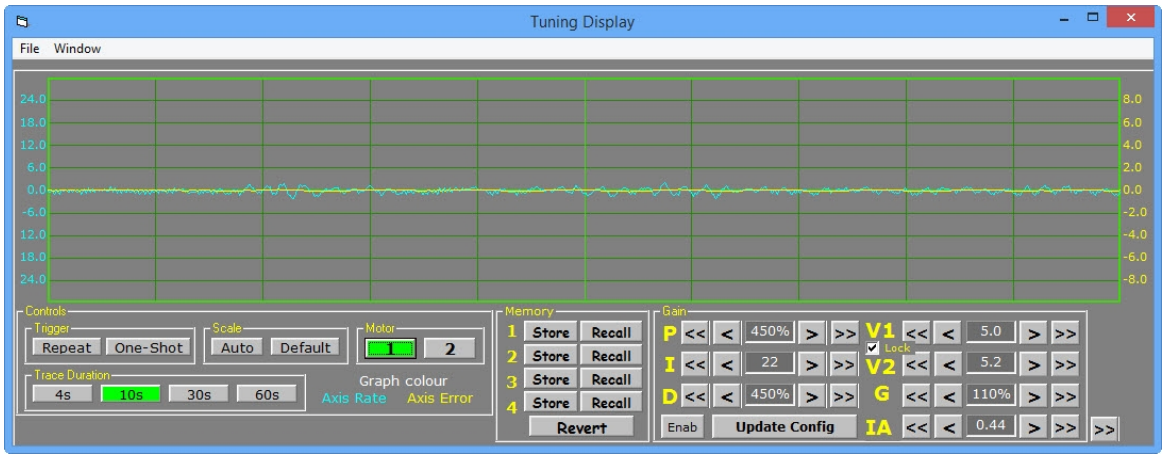
Scale section: If ‘Auto’ is clicked then the vertical axis will be rescaled periodically to fit the maximum and minimum values which have been captured in the trace. If ‘Default’ is clicked, the vertical axis will be set to the default scale.

Motor: This section selects which motor is displayed in the Tuning window. When a motor is clicked, the gain section on the lower right will change to be the gain values for that motor and the graph will show the real-time data for the motor. Once the motor has been selected like this, the gains for the motor can be adjusted in real time using the left/right arrows on the right-hand side. If the ‘Update Configuration’ button clicked then the Tuning window gain settings are copied into the main configuration area for the motor. Note that they are not actually written down into the BLD module until the ‘Write’ button is clicked in the configuration window.

The ‘Memory’ section provides temporary stores for ‘candidate’ tuning parameters. You can save all the current tuning window settings to a memory then recall them instantly. It is especially useful for back-to-back comparison of different gain settings.

If the current tuning window matches any of the memory stores, the ‘Recall’ button will light green to show which one you are using. If you click ‘Revert’, it will reload the current settings in the configuration window.

Tuning Guide



Getting Started

The tuning process involves several stages of tuning the gimbal under different conditions to get the best overall compromise.

Before tuning, the G-Lock module must be fitted to the gimbal and configured correctly – particularly for the orientation and HSL link. When using the G-Lock PC application, you should see all the connected BLD modules HSL status light up green showing they are connected successfully. Also, when the HSL link is valid, the BLD module LED will reverse the LED flash to be normally on, but flashing off.

Make sure you have plenty of room and none of the cables are going to snag while you move the gimbal.

The tuning will focus on each axis in turn. The general method is to tune each axis 'roughly' so it will hold stable without oscillation, then fine-tune each axis.

Tuning is highly dependent on the camera to be used and hence it MUST be fitted. You should prepare the gimbal with everything fitted (camera, batteries, downlink etc) before attempting to tune it – and also the gimbal MUST be balanced as best you can. If the gimbal is properly balanced, you can move the camera to any angle in tilt/roll/pan and it will stay there. There are many videos on the internet which shows how to balance a gimbal – Google is your friend for this.

The easiest way is usually to disconnect the Pan and Tilt motors and start with the Roll. Tune the Roll so that it will hold position without oscillation, then tune the tilt. Once the tilt looks OK, go back and tune the roll some more.

Note that when following the tuning steps, it is usual to keep going backwards and forwards as the tuning needs to be a balance which works for all.

Using the Dynamic-Tuning Controls

To tune a motor, select it by clicking ‘Motor 1’ or ‘Motor 2’ on the ‘Tuning Display’ window. When you do this, all the gain settings from the configuration window will be copied to the ‘Gain’ panel on the Tuning Display.

Now you can modify the gains by clicking the Left/Right arrows. Clicking ‘<<’ or ‘>>’ will cause the value to change by a large increment and ‘<’ or ‘>’ will cause a small increment. You can also click the value and type in a new one if you like.

Note that while the ‘Enable’ box is lit green, the gain is being controlled dynamically – ie the gain in the BLD module changes immediately. You can click the ‘Enable’ to turn the dynamic gain control off if you want and the BLD will go back to it’s internal settings.

Note that these gains are not stored in the BLD module : they are sent in real time from the PC. If you want to save the gain settings, you must click ‘Update to Configuration’ to update them into the ‘Configuration’ window. From there you must click ‘Write’ to actually put them into the BLD module.

V1 and V2: These are the ‘Minimum Voltage’ and ‘Maximum Voltage’ settings which define how much power is applied to the motor. When the ‘Lock V’ checkbox is set, changing one will also change the other to keep the same difference between them. If the checkbox is cleared, you can adjust them independently.

The ‘Scale’ buttons adjust the Y-axis scaling for the graph. If you click ‘Auto’, it will rescale the graph so that all the data is visible. This is useful for some of the stages of tuning. Clicking ‘Default’ will reset the scaling to the default settings which is good to see a like-for-like comparison for all motors.

Gain Parameters – Overview

D (Deriviative) : This parameters is based directly on the rate-of-turn of the axis and it’s effect is to damp any movement. It is used to stop oscillation caused by the ‘P’ term. If there is too much D, it causes a high frequency ‘buzz’ on the motor. D is also very dependent on the power being given to the motor.

P (Proportional) : This parameter is based on how much the actual angle error changes during the stabilisation. It is based on the position of the gimbal, not the rate-of-turn. Too much P is shown as a fast oscillation (but not as fast as D). P oscillation can often be tuned out by adding more D.

I (Integral) : This is a ‘ramping’ input based on the actual angle error for the gimbal. It will correct for any error which remains after ‘D’ and ‘P’ have worked their magic. It is this term which ramps the motor back into position if you displace it by hand.

I Angle : Between zero gimbal stabilisation error angle and ‘I Angle’, the I used for the PID is scaled from zero to the full value. This reduces it’s effect for very small errors and prevents hunting around zero error.

G (Gain) : This is the overall gain for the motor PID loop. It adjusts P, I and D equally and

is good for final fine tuning and for keeping all the other parameters within ‘reasonable’ ranges (for example, if you find you are at 1000% ‘P’, double the gain and take P down to 500% and start again). Try to keep all gains under 500%.

V1 + V2 : These are the power settings for the motor. It is driven at V1 when there is no stabilisation error angle on the gimbal and is increased to V2 when the error is equal to the ‘Max@’ angle in the configuration window.

Preparing to Tune

These steps show how to prepare everything so you can start tuning:

1. Connect the desired BLD to the PC using the USB adapter and a servo cable as shown in the BLD Hardware Manual.
2. Run the BLD PC software. The start-up splash screen should be asking you to connect a BLD module. If you have an error saying “Invalid Com Port Number”, you need to either change the default com port for the USB adapter to 10 (as described in the G-Lock user manual) or change the com port to the correct one.
3. Turn on the gimbal. The PC App should automatically change to the tuning display. Note that when it connects with the BLD for the first time, it will automatically read the config out of the module.
4. It is recommended that you find an existing config file for a gimbal setup which is as close to your own as possible. Check the support forum (carvec.proboards.com) for some examples. This should at least get you in the ball-park to start fine tuning. Be sure to click ‘write’ after loading a new config.
5. At this point you should have a line moving across the tuning display. If the gimbal is moving or buzzing, you should also see movement on the tuning display. At this point, you are ready to start.

Step 1: Set the Motor Direction

The motor direction must be set correctly for each axis within the BLD module. This is done by simply clicking the ‘Test’ button. When you do this, the motor will start to turn slowly. The direction of the camera on the gimbal should be:

Motor Axis	Camera Movement
Pan	Clockwise
Tilt	Upwards (‘nose up’)
Roll	Roll right (‘right wing down’)

If the direction is wrong, click the ‘Reverse’ box and then click ‘Write’ to change it in the BLD module.

You can change the speed and power used by the test function by changing the values in the centre box. This can be useful for trying out the torque and response of a motor.

Step 2: Tuning the stabilisation

Now we are ready to start tuning a motor using the dynamic gain adjustments whilst manually moving the gimbal to see the stabilisation response.

The general idea for this is to manually move the gimbal about +/-30 degrees and watch the display for the actual angle error (the yellow line) and the gimbal rate-of-turn (the blue line).

To do this, click 'Motor 1' or 'Motor 2' for the axis to be tuned. The current configuration will be copied to the Tuning Display gain section. Now start to move the gimbal and adjust the gain settings to get the smallest offsets for both lines on the display.

This part of tuning is what takes experience and experimentation to find the best results. The general principle is to increase the parameters until oscillation starts then back them off a bit. It is an iterative process – for example, if you change the D value, you need to try changing the P again.

A suggested tuning method is:

1. Start with V1 and V2 from a setup as similar to your own as you can.
2. Reduce the I to a low value (5) and the I-Angle to something quite high (about 2)
3. Set the Gain, P and D to 100%
4. If the gimbal is already unstable, adjust P and D until it can at least stay still.
5. Increase P until the gimbal starts to oscillate
6. Then increase D to see if it can stop the oscillation
7. Keep increasing P and D until it is clear that you have reached the limit for what the gimbal can take.
8. When it is somewhere near, it is useful to increase the P and D to the point of oscillation and then back it off to get an idea where the natural limit is.
9. Next increase the I until the gimbal returns to the stabilised position at a comfortable rate (20 or 30 deg/sec) if you manually push the gimbal out of position.
10. Then decrease the I Angle until the stabilisation starts to look unstable.

During this tuning process, you need to keep going back and fine tuning the P, I and D terms as you go on as changing some may have an effect on the others. For example, if you put more D in, you can probably get a bit more P in too (as the D component damps the P component oscillations).

Note that as a general rule, the gains and V1+V2 depend on each other : if you change V1+V2 you might find you need to change the gain (especially the D-Term). More 'V' means you can use less 'D' – but get more holding power from the motor.

Step 3: Tuning the 'recovery'

When the stabilisation gain looks to be as good as possible, it is time to check the gains work well for the recovery mode.

To test the recovery mode, displace the gimbal being tuned by about 30 degrees then watch for a smooth return back to the proper position.

The rate at which the gimbal returns to the position is determined by the I rate. Adjust this until it returns at about 20-30 degrees/sec. Adjust the other parameters so that the blue line on the graph shows little or no oscillation when the gimbal is returning to position.

Once the I rate has been set, gradually adjust the I Angle to try and get the minimum possible without signs of oscillation.

Step 4: Tuning the Slewing

The G-Lock includes a dynamic 'Test' function where the G-Lock simulates slewing input automatically and allows you to tune while the gimbal is being moving. Clicking the 'Tuning' button in the 'Test' section. This causes the angle ramp between the 'Proportional Mode' end points as set in the G-Lock configuration. The ramping will take place at the G-Lock maximum slew rate.

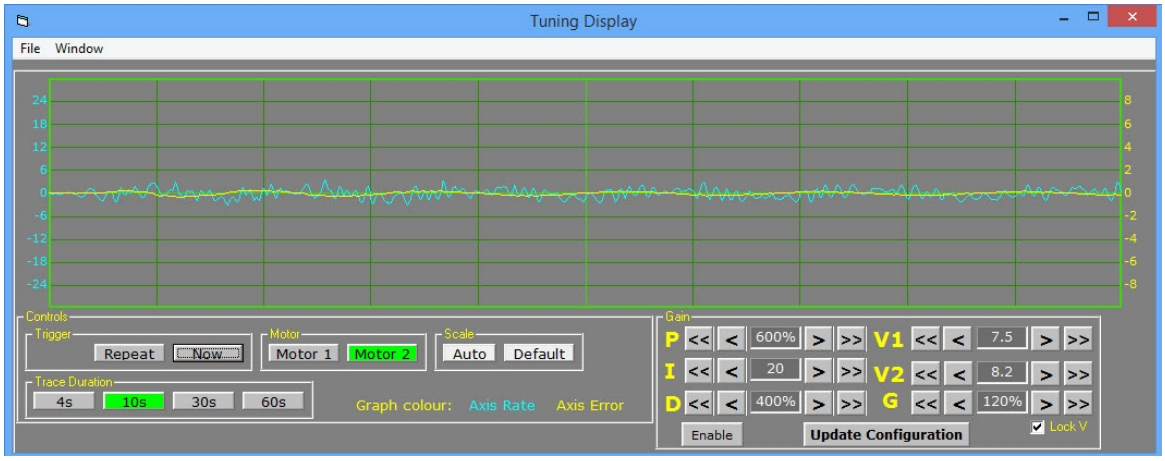
Finally the RC control needs to be hooked up and the gimbal movement checked that slewing is smooth in the real conditions.

Example tuning graphs

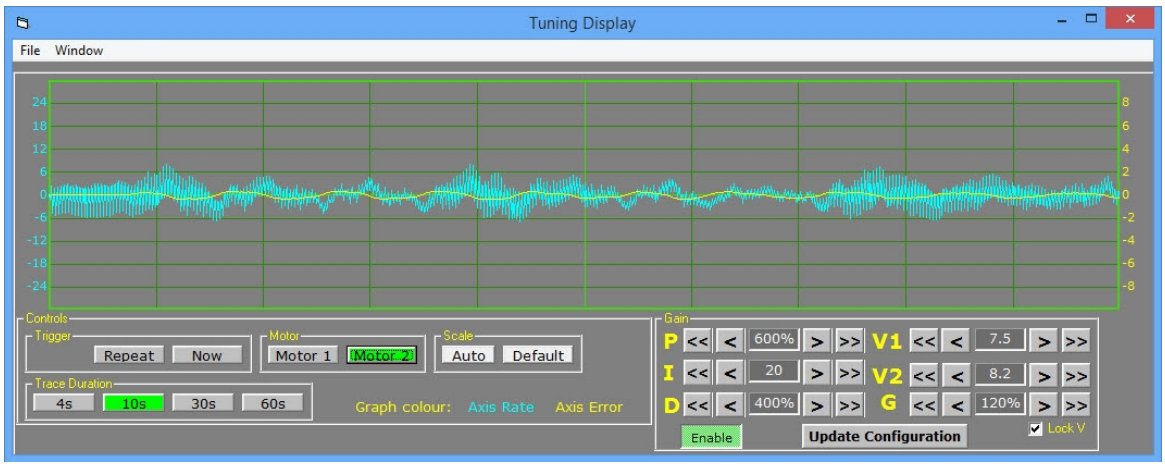
Please note that the final results possible is different for every motor/camera/gimbal combination. These pictures are from the roll axis of a mount which is an example of a good setup.

The samples are taken whilst rolling to gimbal 30-40 degrees in each direction at about 40 degrees/second.

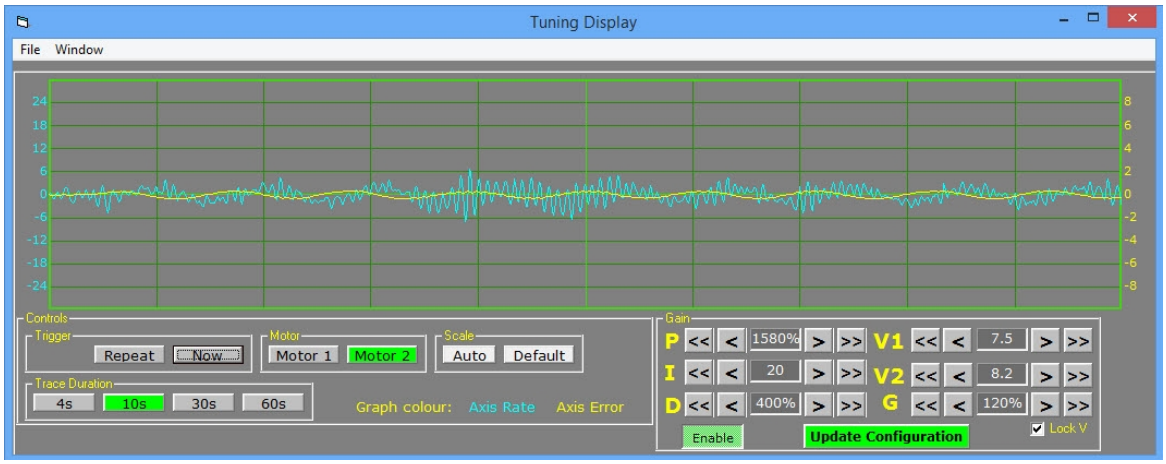
Well tuned response



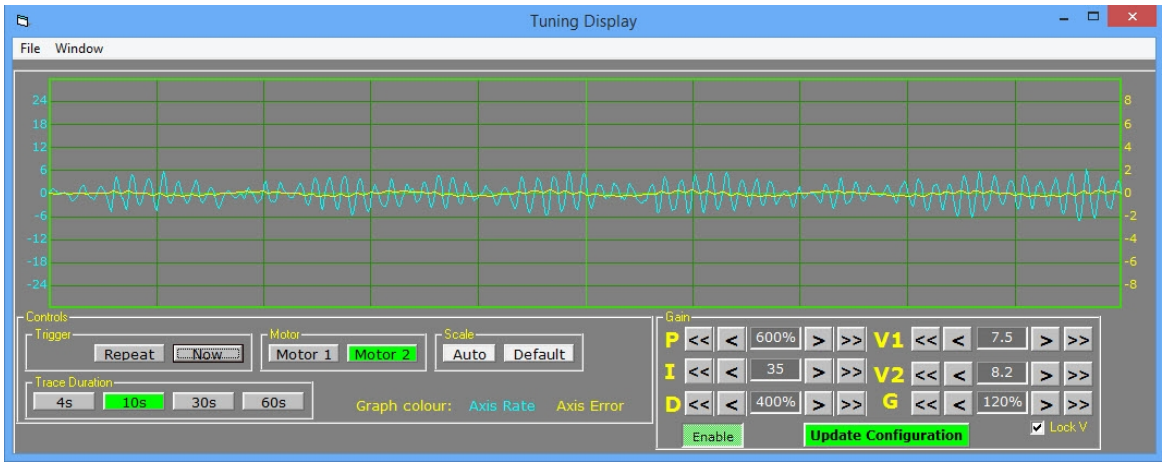
Too much ‘D’ component



Too much ‘P’ component



Too much I component



Appendix A : BLD Bootloader and Firmware Updates

The process for updating the BLD modules is the same as the G-Lock module. First the module is powered up into bootloader mode and then new firmware downloaded using the CARVEC Bootloader application.

The BLD bootloader is entered in the same way by connecting together the two PC link data pins during power-up. For the BLD modules, these are pins a + b of Port-4 (See the BLD hardware manual for more details).