

BFF CL System - Project Overview

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Project Overview - Force Feedback Flight Controls **(with CL_SPU + BLDRV2-24 cards)**

SUCCESSFUL OPERATION OF THE BFF CL SYSTEM DEPENDS ON CORRECT MANUFACTURE, ASSEMBLY, INSTALLATION AND SETUP WORK BY THE SYSTEM BUILDER. IF YOU ARE NOT SATISFIED THAT YOU HAVE THE TECHNICAL SKILLS REQUIRED TO DO THIS WORK THEN PLEASE DO NOT ATTEMPT THIS PROJECT.

The BFF CL system is NOT a Plug 'n Play system. It is very important that you read ALL the documents and study the ALL the plans before starting the project.

If you just buy the cards, apply electrical power and fiddle with the software there is a good chance that all you will succeed in doing is blowing up your expensive hardware.

1. Quick Overview

1. Mechanism Design

If you are NOT using the mechanical plans available on the web site then you must first design the mechanics of your yoke, column or rudder controls. This is NOT a trivial step, and it needs to be done correctly. Your controls must incorporate the correct transmission (gearing) ratios to connect the FFB motors to the control wheel/stick/peddles. And the mechanisms must be designed to be smooth and friction free. They must be completely free of play (backlash) and must be stiff enough to carry the considerable system loads induced by the motors WITHOUT undue deflection or stressing.

Poor mechanism performance can NOT be corrected by the CL software.

2. Build the control mechanics carefully and accurately to the designs, including fitting the electric motors and transmissions.
3. Fit and electrically wire the FFB driver/controller cards.
4. Prepare the power supply for the driver cards. **READ THE DATASHEET COMMENTS ON THE POWER SUPPLY.**
5. Install the FTDI USB/TTL cable and drivers and the BFF CL Software.
6. Test the individual FFB channels using the BFF Driver Test application. This is **IMPORTANT**, damage to the equipment can be done if a step by step approach to the system set up is not taken.
7. Set up and calibrate the joystick card to be used for trim inputs.
8. Run with the full BFF CL Software and flight sim active to test the FFB in flight and to tune the force settings using the Configuration Manager to your requirements.
9. From here on only the BFF CL Software is used to run the system in its normal operational mode. On each system power up a simple movement calibration procedure is undertaken, following which the system is ready for use.

PLEASE FOLLOW CAREFULLY THE STEPS DETAILED BELOW.

2. Detailed Commissioning Steps

1. Make and assemble the mechanics of the flight controls (with brushless motors fitted). Ensure that the movement of the control axes is smooth and friction free – sticky and/or rough mechanical performance CAN NOT be improved by the CL control system! Make sure your mechanisms are completely free of play (backlash) and are stiff enough to carry the considerable system loads induced by the motors WITHOUT undue deflection or stressing.
2. FAMILIARISE yourself with the CL_SPU + BLDRV2-24 data sheet! It contains important information.

http://bffsimulation.com/Images_newCL/CL_SPU_and_BLDRV2_Data_Sheet_R0_1.pdf

LOCATE THE DRIVER CARDS

3. Mount the CL_SPU + BLDRV2-24 cards in a location close to the control mechanism (within range of the motor and encoder cables). Ideally the card LED's should also be visible from the pilot's seated position as they will indicate the initialisation and running status of the CL system. The driver cards should NOT be enclosed without forced ventilation – they require a free flow of air over the heat sinks for effective cooling (see the card data sheet for more information on card cooling, and see item 7 below).

However the card position should be out of reach during normal flight operations – to prevent physical contact by personnel whilst the cards are in operation. The card heat sinks may become hot to the touch.

4. If you intend to operate the FFB system under sustained loaded conditions – eg for flying with simulated systems failures which require large control forces to be sustained, then force air cooling MUST be used. Fit PC case or similar fans over the BLDRV2-24 card heat sinks. In these circumstances the operating temperature of the drive motors must be carefully monitored – motors are less effectively cooled by external airflow.

POWER SUPPLY

5. Set up and position the power supply and wiring to the CL_SPU + BLDRV2-24 cards. See the card data sheet for important information about the choice of card power supply. **THE USE OF AN UNSUITABLE POWER SUPPLY CAN DAMAGE THE DRIVER CARDS OR PRODUCE POOR FORCE FEEL.**

A visually prominent and accessible power cut-off switch should be located close to the pilot/operator's seating position to enable rapid power-down of the CL system should the need arise.

However DO NOT connect power to the driver cards at this stage.

Note the cable type recommendations on the [wiring diagram here](#).

DRIVER CARD WIRING

6. Wire the CL_SPU + BLDRV2-24 cards to the BLDC motors (phases, hall sensor and encoder).

Motor phases 1, 2 & 3 are the main power cable cores Black, Red and White respectively for the recommended MB082 brushless motors.

Hall Sensor signal is black logic cable core Yellow (Hall A) unless otherwise specified, and 5V and 0V are Red and Black respectively.

You MUST refer to your encoder data sheet to correctly identify the A & B encoder channel cables and the 0 & 5V cables on your encoder to connect to the driver card. Even so it may be necessary on testing to reverse the A & B encoder connections to obtain smooth motor commutation; this is because different encoder makes can give different directions of +ve rotation even with the same A & B connections.

Make sure all connections are secure – faulty logic connections to the hall sensor and encoder will disrupt the system operation. The motor and encoder connections are located at the heat sink end of the driver cards.

7. Wire the single throw double pole logic power switch to the CL_SPU jumpers JMP-1 and JMP-3. This will be used in conjunction with your main 24V supply switch to power-up the system.

Ensure that the CL_SPU + BLDRV2-24 cards are fully inter-connected via their on-board inter-pcb header connectors.

CL SOFTWARE INSTALLATION

8. Download and Install the BFF CL Software.

Check out the Configuration Manager folder – the Configuration Manager app will be used first – to set up the COM port and other hardware settings.

9. Install the FTDI USB/TTL cable drivers on the PC and connect the cable to the PC and the CL_SPU card.

For drivers and installation instructions for the FDTI cable see -

<http://www.ftdichip.com/Drivers/D2XX.htm>

Once the USB/TTL cable has been installed a virtual COM port will be created on the PC. Find and note the COM port number of the virtual COM port (view in Device Manager).

Run the **Configuration Manager**, select a default config file closest to your type of aircraft, and then set the COM port in Tab 6 Item 1. Check that it opens properly using the Check button.

Go to Tab 9 Item 4 in the Configuration Manager and use the Update button to copy your

COM port setting to the Driver Test Application configuration file.

NOTE: FTDI USB/TTL cables can be reprogrammed to use a fixed serial number using FTDI's FT_Prog utility – see the FTDI web site. This will cause the cable to keep the same virtual COM port regardless of which USB port it is connected to on your PC.

DRIVER CARD TESTING

10. FAMILIARISE yourself with the BFF Driver Test Application user guide. It contains important useful information. It is in the Documents sub-folder of your CL Software folder.

Set the software comms mode to match the CL_SPU + BLDRV2-24 cards in Configuration Manager Tab 6 Item 3 to **10b-Module**. Then in Tab 9 Item 4 click the Update button to update the Driver Test App with the correct output mode also.

This can also be done manually in the DRVR_Test.ini file in the Test App folder

11. Use the Configuration Manager Tab 9 Item 5 – Test_App button to start the Driver Test Application.

This can also be done manually from the Driver Test App folder.

12. Ensure the 24V power supply voltage is within range AND THE POLARITY IS CORRECT.

Power up the cards by **first** closing your main 24V power switch and **then** closing the STDP logic power switch - monitor the cards for correct LED operation.

If the Test App software is running and the serial comms are good the cards will flash an initialisation sequence and then the Yellow LEDs on the CL_SPU and the BLDRV2-24's should blink rapidly; this will continue until the power-up movement calibration of each axis is completed. As each axis is calibrated the yellow LED on its BLDRV2-24 card will go out. Once all the active axes have been calibrated the yellow LED on the CL_SPU will also go out.

Manual Power-up calibration involves moving the control axis back and forward at a steady pace **end stop to end stop** until the Yellow LED goes out on the axis driver card.

If there are any signs of overheating or excessive current draw immediately power-down the cards and double check the power supply and other wiring.

13. Use the BFF Driver Test Application to check the operation of each FFB axis individually. Note the power-up calibration procedures and LED sequences described above and in the driver card data sheet.

I suggest first loading should be with a modest "Constant Force" loading – say 50 (out of a max 255). This should produce a light but significant steady load on the axis.

Check each axis for smoothness of force feel and monitor continuously the temperatures of the driver cards for signs of overheating. If they are operating in a high ambient temperature or are loaded at high levels for periods of several minutes there is a danger of overheating and damage – in these circumstances it is strongly recommended that additional forced air (fan) cooling is provided for the cards.

Test initially with light loads and then increase the loading by steps to check the integrity of the electrical and mechanical systems.

If calibration completes and gives smooth response, but on the application of a "constant force" test loading the control axis feels "coggy" then power down the system and reverse the encoder A & B channel connections to the driver card concerned. Repeat the power-up sequence and calibration and re-check the force feel under the constant force condition.....

14. Power down the cards.

JOYSTICK CARD SETUP FOR TRIM

15. Set up and connect the trim input potentiometers or buttons to a USB joystick card.

Remember to calibrate the joystick card as a Game controller in Windows.

Once you have set up your pots or buttons go to the Configuration Manager Tab 6 Item 7 and set the joystick card as the Primary Joystick. Use the Sel_Joy button to do this.

Go to Tab 7 and set Items 1, 2 & 3 to specify pot or button input for each axis. Then set the pot or button inputs below as required.

SAVE your settings....

USING USB JOYSTICK CARD INPUTS FOR POSITION

16. In the default "pot-less" operating mode the CL system will feed control axis positions to the flight sim based on the drive motor encoder data.

If you instead wish to use your own joystick card pots to control axis position in the flight sim then go to the Configuration Manager Tab 5 and select check-box Item 2, click Apply and then SAVE.

This will stop the CL software position feed to the flight sim. You will then need to assign your own position inputs in FS/X-Plane as normal.

NEARLY THERE

17. Make sure the main CL software is set for **10b-Module** output mode in the Configuration Manager Tab 6 Item 3. This is the required output mode for the CL_SPU + BLDRV2-24 cards.

18. You can now run the main BFF Control Loader software with the saved configuration file and commence to tune the settings for your system.

Note that the flight sim can be placed in a particular flight situation and then paused to

maintain specific flight conditions for loading; for example pausing during straight and level flight at a slow speed will allow the main control centering force behaviour to be checked at low force levels. Pausing the flight during takeoff whilst on the runway will allow runway vibrations to be checked etc

Please refer to the CL software on-line user guide for information on system tuning - <http://bffsimulation.com/Manual-CL/Introduction.php>

3. Normal System Operation

For normal operation of the BFF CL system use the **BFF CL Software**. Further details of the software are available online – see

<http://bffsimulation.com/Manual-CL/Introduction.php> .

Please review this user documentation fully before using the system.

Typical steps for normal system operation are:

1. Start Flight Simulator, load a flight and place the aircraft in the required situation. Check all FS internal trims are initially centred (done automatically by the CL software for FSX/P3D & X-Plane but not FS9).
2. Start the BFF CL Software and select the required configuration file.
3. Power-up the CL_SPU + BLDRV2-24 cards.
4. Complete the CL system power-up calibration by cycling each control axis over its full range of movement at a steady pace until the flashing Yellow LED for the axis driver card goes out and finally the CL_SPU yellow LED goes out..

(See section 4 below for additional automatic power-up calibration options)

5. Engage the control loading by clicking the ENGAGE button on the BFF CL software window or pressing any programmed joystick ENGAGE hot-button (Tab 6 Item 8).
6. To release the control loading click RELEASE on the software window or press your RELEASE joystick hot-button.

Many loading settings can be adjusted whilst the system is active, to allow adjustments to be made to the force feel. These are mainly the **Blue** settings in the Configuration Manager.

To do this start the **Configuration Manager** and load the working configuration file. Make any settings changes you require and then click **MAKE_ACTIVE** – this will save the changes and instruct the **BFF CL Software** to load the new settings. The CL software will **RELEASE** loading when it does this, so you will need to re-engage the loading. It is wise however to check the force level output in the progress bars before re-engaging the loading.

Data and error logging is provided in the files in the Logs sub-folder. Log files BFF_CL.log and BFF_Pry.log are of most use and should be consulted for error messages in the event of disruption of system operation.

The PING button on the CL software GUI is used to request status data of the CL_SPU + BLDRV2-24 cards, this data is written to the BFF_PRY.log file. If a card error occurs (regular flashing of both green and yellow LEDs at 1 Hz on the CL_SPU) then use the PING button to read the card status **before** powering-down the cards and then inspect the BFF_PRY.log file for details.

A complete dump of the CL_SPU card working memory is also recorded by the Ping function to file Scratchpad_Dump.log. This can be very useful for system debugging and should be included along with other log files in email requests for technical support.

NOTE the log files are over-written each time the CL software is started.

4. Power-Up Calibration (PUC) Options

GENERAL

The drive system uses quadrature motor encoders to report motor shaft position to the drive cards. This provides the precise feedback of shaft position required for smooth motor commutation. Quadrature encoders are incremental encoders – they report change in shaft position rather than absolute shaft position.

On card power-up therefore the system does not know the absolute positions of the motor shafts and is unable to properly commutate the motors until it does so. A power-up calibration procedure is used to achieve this. It is undertaken each time the cards are powered-up.

The default power-up calibration method is MANUAL (see below). This is the only method available for cards with early firmware (ie those supplied before Sept 2017).

For cards with more recent firmware two additional automatic calibration methods are now available. These are also described below.

Automatic calibration options (APUC) are available for cards with 28X2 (CL_SPU) firmware R35 Build 29 or later, AND dsPIC (BLDRV2) firmware R42 Build 43 or later.

APUC is not available for older BLDRV-12/24 cards.

CALIBRATION OPTIONS

1. MANUAL:

This is the default as-delivered setting for ALL cards, and the ONLY method available for pre-Sept 2017 cards. It should be used until full and proper function of the system has been confirmed. The operational sequence is....

Start the CL or Driver Test App software.

Power-up the CL_SPU + BLDRV2-24 cards.

Manually cycle each control axis over its full range of movement (end stop to end stop) at a steady pace until the flashing Yellow LED for the axis driver card goes out and finally the CL_SPU yellow LED goes out.

Click Ping on the software to confirm the calibration is complete and the software is reading the card status.

2. AUTOMATIC - WITH WAIT FOR GO-AHEAD:

Available on post-Sept 2017 CL_SPU + BLDRV2 cards. The operational sequence is...

Start the CL or Driver Test App software.

Power-up the CL_SPU + BLDRV2-24 cards.

The CL software will then display a pop-up window indicating cards are awaiting APUC Go-Ahead. (When using the Driver Test App click Ping to initiate the pop-up window).

When you are ready click Go-Ahead – the cards will then proceed with automatic position and range finding movements. The card Yellow LED's will go out once the procedure is complete.

Click Ping on the software to confirm the calibration is complete and the software is reading the card status.

3. AUTOMATIC – WITHOUT GO-AHEAD:

Available on post-Sept 2017 CL_SPU + BLDRV2 cards. The operational sequence is...

Start the CL or Driver Test App software.

Power-up the CL_SPU + BLDRV2-24 cards.

The cards will then proceed IMMEDIATELY with automatic position and range finding movements. The card Yellow LED's will go out once the procedure is complete.

Click Ping on the software to confirm the calibration is complete and the software is reading the card status.

PREQUISITES

It is strongly recommended that the automatic power-up calibration (APUC) options are NOT used until the system has first been set up and commissioned using the default MANUAL power-up calibration method.

The APUC options require the good function of the mechanical transmissions, and this should be confirmed through the standard setup and commissioning of the system.

The specific prerequisites for successful APUC are:

SOFTWARE:

- CL Software V1.322 with CL_Background process V1.550 or later
- Driver Test Application V51 or later

MECHANICAL:

- Solid mechanical end stops must be in place – the motors will be driven against the end stops to detect working range. If the end stops are missing or are soft the range detection will not complete properly. Approx 30% motor torque output is used for end stop detection, although this is adjustable in EEPROM settings.
- The mechanical transmissions should be stiff – ie no soft/sloppy belt stages or components that bend or slip under load.
- The controls should not have any significant unbalanced loads built-in. The motors

should be free to take up position during APUC as demanded by the cards. This will normally be the case unless the controls require significant force from the motors to move them.

- Related to the above – the controls' movements should be smooth and low friction over their full range. If they are sticky or stiff in places the range finding may not work properly.
- The correct EEPROM voltage scaler settings must be active. This will not usually be an issue unless you have altered the EEPROM settings for the cards.

The cards will briefly apply maximum current to the motors during APUC and if the wrong voltage settings are active for the motor in EEPROM this may result in over-current of the card and motor.

SETTINGS

The PUC settings are held in the BLDRV2.ini settings file in the Config Mngr folder.

The settings are changed manually in the ini file, and the Driver Test Application is then used to write the new settings to the CL_SPU EEPROM.

The relevant settings are in the [Shared] parameters section of the ini file:

```
=====
; Power-up calibration (PUC) method
; 1= standard manual movement calibration
; 2= reserved
; 3= automatic movement - starts immediately on power-up
; 4= automatic movement - awaits go-ahead from user
; 5= automatic movement - test mode - sets working range = 8 x encoder rollover edge counts = 2 shaft revs for
MB082 with 360ppr encoder
; NOTE: DO NOT use 3 or 4 until your build is operating normally with manual power-up calibration.
```

Calib_Method=4

```
; Automatic power up calibration force level in % of maximum. Too low a value may prevent smooth movement
; during APUC, higher values may enable smoother movements. 30% is normally sufficient.
```

APUC_Force=30

```
; Automatic power up calibration rate – increase setting to slow the APUC speed of movement, decrease the
setting to speed-up the movement. Typical range 20 to 50.
```

APUC_Delay=20

```
=====
```

Note: the new settings can be saved to a renamed BLDRV2.ini file if required.

To change the settings....

1. Open the BLDRV2.ini file in Notepad or similar text editor.

2. In the [Shared] settings area adjust the Calib_Method, APUC_Force and APUC_Delay parameters as required.
3. Save the file
4. With the cards powered-up and Driver Test Application V51 (or later) running click **Ping**, then click **Update_EEPROM** and follow the prompts.

(Note the cards do not have to be power-up calibrated first – but do wait until the power-up LED sequences have stabilised.)

5. Power-cycle the cards to enable the new PUC setting. Note if Calib_Method=3 has been set the system will immediately go into its auto-movement sequence.

The settings are written to the CL_SPU EEPROM and so will persist until next changed using the same procedure.

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