

Project Overview - Force Feedback Controls

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

This DIY force feedback flight control project is an ADVANCED level project. It needs good mechanical and electrical build skills to complete.

The DIY FFB 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 simply 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. If you attach the motors to poorly designed and constructed control mechanisms the final system performance will be poor and can NOT be corrected by the CL software.

You will need to undertake and complete the following overall steps:

- 1. If you are NOT using plans available on the web site the 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 transmissions and movement mechanisms must be designed to be smooth and friction free. Your mechanisms 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.**
2. Build the control mechanics carefully and accurately, including fitting the electric motors and transmissions and the position feedback potentiometers.
3. Set up and calibrate the controls (and joystick card) as a normal game controller "joystick". (In the case of "potentiometerless" operation this is required for the trim axis inputs only).
4. Prepare the power supply for the driver cards. READ THE DATASHEET COMMENTS ON THE POWER SUPPLY.
5. Connect the FFB driver/controller cards and, if required re-program the 20X2 control chip if non-standard motors, encoders etc are being used.
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. This is NOT a "Plug and Play" system.
7. Run with the full BFF CL Software and flight sim active to test the FFB in flight and to tune the force settings to your requirements.
8. 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.

Detailed Flight Control 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. For systems using position reporting by joystick card potentiometers - connect the elevator and aileron position and trim potentiometers to a (preferably 12bit) joystick card.

Elevator position – joystick Y Axis
Aileron position – joystick X Axis
Rudder position – joystick Z Axis
Elevator trim – joystick R Axis (if required)
Aileron trim – joystick U Axis “
Rudder trim – joystick V Axis “

Connect the joystick card to the PC and make the controls fully operational as a normal windows game controller – calibrate the movement using the PC game controller calibration applications. The BLDRV-12/24 cards will require to see (via the BFF CL software) calibrated **full scale** game controller movement of the joystick axes in order to fully complete their power-up calibration procedures. Also any significant end of travel dead band on the joystick axes (due to partial game controller calibration) will trigger an error in the BLDRV-12/24 cards during operation.

It is useful at this stage to set up the game controller axes in Flight Sim so that the yoke correctly controls the main aircraft controls. NOTE - DO NOT assign the CL Yoke trim pots in Flight Sim – the CL system trim is separate from Flight Sim's internal trim.

IMPORTANT – For “potentiometer-less” CL system configurations joystick card position feedback for the main control axes is NOT required. The control axis positions are instead derived from the motor encoder positions and sent to FS via the CL software and FSUIPC. However a joystick card will still be required for the trim pot or button inputs – but position pots are NOT needed on the main control axes in “potentiometer-less” configurations.

3. READ the BFF Driver Test Application user guide from start to finish! It contains important useful information.
4. Use the **BFF Driver Test application** to check that the joystick axis letters are correct for the CL software - check that Elevator, Aileron and Rudder are on X, Y and Z respectively (**NOT required for “potentiometer-less” configurations**).

Check that Elevator trim, Aileron trim and Rudder trim are on R, U and V

respectively (unless trim axis assignments are changed in the Pry_S.cfg file via the BFF Setup application). If the trim button option is used then check that the correct joystick card buttons have been specified – use the Windows game controller set-up facilities to check joystick button operation.

Check also that each axis reports a full range of movement (+/- 50 units) when the controls are moved over their full range of movement.

NOTE the Test App may generate an error if its output COM port setting is wrong – you may need to install the AXE027 cable BEFORE using the test app to obtain the correct COM port number. See step 11 below....

5. READ the BLDRV-12/24 data sheet from start to finish! It contains important information.
http://bffsimulation.com/FFB-Yoke-2/BLDRV-1224_Data_Sheet.pdf
6. Mount the BLDRV-12/24 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 – 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.

7. 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 BLDRV-12/24 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.
8. Set up and position the power supply and wiring to the BLDRV-12/24 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.

9. Wire the BLDRV-12/24 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.

10. Connect each card to the serial data "daisy chain" (CN3-1) – ie link together S-in on each card, and link together S-out on each card. If you are using dual PICAXE cables then one card will not be on the daisy chain but will instead be connected to the 2nd PICAXE cable.

Set the correct address for each card (JMP-1). Elevator is address 1, Aileron is address 2, Rudder address is 3.

11. Install the PICAXE AXE027 USB download cable drivers on the PC and connect the cable to the PC and one BLDRV-12/24 card.

For drivers and installation instructions for the AXE027 cable see -

<http://www.picaxe.com/Software/Drivers/AXE027-USB-Cable-Driver/>

Once the AXE027 cable has been installed a virtual COM port will be created on the PC. Obtain the COM port number of the virtual COM port (view in Device Manager). This will need to be specified in the **BFF CL Software** and **BFF Driver Test Application** configurations.

For the Test App the COM port is set in the **DRVR_Test.ini** file in the test application folder (parameter **COMPort=**)

For the BFF CL Software the COM port is set in the individual .cfg file being used. Open the config file using the **BFF CL Settings** application and set the COM port number in the **Elevator-Setup Tab**.

If dual PICAXE cables are to be used then the COM port number of the second cable must be manually set in the .cfg file – parameter COMPortB. Please note that this 2nd COM port will need to be used in the BFF Test app when testing the card attached to it.

12. If the driver cards require non-default programming the free PICAXE Programming Editor Software will need to be downloaded and installed on your PC.
13. Ensure the power supply voltage selector jumpers (JMP-3 and JMP-4) on the BLDRV-12/24 cards are correctly set for your supply voltage (24V), ensure the power supply voltage is within range AND THE POLARITY IS CORRECT.

Connect power to each of the cards **ONE AT A TIME AND SEPARATELY** - monitor the cards for correct LED operation (if software is running and the serial comms are good the Yellow LED should flash rapidly until the power-up movement calibration of that axis is completed).

NOTE that the voltage regulator heat sinks (the small ones) will become hot to the touch (approx "hot radiator" temperature), this is normal. However if there are any other signs of overheating immediately power-down the cards and double check the power supply and other wiring.

14. If any BLDRV-12/24 card requires to be reprogrammed do so now. See the card data sheet Appendix 1 for instructions (but you will already know this having read the data sheet from start to finish in step 5 above).
15. In the case of "potentiometer-less" configurations each driver card will need to be pre-set for "potentiometer-less" power-up calibration before the main testing can begin. This is done using the **Change_Calib_Method** button on the BFF Driver Test App (V1.7 or later). Please read the test app user documentation for details.

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

Take particular care with the loading proportional to axis displacement – if on first use the driver test app reports inconsistent joystick and electrical drive directions adjustments will be needed to your settings. In this case follow the on-screen prompts, they will ask you to invert the axis reporting in the test application and re-power and re-calibrate the card. Take note of any axes you need to do this for – it is likely that the axis will need to be inverted in the main CL software aircraft configuration file also.

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.....

16. Power down the cards.

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

Load the aircraft cfg file using the BFF CL Setup application and start with the

settings for COM port, engage/disengage buttons, axis inversion etc.

For "potentiometer-less" operation the control axis position reporting method must be set to use encoder rather than joystick data. Refer to the **Line 74: Position reporting method** setting in the background settings area of the setup application.

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

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.
2. Start the BFF CL Software and select the required configuration file.
3. Power-up the BLDRV-12/24 cards.
4. Complete the CL system power-up calibration by cycling each control axis over its full range of movement two or three times until the flashing Yellow LED for the driver card goes out.
5. Engage the control loading by clicking the ENGAGE button on the BFF CL software window or pressing any programmed joystick ENGAGE hot-button.

NOTE if on first operation if the software indicates a "drive direction error" then the settings for the axis concerned will need to be adjusted. This is achieved in the setup application by ticking (or unticking) the "Invert Pos Feedback" check box in the Setup Tab for the relevant control axis and saving the change. Following this the BFF CL software should be restarted and the BLDRV-12/24 cards should be power-cycled and the power-up calibration repeated.

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. To do this start the **BFF CL Settings application** and load the working configuration file. Make any 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 BLDRV-12/24 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) then use the PING button to read the card status before powering-down the card and then inspect the BFF_PRY.log file for details.

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

V1.1 June 2013

Ian Hopper (BFF Design Ltd)