D-FIN™

USER MANUAL

MOTOR CONTROLLER

HYDROMEA

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INTRODUCTION

The Hydromea D~FinTM is a motor controller for brushless permanent magnet DC (BLDC) motors, featuring sensorless and hall-sensored commutation, field oriented control (FOC) for efficient, quiet and smooth operation, in a very compact form factor.

D~FinTM can be controlled and configured via its RS485, CAN and USB interfaces, and further has a PWM input to control it via typical remote-control receivers.

SPECIFICATIONS [1]

Input voltage	10 – 26 V
Maximum current	25 A
Motor interface	3-phase BLDC
Data bus interface	RS485 / CAN (configurable)
USB interface	Virtual serial port over USB
Protocol	MavLink v1.0
PWM interface	1 ms – 2 ms on-period (neutral at 1.5 ms)
Commutation modes:	0: hall-sensor trapezoidal 1: hall-sensor FOC 2: sensorless trapezoidal 4: sensorless FOC 253: self-calibration mode

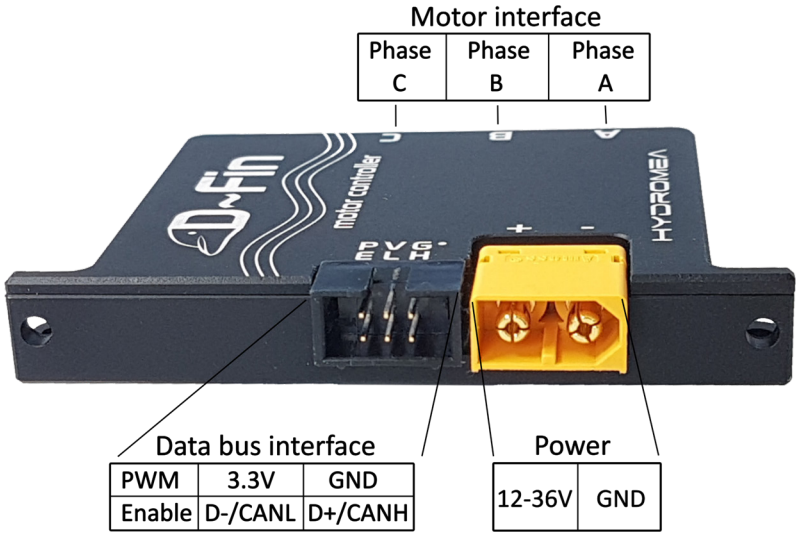


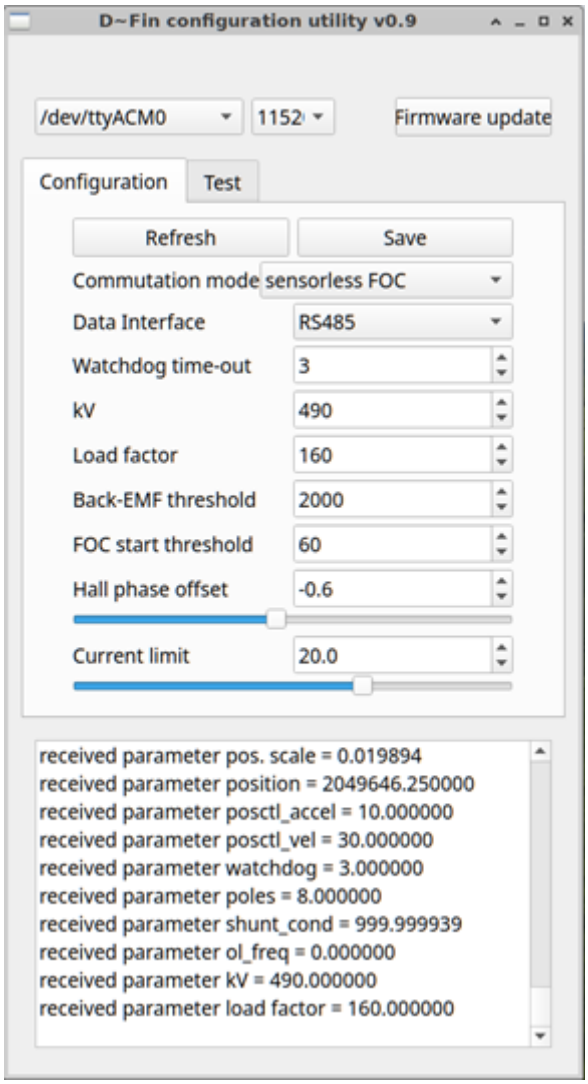
Figure 1: Electrical interfaces

1 specifications are preliminary and subject to change

DCONF CONFIGURATION APPLICATION

DConf is a graphical application to configure and test D-Fin motor controllers. It can be downloaded here:

TODO: insert download link!



SETUP

- Connect the D~Fin to your PC using a micro-USB cable. Alternatively, connect via RS485 using a USB-RS485 converter.
- connect the motor (e.g. the Hydromea DiskDrive thruster) to the D-Fin, using the Phase A, B and C terminals.
- connect a suitable power source to the power terminal (lab power supply, or battery).
- select the appropriate COM serial port in the dropdown menu at the top left.
- click “Refresh”. The parameters should now become active (not greyed out), and messages should appear in the text box at the bottom. You are now ready to configure and test D-Fin.

PARAMETERS

COMMUTATION MODE

- **0: Hall sensor trapezoidal.** Rectangular drive voltage, rotor position measured with analog hall sensors.
- **1: Hall sensor FOC.** Sinusoidal drive voltage, field-oriented control, rotor position measured with analog hall sensors.
- **2: sensorless trapezoidal.** Rectangular drive voltage, rotor position measured from back-EMF via the 3 motor terminals.
- **4: sensorless FOC.** Rectangular drive voltage, rotor position measured from back-EMF via the 3 motor terminals. This mode is the recommended default, in particular for Hydromea DiskDrive thrusters.
- **253: Calibration mode.** If an amplitude command is given, the controller will spin up the motor in sensorless mode, and estimate the kV value of the motor, and the hall sensor phase offset. The parameters are automatically updated, but not stored to flash (needs to be saved manually / explicitly).

DATA INTERFACE

- **CAN:** configures the two data bus pins for CAN communication, 500kbit/sec, 11 bit header.
- **RS485:** configures the two data bus pins for RS485 communication (default 115200 bps, 1 start bit, no stop bit)

WATCHDOG TIME-OUT

The motor controller features a watchdog time-out feature, that de-activates the motor if no new commands have been received for the specified time. This is to prevent run-away vehicles if the remote control or guidance system is out of range, has a failure, or the signal cable has a fault. The parameter is specified in seconds:

- 0: the watchdog feature is disabled
- 1 - … seconds: The time after the last received motor command message or valid PWM input, after which the controller will deactivate

KV

The kV number of the connected brushless motor. The kV number indicates the RPM per Volt in idle condition. This parameter can be automatically determined using the calibration method described below.

LOAD FACTOR

A motor constant used for stall detection. Default value for DiskDrive thrusters: 160

BACK-EMF THRESHOLD

Used in sensorless trapezoidal mode, defining the threshold after which the commutation switches to the next phase. A higher value improves start-up behaviour.

FOC START THRESHOLD

For sensorless FOC mode, the motor needs to run above a minimum RPM speed to provide sufficient voltage and current feedback to the controller. Below that speed, D~Fin uses sensorless trapezoidal communication to start up the motor. This threshold defines the minimum speed at which D~Fin switches to FOC mode when in "sensorless FOC" commutation mode. The value is given in electrical Hertz. To calculate the corresponding RPM, multiply with 60 and divide by number of poles. E.g. for a threshold value of 50:

RPM = 50 * 60 / 8 = 375 RPM

HALL PHASE OFFSET

Angle offset between the analog hall sensors and the motor coil. This parameter is required for sensored commutation modes. The value can be automatically determined using the calibration mode described below.

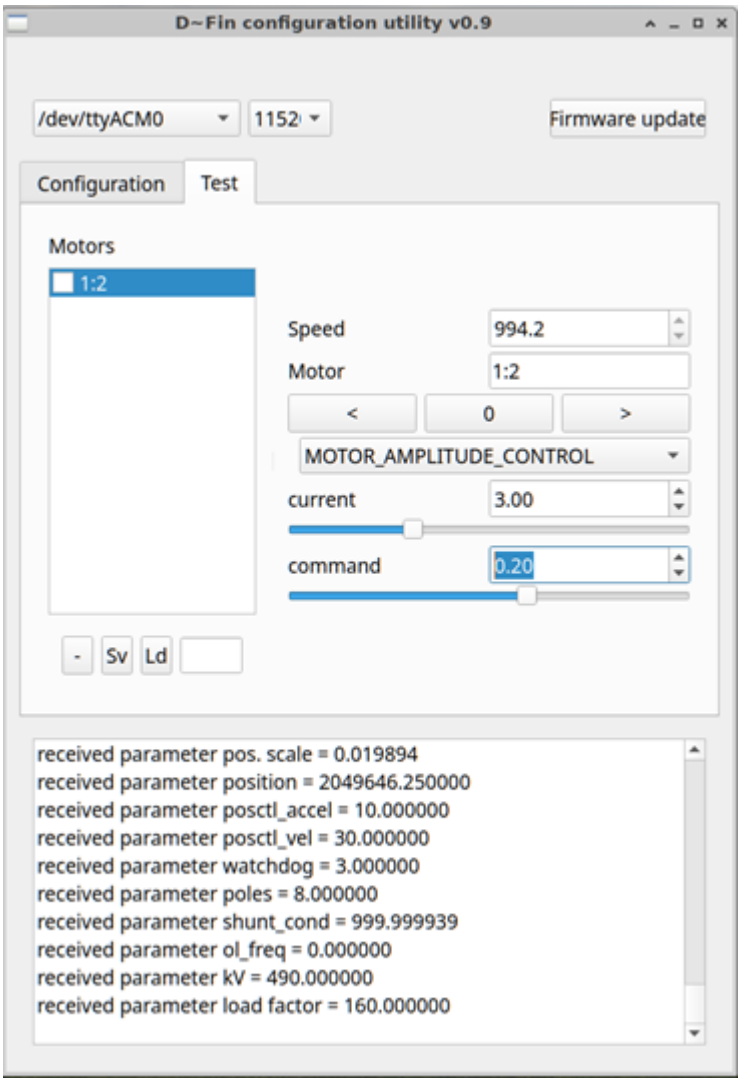
CURRENT LIMIT

Software-defined current limiter. When a current higher than the given value is detected, the controller reduces the amplitude of the output until the current is below the allowed value. If load is removed, the amplitude is allowed to rise to the commanded value again.

TESTING D-FIN AND CONNECTED MOTORS OR THRUSTERS

DConf provides simple test widget to send motor commands, and monitor the RPM of the motor.

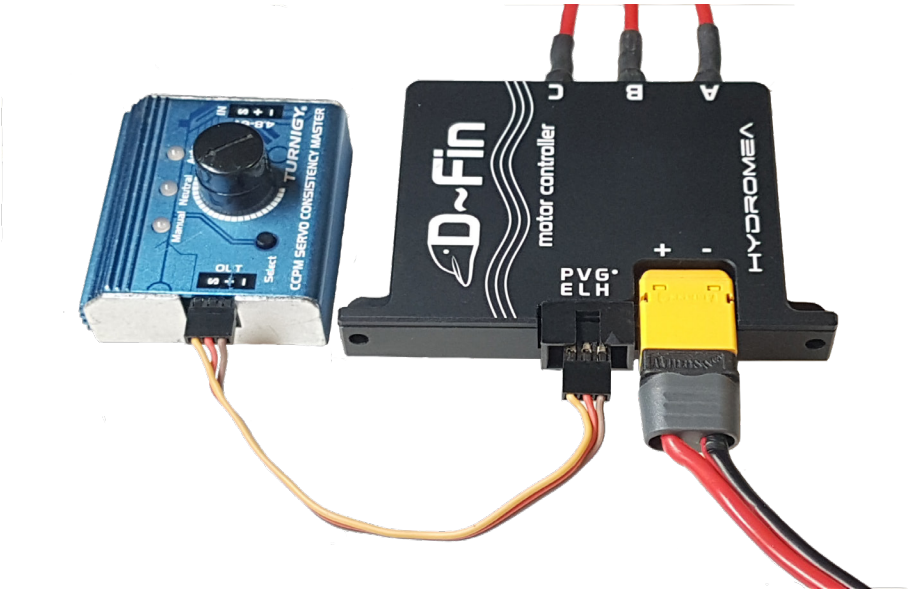
If multiple D~Fin controllers are connected to the data bus, with different system/component IDs, they appear in the list on the left. After selecting a controller, the controls on the right allow sending commands to spin the motor in both directions, and different speeds. The actual measured motor speed in RPM is displayed at the top.



EXTERNAL PWM COMMAND

D~Fin accepts a pulse-width modulated (PWM) signal to command the motor speed, to make it easy to use in RC-style setups. The common standard used for remote controlled airplanes, cars and boats is a signal with a nominal on-period of 1.5 milliseconds for neutral, 1 millisecond for full left / full reverse, and 2 milliseconds for full right/full forward. The signal level is 0V for "off", and 3.3V – 5V for "on".

The top row of the data pin header has 3 pins: GND, 3.3V and PWM-in. A standard RC servo cable with Dupont-style connector can be used to connect D~Fin to a typical RC receiver, or RC servo tester. The middle pin can provide 3.3V to the receiver or servo tester. It is only intended for low currents up to 100mA. In systems that have other loads such as RC servos connected to the 3-pin header or receiver, it is recommended to leave the middle pin on D~Fin disconnected, and provide 5V power to the RC system from another source, e.g. a receiver battery or a BEC module.



If a valid PWM signal is detected, D~Fin will initially confirm if the PWM signal is in the neutral position (1.5 milliseconds). If it is not neutral, D~Fin will wait until it is, before accepting the input. After a neutral start signal has been confirmed, D~Fin will accept the PWM signal as the amplitude command to the motor, and activate the motor accordingly. If the PWM signal disappears during operation or becomes invalid (e.g. if the receiver is out of range, or fails for other reasons), D~Fin will continue operating with the last received command until the watchdog time has elapsed. If the watchdog parameter is 0, operation will continue indefinitely. Otherwise, the motor will stop after the given number of seconds, until a valid command is received again.

CALIBRATION FOR SPECIFIC MOTORS

For proper operation in FOC mode, the motor controller has to be adjusted to match the properties of the connected motor. In particular, the kV value of the motor has to be set correctly. In hall-sensored FOC mode, the controller additionally needs the correct phase offset between the sensors and the motor coil.

To facilitate the setting of these parameters, D-Fin has a calibration mode which can estimate the correct values automatically.

During calibration, the motor has to be able to spin freely. Ensure that the rotor is not blocked, and that it can safely rotate without endangering nearby objects, fingers or other body parts. The motor should be mounted or fixed to keep it stable and safe from tipping or falling when starting to spin.

Ideally the calibration should be carried out without any mechanical load attached to the motor. For DiskDrive thrusters, which should not be run dry, and where the load under water is quite uniform, the calibration should be carried out with the thruster submerged in water, safely mounted to avoid undue movements.

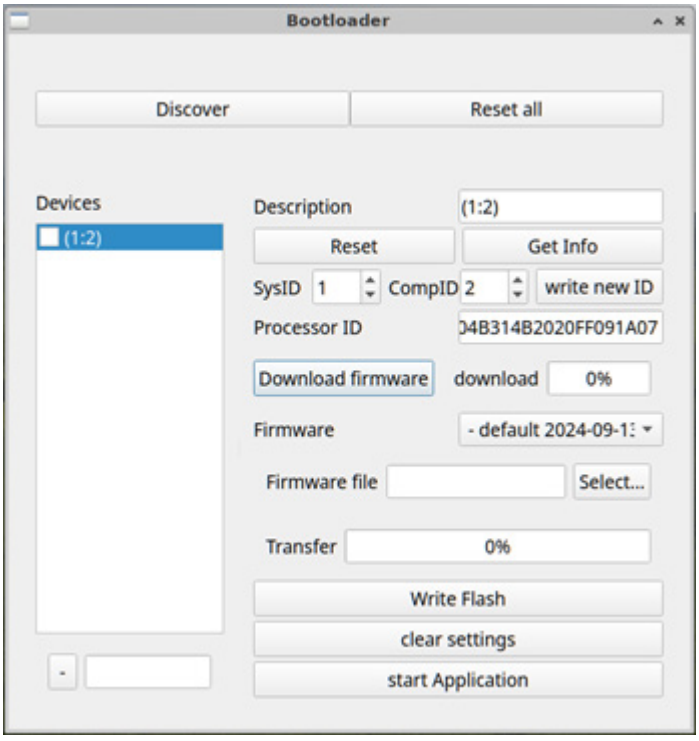
STARTING A CALIBRATION

- In the “Configuration” tab, select commutation mode “Calibration”
- Go to the “Test” tab
- if not already selected, select “MOTOR_AMPLITUDE_CONTROL”
- Slowly increase the motor speed by clicking the “>” button, or slowly increasing the “Command” slider. It is generally sufficient to reach an amplitude of 0.3-0.5.The motor should reach at least 1000 RPM to ensure a stable calibration.
- Let the motor run for at least 5 seconds.
- Stop the motor by pressing the “0” button
- Go back to the “Configuration” tab. Click “Refresh”
- The kV parameter should now have updated to a value close to the nominal kV specification of the motor. For example, for a DiskDrive50 a value around 450 kV is expected (+/- 50 tolerance is normal).
- Switch “commutation mode” to “Sensorless FOC”
- Test the motor in the Test tab to ensure smooth operation across the operational range
- If satisfied, click “Save” to store the values to the internal non-volatile memory. Make sure to stop the motor before saving, as the currently commanded amplitude is also saved (this is on purpose, in case it is desired that the motor controller automatically starts the motor at a programmed speed without waiting for a command)

FIRMWARE UPDATE

A firmware update is required in case a new firmware with additional features is available.

- confirm that communication with the modem is established as described in Setup
- turn off the power supply to the controller (or unplug the power connector, but leave the serial dongle in the USB port)
- set the serial port settings to 115200 bps (at the very top of DConf, the speed for your COM port, not the settings of the D~Fin baudrate)
- click “Firmware update”. A new dialog opens (see Figure 2).
- switch on power to the modem (or plug it back in).
- Now, an entry should appear under “Devices”. On the right-hand side are a few options, you can ignore most of them. If the built-in USB connection is used, it is required to wait 1-2 seconds, and repeatedly click “Discover” until the dialog appears.
- On the right, click “Download Firmware”
- select the desired firmware from the dropdown menu. Alternatively, a firmware file can be opened from the local files. Firmware files can be requested from Hydromea on demand.
- click “write Flash”
- wait until the progress bar reaches 100%. If it doesn’t go through, click “Write Flash” again until it does complete.



- click “Start application”. You should now be able to connect to the controller again as described above. Verify that the parameter settings are still correct - they should carry across firmware updates in general, but bigger updates may invalidate the settings and revert to factory defaults.

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