Electronic Speed Controller selection
for DiskDrive thrusters

A simple summary about what an ESC is and how to choose the right one for Hydromea's DiskDrive.

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1   INTRODUCTION

An electronic speed controller (ESC) is an electronic circuit that controls and regulates the speed of an electric motor. It may also provide reversing of the motor, dynamic braking, current control, etc.

There are a lot of ESCs on the market and it is hard to assess which one is the best for your application.

What to consider:

- bidirectional or unidirectional operation of the motor
- communication protocols
- telemetry
- size
- price
- customization in the control strategies
- open source

Our DiskDrive50 requires an ESC which is suitable for brush-less motors (3 leads on the motor side) and can be used in the specified voltage range for the DiskDrive50 (12 V to 16 V). It needs to be able to deliver more than 20 A to operate the motor at the maximum rated power. The ESC needs to be compatible with a "sensor-less" motor as there are no hall sensors present on the motor to determine the position of the rotor.

2   FEATURES

2.1   DIRECTION CONTROL

Depending on your application, you may want to use the motor in only one direction or in both. Some ESCs allow for the motor to only be operated in one direction (and dynamic braking), but not reversing. Other ESCs can operate the motor in both directions and change it to go into reverse without needing to execute a special sequence of control commands.

If you want to use your motor in bidirectional mode, make sure that your ESC is specifically designed for bi-directional (or "reverse") operation. Some ESCs may not advertise this feature despite actually having it.

2.2 COMMUNICATION PROTOCOL

Most of the suitable ESCs for the DiskDrive50 that you will find on the market can be controlled with a PWM signal for RC servos as typically provided by RC receivers.

Some ESCs are compatible with other communication protocols, such as UART, CAN, Dshot, etc. These protocols improve the robustness of the communication against noise.

Dshot is a special protocol made for drones and is difficult to work with for beginners as this is not a standard protocol, but the ESCs that support this protocol are generally quite small and powerful.

Be aware that the PWM signal is one of the simplest control signals to implement at first and that most of the other ones require more complex code and specific driver hardware.

2.3 TELEMETRY

To get the RPM, the supplied voltage or the current drawn for example, you will need telemetry on your ESC. Telemetry is typically available on ESCs that have protocols other than the standard PWM.

A simple way of spotting non-telemetry ESCs is if they have only 3 control wires (PWM signal input) and no other connectors or visible pads to solder to.

2.4 CUSTOMIZATION AND OPEN SOURCE

Sometimes you may want to reduce the maximum allowable RPM or current running through the motor or adapt the start-up strategy. Being able to customize such variables is a plus and can save you time by not having to implement such features in high-level code. When you see a USB connector, it generally means that it is customizable. Also note that for most cheap ESCs, which have "programable" written on them, this refers only to the fact that you can calibrate them for a different "zero" position.

3 ESC CATEGORIES

3.1 RC CAR ESC

Most RC car ESCs are unidirectional. They can be used in one direction and can brake if you send a command to go into reverse. They then need to go past the zero position to go into reverse. If this feature can be turned off with the programmer, which is available for some ESCs, they may be a good option.

Most of the time, RC car ESCs use PWM without telemetry and are not very customizable.

3.2 Drone ESCs

Drones have come a long way in the last couple of years and have pretty good and unique ESCs. Some drone ESCs are called "4 in 1" and combine 4 ESCs into one board. This is good for compact robots. Most of them have telemetry built-in and are programable to communicate via PWM, Dshot or Multishot.

What you want to look for in these ESCs is the mentioning of "BLHeli", "BLHeli_S" or "BLHeli_32". This refers to the firmware running on the ESC. "BLHeli_32" is the most feature-packed one and the most recent one as well. It has Field Oriented Control (FOC) (FOC explanation video) as a selectable control strategy which can run the motor at low RPM. All of them can provide telemetry data as well and can provide bi-directional control of the motor.

More info on the firmware and programming:

BLHeli_S Github repo

BLHeli_S Manual Pdf

BLHeli_32 Github repo

BLHeli_32 Manual Pdf

Dshot discussion in RCGroups

Dshot Oscarliang

Note that in order to use the full potential of the Dshot protocol, you should use a microcontroller that has a DMA to stream the command for the ESC regularly.

3.3 VESC

VESC is an open-source project for high performance ESCs. The schematics, PCB layout and firmware are open-source (VESC_hardware git repo VESC_Firmware git repo). You can design your own ESC or use already made ones which are commercially available from different brands (listed in the next section). Most of the time, they are designed for higher currents than needed for the DiskDrive50, but they do the job and even their standard firmware already lets you customize multiple parameters.

They can handle PWM, CAN, UART, etc. as communication protocols and they can be used with sensor-less or sensor-equipped motors. They also provide an automatic tunning procedure for all the motor parameters. They also have Field oriented control (FOC) as a selectable control strategy which allow the motor to be used at low RPM.

3.4 ODRIVE

ODrive controllers are very similar to the VESC ones mentioned in the previous section. They are designed to control the position of the motor rather than its speed. They are suited for very high currents (120 A), which is way more than needed for DiskDrive50.

4 EXAMPLES

4.1 DRONE ESC

4.1.1 Basic ESC

	+ simple to use (PWM-controlled) + cheap + Integrated 5V supply - no telemetry - limited voltage rating (4S = 4 * 4.2 V) - cannot be programmed

4.1.2 BLHeli_32 ESC

	+ simple to use (PWM-controlled) + can be used with Dshot-protocol as well + telemetry (TLM pin) + higher voltage rating (6S = 6 * 4.2 V) + programable (with FOC) - do no provide 5V supply Lumenier 36A BLHeli_32

4.2 VESC

	+ simple to use (PWM) + can be controlled through with UART, CAN as well + telemetry (via UART) + very high voltage rating (13S = 13 * 4.2 V) + programable (with FOC) + integrated 5 V supply - big and bulky - hard to find the right settings Flipsky ESC FSESC4.20