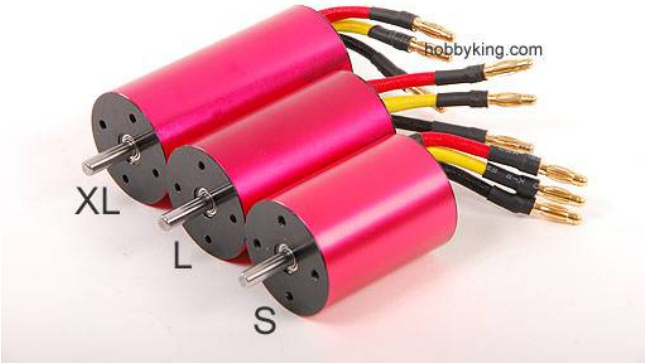
Brush-less Motors For Scale Boats

Brush-less motors and ESC's (Electronic Speed Control)

Brush-less motors are motors that do not have brushes, they are similar to 3 phase AC motors in that there are 3 wires to supply power to the motor. lower maintenance and sized from a couple of grams up to motors powerful enough for full sized cruise liners. They can be more efficient than brushed motors. The most important difference is the magnets rotate and the windings remain stationary. They gain their efficiency by not having brushes that cause drag on the motor, they also don't have the electrical resistance that brushes have. Radio Controlled brush-less motors require a special brush-less motor ESC.

There are 2 types of brush less motor in use in RC, In-runner and Out-runner,

The In-runner looks similar to the brushed motors we are used to but the windings (stator) are on the outside and the magnets are on the rotating shaft. In-runner's are generally high rpm lower torque motors that are happiest using a gearbox, like in RC cars and helicopters. Fast electric are an exception to this rule, because of the smooth case the in-runner is very easy to water-cool.

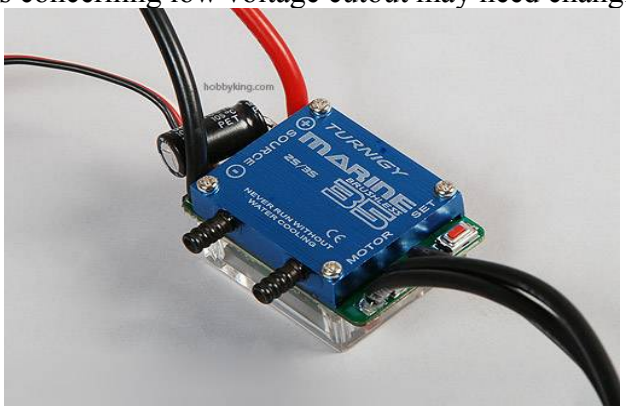


In-runner Motors

The Out-runner has the windings(stator) in the center and the magnets are on the rotating case. Out-runners are mostly low RPM higher torque motors, very suited to scale boat applications, these are what I recommend for scale boat applications and what the focus of this article is about.

Out-runner Motor

Electronic Speed control.
As stated earlier, brush-less motors need a brush-less ESC to operate,
YOU CAN NOT RUN A BRUSHLESS MOTOR DIRECTLY OFF A BATTERY OR THROUGH A BRUSHED ESC
90 percent of brush-less ESCs are dedicated to airplane use therefore do not have reverse, there are more and more ESC's becoming available with reverse, Most ESC's labeled for boat use operate in exactly the same way as a brushed ESC with reverse i.e. stick center, off. Stick back, astern. Stick forward, Ahead.
Contrary to popular belief brush-less motors do not need Li-po (Lithium Polymer) batteries, they will operate happily on the same power source as you would use on a brushed setup, The only caveat being some settings concerning low voltage cutout may need changing in the ESC.



A brush-less controller for boats

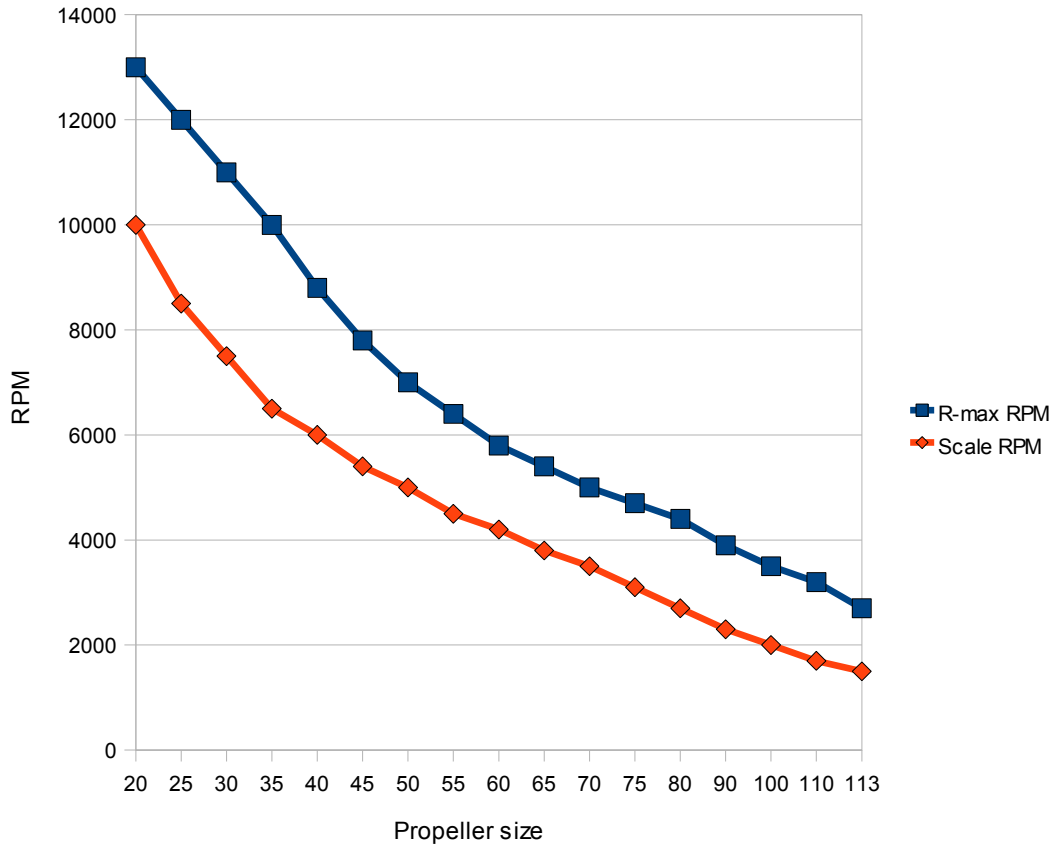
Note:
Some ESC's designed for RC car use with reverse need a double application of reverse to actually rotate the motor in reverse, the first stick movement operates the motor brake, the second then reverses the motor. Once forward is engaged the double stick movement is needed again to engage reverse, not practical for boats.

Deciphering the numbers.

Brush-less motors usually have several figures describing their characteristics, as they tend to be much more standardised over all the brands. It makes it simple to select a motor to suit an application.

Kv. RPM per Volt, the most important figure, gives the no load RPM motor as a constant, so a 1000 Kv motor will be 6000 RPM at 6 volts, 12000 RPM at 12 volts etc (Kv x V = RPM)
Io. No load current, at 10 volts usually.
Rm, Internal resistance of the windings.
These two figures can be used to calculate amp draw of the motor
Size, most out-runners state the stator size not case size, but the overall dimensions are usually stated in the specifications as well. The motor is usually labeled something like this, 22-20 or 28-36 with some letters added to the front and back. The 22-20 has a stator size of 22mm diameter and 20 mm long the 36-40, 36 mm diameter and 40 mm long, you get the picture.
A further note the larger the diameter or the longer the stator size increases torque but usually lower Kv, Motor turns (number of windings) also affects Kv.

Selecting a motor for your scale boat.
The best way to start is to obtain the desired RPM of the propeller. If you already have a brushed setup then measure the RPM of the propeller. As a ball park figure a 40 mm prop for a tug would be around 5000-6000 RPM, larger props require lower RPM as the graph below illustrates.



Blue = Raboesch Maximum RPM
Red = RPM for scale tug speed, approximate and extrapolated from 2 of my own boats

Now we have a ball park RPM, and we can pick a motor,
I recommend that a propeller should be no larger than 2x diameter of stator for an out-runner.
My Springer has a 22 mm stator size and 40 mm propeller.

Lets say we want to use a 60 mm propeller, in a tug. The graph suggests a RPM of around 4200 RPM, so at 12 volts we would like 350Kv or 700Kv at 6 volts. A motor of 30 mm stator size (closest is 28 mm) will do the job so start perusing the catalogs for a motor that matches these specs. I found a 28-30-(16) with 730Kv. Maximum current 12 amps, Io 0.5 amp, and it only costs around $30 including shipping from Asia. Juggling different motors Kv with voltage will give you the motor required

A suitable ESC will cost around the same price as a good quality brushed ESC $70-$100 and up to $250 if you want US quality. If you can live with forward control only some very cheap controllers can be found

Using a program called FE Calc I can give you some performance figures,
On 6 volts
RPM 4136
Amps 5.19
30 watts In
26 watts out
Runtime on a 4.5 Ah 6 volt Battery 48 minutes
86% efficient

This particular motor has a power handling capacity of 250 watts, so we are far under its capabilities and will not need any form of cooling.

Brush-less motors have all but taken over the electric airplane scene, are very strong in the RC car's and have a strong following for fast electric boats, Its only a matter of time before brush-less motors become an accepted form of power for scale boats as well