# RC Aircraft Electric Motors

1/6/2012 Rev 2

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### RC Aircraft Electric Motor Types

**Brushed-**

Are Permanent magnet DC power
- low efficiency (typically 50% or less)
- relative heavy for power output
- limited brush and commutator life
- require a speed controller specifically for DC Motors

**Brushless-**

Are AC three phase synchronous (refer to end of this document for explanation)
- good efficiency (typical 80 to 90% when properly applied)
- relative light weight for power output (compared to brushed)
- long life dependent primarily on quality of bearings, insulation and construction
- require a speed controller specifically for Brushless Motors

### Innruner and Outrunner Brushless Motors

For the **Inrunner** type motor the outside can is stationary and only the inside armature and attached shaft spins. The motor's stator (3 phase AC windings) is located on the inside wall of the can surrounding the magnetic armature. Typically, but not always, this type of motor requires a gearbox which allows them to swing larger props efficiently. A few brushless Inrunners can spin a larger prop directly without the need for a gearbox. However, for most **Inrunners**, when a gearbox is not used, only a smaller prop can be used that spins at high RPM.

For the **Outrunner** motor, both the outer case with magnets on the inside wall and the attached shaft spins. The armature in this case becomes the stator and does not move. By having the outer case that contains the magnets spin, a longer moment arm is created therefore increasing the torque. With more torque than a normal Inrunner motor, the **Outrunner** can typically spin a larger prop without the need for a gearbox. This is sometimes referred to as direct drive since it drives a prop directly. Direct drive reduces the cost, complexity, added weight, maintenance and additional reduction of overall efficiency of using a gearbox.

### Brushless Electric Motor Selection

This following discussion will focus on basics of Outrunner brushless motor selection for RC model aircraft. RC helicopter motors and ducted fans are special cases and are not covered here. However, in general, most of the overall process is applicable. More knowledge, considerations and thought are required in electric motor selection than in nitro glow engine selection that has almost always been predefined for the aircraft model by the kit manufacturer. However, manufacturers of electric powered aircraft are now typically providing recommended motors and/or detail design data making selection a lot easier compared to very limited information in years past. There is a large volume of relevant information available on the internet.

**RC Aircraft type, performance and weight**

**Basic RC Aircraft Types**

Trainer, Sport/Aerobatic, 3D, Sailplane, Ducted fan

**Performance and weight**

These are linked together and are primary factors determining required motor size.

For example, a Trainer would typically require 70 to 90 watts per pound to fly in a trainer manner but to push performance up a notch for looping and other mild aerobatics the power would need to be increased to 100 to 110 watts per pound.

Similarly for a powered sailplane, 80 to 90 watts per pound is OK to climb to soaring altitude at a mild rate however for a high angle climb the power needs to increase into range of 110 - 130 watts per pound.

One Horsepower = 746 watts
DC Amps x DC Volts = Watts (Input)

**Typical Watts per Pound**

Trainer = 70 - 90
Sailplane =
(mild climb) = 80 - 90
(high angle climb) = 110 - 130
Sport / Aerobatic = 110 - 130
3D = 150 - 180
Ducted Fan = 200 – 300
Note: Minimum power level of 50 - 70 watts is OK for lightly loaded slow flyer and park flyer aircraft

**Brushless motor watts rating** is usually stated as - -

**Continuous watts** – The watts input that the motor can sustain continuously without overheating.

**Maximum watts** – The maximum watts (also referred to as **Peak or Burst)** input that the motor can sustain for a specified short amount of time (such as 10 to 20 seconds) without overheating.

**Other brushless motor parameters**

When comparing motors of similar size, there are several characteristics that you will notice. An important one that needs consideration in the selection process is Kv or RPM per Volt.

Motors with higher winds spin slower for a given voltage. Higher winds means they have lower Revolutions Per Minute (RPMs). This is also referred to as Kv (or RPM/V) in motor gain terminology. These motors have more torque and can spin a larger propeller at slower speeds than lower turn (higher Kv) motors. As motor size increases, generally the Kv decreases. These motors typically require more LiPo cells (higher voltage) to reach max power and RPM.

Motors with lower winds spin faster for every volt of electricity applied. They have a higher Kv (or RPM/V). They can spin a smaller propeller at higher RPMs than higher turn (higher Kv) motors. As motor size decreases, generally the Kv is higher. This allows use of lower voltage (less LiPo cells) to help reduce weight for smaller lighter aircraft. For high flight speed applications, a motor of higher Kv is desired to spin a smaller higher pitch prop at high RPM. The extreme of this are motors (generally Inrunners but some special Outrunners are available) designed for ducted fans with high Kv typically in the range of 1500 to 5000.

Sometimes you can take advantage of the fact that higher Kv motors use thicker gauge wires compared to the same size lower Kv motor. This means that you can draw more current through the motor and gain higher burst power levels for 10-20 seconds without damage to the motor. The result is an impressive fly-by or vertical climb when needed during the flight. Another reason for choosing the motor with higher Kv is to be able to use a smaller prop for ground clearance. However, remember that the higher Kv motor will typically draw more current and may reduce flight time dependent on flight execution.

Example: A motor with a Kv of 1000 will theoretically at no-load spin 1000 revolutions per minute per volt applied. On a 11v supply (3 cell LiPo under load), it will theoretically spin 11 * 1000 = 11,000 RPM. This is at no load and in actual operation will be less depending on prop size and voltage.

If one is interested in optimizing Kv, prop and voltage to extract maximum thrust efficiently from the motor, consulting of charts of motor performance with various props and voltage combinations is useful to make a choice for the application at hand. Innov8tivedesigns.com has this type information and to a lesser degree so does BPHobbies.com and Maxxprod.com for HiMax motors. Also a motor performance simulation program can be used during the selection process. Confirmation of the effort and tweaking can be accomplished using a wattmeter and tach, or data/chart displayed on a computer screen from a Castle ICE type speed controller with built in recording of volts, watts, current, rpm, mah used.

**Understanding an Outrunner's Designation Numbers**

Most Outrunners use a 6-digit numbering system like the AXI 5330/18. The first two numbers (53) represent the diameter of the stator in millimeters. The stator is the fixed part in the middle of the motor. The second two numbers (30) represent the length of magnets in millimeters. These long rectangular magnets are attached to the inside of the rotating case. The third set of two numbers (18) represents the number of wire winds, also called turns.

Several manufacturers such as ElectriFly include the motor Kv (explained earlier) instead of number of turns. For example, the ElectriFly Rimfire (Outrunner) 42-50-800 has a 42mm stator and 50mm long magnets and a Kv of 800. This particular motor is equivalent to a nitro glow .46 engine.

Other manufacturers use variations on this numbering scheme. Sometimes the second set of numbers may represent the length of the rotor or motor can (case) instead of the magnet, or they have a letter designation to represent a size like S for Short and L for Long. In any case, it is easy to remember that larger diameter and/or more length means more power!

**Steps for motor selection**

1. Determine RC model estimated flying weight (most suppliers provide this info). Should include weight estimate of required LiPo battery

2. Determine desired performance

3. Determine required watts per pound

4. Make an initial selection of motor type that has the required power from various available supplier lists. Use Vendor Web site recommendations (most vendor sites post charts of motor power levels as well as complete recommended setups for a particular model). Tower Hobbies gives good information describing application for each of their motors in the ElectriFly series. Here is an example:

***This is the Great Planes ElectriFly RimFire .15 35-36-1200 Brushless Outrunner Electric Motor.***

***FEATURES:*** *For Sport airplanes up to 4lbs (1815g) and 3D airplanes up to 2.5lbs (1135g)*
*Designed for explosive acceleration and maximum torque*
*Lightened aluminum can houses high torque rare earth Neodymium magnets*
*Double shielded bearings*
*Virtually maintenance-free; no commutators or brushes to wear out*

***INCLUDES:*** *Great Planes ElectriFly RimFire .15 35-36-1200 Brushless Outrunner Electric Motor with prop adapter (GPMQ4903), motor mount and 3.5mm connectors*

***REQUIRES:*** *SS-45 (45amp)ElectriFly Brushless Speed Control (GPMM1840)*
*Propeller: 10 x 7 - 11 x 7*

***SPECS:*** *Can Diameter: 1.38" (35mm)*
*Can Length: 1.42" (36mm)*
*Shaft Diameter: .16" (4mm)*
*Shaft Length: .65" (16.5mm)*
*RPM/V (kV Rating): 1200*
*Weight: 3.6oz (102g)*
*Input Voltage: 11.1-14.8V (3-4S LiPo)*
*Max. Constant Current: 45A*
*Max. Surge Current: 55A*
*Burst Watts: 650*
*No Load Current: 1.8A*

***COMMENTS:*** *The three-number designation refers to Motor Diameter, Motor Length and kV Rating.*

Similarly, BPHobbies.com also provide motor data and recommendations that help in selection. In addition for most motors, they provide a chart of performance (key is power input) with different props and voltages. Here is an example:

***BP A2217-9 Brushless Outrunner Motor Item: 13 of 28***

*Click on image for larger or alternate view.*

| | |
|---|---|
| ***No. of Cells:*** | *2 - 3 Li-Poly*<br>*6 - 10 NiCd/NiMH* |
| ***Kv:*** | *950 RPM/V* |
| ***Max Efficiency:*** | *80%* |
| ***Max Efficiency Current:*** | *5 - 15A (>75%)* |
| ***No Load Current:*** | *0.9A @10V* |
| ***Resistance:*** | *0.095 ohms* |
| ***Max Current:*** | *18A for 60S* |
| ***Max Watts:*** | *200W* |
| ***Weight:*** | *73.4 g / 2.59 oz* |
| ***Size:*** | *27.8 mm x 34 mm* |
| ***Shaft Diameter:*** | *4mm* |
| ***Poles:*** | *14* |
| ***Model Weight:*** | *300 - 1000g / 10.5 - 35 oz* |

| Propeller: | Volts (V): | Amps (A): | Thrust (g/oz): | Power (W): |
|---|---|---|---|---|
| APC 10 X 5 E | 12.31 V | 14.20 A | 29.62 oz | 172.41 W |
| APC 10 X 7 E | 10.83 V | 12.04 A | 24.67 oz | 128.37 W |
| APC 10 X 7 E | 11.06 V | 9.31 A | 16.61 oz | 99.78 W |
| APC 11 X 5 E | 10.78 V | 13.86 A | 27.92 oz | 145.41 W |
| APC 11 X 7 E | 12.12 V | 17.91 A | 31.41 oz | 212.55 |

*Use this motor with 2-3 cell Li-Poly packs and 10-11 inch props on planes up to 35 oz flying weight. Manufacturer recommends a 10x6 prop on 3-cells and a 11x4.7 prop on 2-cells. We suggest propping for around 180 watts continuous. Similar to AXI Gold 2217/20.*

If you are still not quite sure, then look at and compare known motor applications for similar type aircraft and performance. Along these lines, consult Hobby-Lobby.com that provides recommended motor, LiPo and Prop combination for the aircraft ARFs and kits they sell. Look for a similar size plane with similar design and wing area to yours. Here is an example from Hobby Lobby site:

## F4F Wildcat


*Description* *Reviews* *Parts & Accessories* *Everything You'll Need* *Support*

*New low cost power system with great performance*

*32-3/4 in. wingspan, 24-1/2 in. long, 194 sq. in. wing area, 15 oz. flying weight. Grumman's first monoplane modeled in pre-painted molded foam. Lightweight and nearly ready when you open the box. Install your motor and speed control as well as your radio equipment, charge your batteries, apply the decals and you are ready to fly.*

*We have two recommendations for power. The eRC 300 (ERCBL300) is a direct bolt in with no modifications to the firewall. This motor on 2 Lithium cells and an APC 9x6 prop makes a lightweight yet powerful combination. If you are looking for an overpowered model the eRC 400 (ERCBL400) is a good choice. With the BL400 some modification to the firewall is required for correct prop clearance to the cowl. Check out our photo instruction on how to do this.*

***F4F Wildcat ARF***

- ***Wingspan:** 32-3/4 in.*
- ***Flying Weight:** 15 oz.*
- ***Controls:** Ailerons, Elevator, Throttle*
- ***Wing Area:** 194 sq. in.*

***Here's Everything You'll Need:***
***Radio***
*1 - SPM5510 DX5e 5-Channel Transmitter/Receiver Only Mode 2*
*2 - ERCS800 eRC 8 Gram Precision Micro Servo*

***Motor/Battery/Prop (Super power)***
*1 - ERCBL400 400 Size Brushless Outrunner 1200Kv*
*1 - YTB16003 3-Cell 11.1V 1600mAh 20C LiPo Pack*
*1 - P09060SF APC 9x6 Slowflyer Prop*
*1 - WSD1300 Deans Ultra Connectors, pair*

***Motor/Battery/Prop(Good power)***
*1 - ERCBL300 300 Size Brushless Outrunner 1400Kv*
*1 - YTB16002 2 Cell 7.4V 1600mAh 20C LiPo*
*1 - P09060SF APC 9x6 Slowflyer Prop*
*1 - WSD1300 Deans Ultra Connectors, pair*

***Motor Controller***
*1 - CASTH18 ECO 18 Amp Brushless Controller*

Look for reviews in RC model magazines of aircraft and motor and prop used that you can benefit from reading for your own application    If a review uses a certain power system on a .40-size high wing trainer, it will likely work fine on your similar application.

Use a computer program to assist you in the motor selection process.   Innov8tivedesigns.com has a free motor performance simulation program.    Their motors (Scorpion brand) are fairly easily simulated by inputting the motor designation number.   The simulation can be run for various prop sizes and LiPo voltages. It is possible to do a custom simulation of other motors using their detail motor design parameters.   At least three web sites, BPHobbies.com, ExceedRC.com and Hobbypartz.com provide detail motor parameters. Previous BPHobbies.com example provided needed data (highlighted).
Here is another example from ExceedRC.com.   In this case the motor is an equivalent to .25 glow engine.

**SPECIFICATIONS**

| | |
|---|---|
| ***Model #:*** | ***Monster Power 25 (63M52)*** |
| *Kv:* | *870Kv* |
| *Input Watts:* | *550W* |
| *Resistance:* | *.03 ohms* |
| *Idle Current:* | *2.40A* |
| *Continuous Current:* | *32A* |
| *Max Burst Current:* | *44A* |
| *Cells Ni-Cd/Ni-MH:* | *10-14* |
| *Cells Li-Po:* | *3-4* |
| *Weight:* | *6.0 oz (170g)* |
| *Overall Diameter:* | *1.4 in (35mm)* |
| *Shaft Diameter:* | *.16 in (4mm)* |
| *Overall Length:* | *1.90 in (48mm)* |

Also useful are conversion charts of nitro glow power engine sizes to equivalent brushless motors.    Such charts are provided at the end of this document.    Refer to the last pages of this document.

Several RC hobby supplier sites have a good selection of motors with basic motor information (Watts input, KV, Prop size range, LiPo cell count, etc.) sufficient to make a selection and in several cases they provide recommendations for aircraft type and weight.   These include the following that are all in the USA except Hobby King (for motors).

BPhobbies.com (good prices and selection)
Valuehobby.com (good prices and selection)
ExceedRC.com (good prices and selection)
Hobby-Lobby.com (primary supplier for AXI motors)
Innov8tivedesigns.com (high quality and good selection and also have a motor (brand names) comparison chart and motor performance charts for different size props and battery voltages and also a free motor performance simulation tool)
E-fliteRC.com (limited selection but adequate to cover most applications, high quality)
Towerhobbies.com (Tower provides very good motor information to aid in selection)
Hobbyking.com (huge overwhelming choice of motors and low prices but higher shipping costs from China)
Hobbypartz.com (good prices and selection)

**Additional Information**

There are many web sites discussing RC motor selection and providing brushless motor data. Here are just a few of these sites that may be useful in gaining more knowledge regarding brushless motors and experience in selection.

http://www.rcuniverse.com/magazine/reviews/976/ampd3.pdf

http://www.hooked-on-rc-airplanes.com/brushless-rc-motors.html

http://www.hobbypartz.com/moforrcai.html

http://www.rctoys.com/pr/2006/12/08/choosing-the-right-brushless-electric-motor-for-your-rc-airplane/

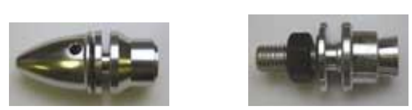
http://en.wikipedia.org/wiki/Brushless_DC_electric_motor

**Synchronous Electric Motors**

*A synchronous electric motor is an AC motor in which the rotation rate of the shaft is synchronized with the frequency of the AC supply current; the rotation period is exactly equal to an integral number of AC cycles. Synchronous motors contain electromagnets on the stator of the motor that create a magnetic field which rotates in time with the oscillations of the line current. The rotor turns in step with this field, at the same rate. Another way of saying this is that the motor does not rely on "slip" under usual operating conditions, and as a result produces torque at synchronous speed. Synchronous motors can be contrasted with induction motors, which must slip in order to produce torque. The speed of the synchronous motor is determined by the number of magnetic poles and the line frequency.*

**Outrunner Mounting**

The mounting requirements must be considered in the selection of the Outrunner motor. Here are the basic arrangements.

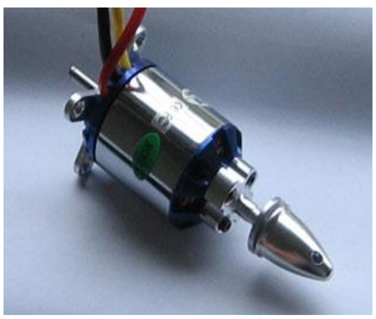



Some Outrunner motors can only be mounted to the front of a firewall. Couple examples of these are E-flite and BP-Hobbies motors( shown above). They are supplied with the X mounting Bracket that fits on the rear of the motor and a collet type prop adapter.

Typical collet type Prop Adapters

Outrunner with mounting hardware

Typical Bolt On Prop Adapter



Most Outrunner motors can be mounted to the front of the firewall as well as behind it. Front firewall mounting hardware is usually supplied and includes the X bracket and a bolt on type prop adapter. Some examples of these type motors include G-Force from Value Hobby, Rimfire from ElectriFly, AXI from Hobby Lobby, Monster Motors from ExceedRC and TACON from HobbyPartz, Turnigy from Hobby King, etc. To mount from behind the firewall a collet type prop adapter is required.

**Prop Chart**

Here is a link to a prop chart provided by Innov8tivedesigns.com for many of their motors. This data can be used for optimizing the choice of motor size, Kv, prop and LiPo voltage (number of cells). For this example the motor is one of their 30mm stator diameter rated at 370 watts and 1090Kv. Even though developed for their motors, these type charts can be useful to consult for an equivalent brand type of the same size and ratings. http://innov8tivedesigns.com/Scorpion/Scorpion%20SII-3008-1090%20Specs.htm.

**Motor Leads**

Brushless motors are supplied with wire leads. **Do not cut/shorten these leads.** They are part of the motor stator windings brought outside of the motor case a certain length and help define the windings resistance. Cutting the leads will change the resistance and can effect motor performance.

**Glow Engine to Electric Motor Conversion**

Here is such a chart from http://www.electrifly.com/powersystem/powersystem-index.html. Note that this chart is specifically for ElectriFly brushless motors. Other manufacturers/brands have similar equivalents sizes. These particular ElectriFly "Rimfire" motors have slightly higher Kv rating than is typical for other manufacturers and apparently were designed this way to be more close to the nitro glow engine in output RPM and prop size. However, if lower Kv is desired or available only in a lower cost alternate, look at comparable sizes, watts and prop sizes for other manufacturer/brand motors (such as ExceedRC.com, Hobbypartz.com, E-fliteRC.com, etc.) to determine an equivalent. Worst case, the LiPo cell count may have to be increased.

Brushless Power System

| Convert Your Glow Airplane To RimFire Outrunner Brushless Motor | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **2-Stroke Engine (cu. in.)** | **Replacement Motor** | **Motor Stock #** | **ESC** | **ESC Adapter** | **Motor Mount** | **Rear Shaft Dia. (mm)** | **Prop Size (in)** | **RPM** | **Current (A)** | **Minimum LiPo Batt** |
| .10 | 28-26-1600 | GMPG4535 | SS-25 | Not Needed | Small | 3 | 7 x 4SF | 13,440 | 17 | 3 cell (1250) |
| .25 | 35-30-1450 | GPMG4600 | SS-45 | GPMM3123 | Medium | 4 | 9 x 6E | 11,040 | 35.4 | 3 cell (2100) |
| .32 | 35-36-1500 | GPMG4625 | SS-60 | GPMM3123 | Medium | 4 | 9 x 6E | 12,370 | 47.0 | 3 cell (3200) |
| .40 | 42-40-1000 | GPMG4675 | SS-60 | Not Needed | Medium | 5 | 10 x 5E | 12,450 | 46.4 | 4 cell (3200) |
| .46 | 42-50-800 | GPMG4700 | SS-60 | Not Needed | Medium | 5 | 10 x 5E | 13,080 | 40.2 | 5 cell (2100) |
| .50 | 42-60-800 | GPMG4725 | SS-80 | Not Needed | Medium | 5 | 10 x 5E | 14,040 | 50.2 | 5 cell (2x3200) |
| .61 | 50-55-650 | GPMG4745 | SS-80 | Not Needed | Large | 8 | 11 x 8E | 11,970 | 66.0 | 5 cell (2x3200) |
| .91 | 50-65-450 | GPMG4770 | SS-80 | Not Needed | Large | 8 | 16 x 6E | 8160 | 43.0 | 5 cell (3200) |
| 1.60 | 63-62-250 | GPMG4795 | SS-100 | Not Needed | X-Large | 8 | 20 x 10E | 6480 | 67.0 | 9 cell (2x3200) |
| 2.10 | 63-62-250 | GPMG4795 | SS-100 | Not Needed | X-Large | 8 | 18 x 8E | 8770 | 66.0 | 12 cell (3200) |
| **4-Stroke Engine (cu. in.)** | | | | | | | | | | |
| .70 | 42-60-480 | GPMG4715 | SS-60 | Not Needed | Medium | 5 | 15 x 8E | 7830 | 54.0 | 6 cell (3200) |
| .91 | 50-55-500 | GPMG4740 | SS-60 | Not Needed | Large | 8 | 13 x 8E | 9450 | 51.0 | 6 cell (3200) |
| 1.20 | 50-65-450 | GPMG4770 | SS-80 | Not Needed | Large | 8 | 16 x 10E | 8130 | 89.0 | 6 cell (2x3200) |

| Convert Your Glow Airplane To Ammo Inrunner Brushless Motor | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2-Stroke Engine (cu. in.)** | **Replacement Motor** | **Motor Stock #** | **ESC** | **ESC Adapter** | **Gearbox** | **Gearbox Shaft Dia. (mm)** | **Motor Mount** | **Gear Ratio** | **Prop Size (in)** | **RPM** | **Current (A)** | **Minimum LiPo Batt** |
| .10 | 24-33-4040 | GPMG5165 | SS-35 | Not Needed | GPMG0505 | 4 | Small | 3.1:1 | 7x5E | 12,180 | 15.4 | 3 cell (1250) |
| .25 | 36-40-3900 | GPMG5265 | SS-60 | Not Needed | GPMG0515 | 6 | Large | 6.4:1 | 9x6E | 12,060 | 32 | 5 cell (2100) |
| .32 | 36-50-1500 | GPMG5285 | SS-80 | Not Needed | GPMG0515 | 6 | Large | 3:1 | 10x7E | 10,860 | 27.5 | 6 cell (2100) |
| .40 | 36-50-2300 | GPMG5290 | SS-100 | Not Needed | GPMG0515 | 6 | Large | 3:1 | 10x7E | 12,510 | 61 | 5 cell (3200) |

### E-Conversions for Top Selling Glow Airplanes

Here is such a chart from http://www.electrifly.com/powersystem/powersystem-index.html. Note that this chart is specifically for ElectriFly "Rimfire" brushless motors. Other manufacturers/brands have similar equivalent sizes.

Brushless Power System

| **E-Conversions for Top Selling Glow Airplanes** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RimFire Outrunner Brushless Motor - Conversion from glow to brushless | | | | | | | | | | | | | | | |
| **Airplane** | **Airplane Stock #** | **Type of Engine** | **Size of Engine (cu. in.)** | **Replacement Motor** | **Motor Stock #** | **ESC** | **ESC Adapter** | **Motor Mount** | **Rear Shaft Dia. (mm)** | **Prop Size (in)** | **RPM** | **Current (A)** | **Minimum LiPo Batt** | | |
| NexStar | HCAA17** | 2 Stroke | .46 | 42-50-800 | GPMG4700 | SS-60 | Not Needed | Medium | 5 | 10 x 5E | 13,080 | 40.2 | 5 cell (2100) | | |
| Avistar ARF .46 Trainer | HCAA2016 | 2 Stroke | .46 | 42-50-800 | GPMG4700 | SS-60 | Not Needed | Medium | 5 | 10 x 5E | 13,080 | 40.2 | 5 cell (2100) | | |
| Avistar select RTF | HCAA16** | 2 Stroke | .46 | 42-50-800 | GPMG4700 | SS-60 | Not Needed | Medium | 5 | 10 x 5E | 13,080 | 40.2 | 5 cell (2100) | | |
| U-Can-Do 3D .46 ARF | GPMA1269 | 2 Stroke | .50 | 42-60-800 | GPMG4725 | SS-80 | Not Needed | Medium | 5 | 10 x 5E | 14,040 | 50.2 | 5 cell (2x3200) | | |
| | | 4 Stroke | .70 | 42-60-480 | GPMG4715 | SS-60 | Not Needed | Medium | 5 | 15 x 8E | 7830 | 54.0 | 6 cell (3200) | | |
| U-Can-Do 3D .60 ARF | GPMA1270 | 2 Stroke | .61 | 50-55-650 | GPMG4745 | SS-80 | Not Needed | Large | 8 | 11 x 8E | 11,970 | 66.0 | 5 cell (2x3200) | | |
| | | 4 Stroke | .91 | 50-55-500 | GPMG4740 | SS-60 | Not Needed | Large | 8 | 13 x 8E | 9450 | 51.0 | 6 cell (3200) | | |
| Superstar .40 ARF | HCAA2020 | 2 Stroke | .46 | 42-50-800 | GPMG4700 | SS-60 | Not Needed | Medium | 5 | 10 x 5E | 13,080 | 40.2 | 5 cell (2100) | | |
| Twinstar .25 Twin ARF | HCAA2076 | 2 Stroke | .25 | | | SS-45 | Not Needed | Medium | 4 | 9 x 6E | 11,040 | 35.4 | 3 cell (2100) | | |
| Big Stik 60 ARF w/MonoKote | GPMA1221 | 2 Stroke | .60 | 50-65-450 | GPMG4770 | SS-80 | Not Needed | Large | 8 | 16 x 6E | 8160 | 43.0 | 5 cell (3200) | | |
| | | 4 Stroke | 1.20 | 50-65-450 | GPMG4770 | SS-80 | Not Needed | Large | 8 | 16 x 10E | 8130 | 89.0 | 6 cell (2x3200) | | |
| Big Stik 40 ARF w/MonoKote | GPMA1220 | 2 Stroke | .46 | 42-50-800 | GPMG4700 | SS-60 | Not Needed | Medium | 5 | 10 x 5E | 13,080 | 40.2 | 5 cell (2100) | | |
| | | 4 Stroke | .70 | 42-60-480 | GPMG4715 | SS-60 | Not Needed | Medium | 5 | 15 x 8E | 7830 | 54.0 | 6 cell (3200) | | |
| Cessna 182 ARF .40 | GPMA1228 | 2 Stroke | .46 | 42-50-800 | GPMG4700 | SS-60 | Not Needed | Medium | 5 | 10 x 5E | 13,080 | 40.2 | 5 cell (2100) | | |
| Combat Corsair ARF | GPMA1470 | 2 Stroke | .25 | | | SS-45 | GPMM3123 | Medium | 4 | 9 x 6E | 11,040 | 35.4 | 3 cell (2100) | | |
| Seawind Amphibian .60 ARF | GPMA1360 | 2 Stroke | .61 | 50-55-650 | GPMG4745 | SS-80 | Not Needed | Large | 8 | 11 x 8E | 11,970 | 66.0 | 5 cell (2x3200) | | |
| | | 4 Stroke | .91 | 50-55-500 | GPMG4740 | SS-60 | Not Needed | Large | 8 | 13 x 8E | 9450 | 51.0 | 6 cell (3200) | | |
| Combat Mustang | GPMA1475 | 2 Stroke | .25 | | | SS-45 | GPMM3123 | Medium | 4 | 9 x 6E | 11,040 | 35.4 | 3 cell (2100) | | |
| **Ammo Inrunner Brushless Motor - Conversion from glow to brushless** | | | | | | | | | | | | | | | |
| **Airplane** | **Airplane Stock #** | **Type of Engine** | **Size of Engine (cu. in.)** | **Replacement Motor** | **Motor Stock #** | **ESC** | **ESC Adapter** | **Gearbox** | **Gearbox Shaft Dia. (mm)** | **Motor Mount** | **Gear Ratio** | **Prop Size (in)** | **RPM** | **Current (A)** | **Minimum LiPo Batt** |
| NexStar | HCAA17** | 2 Stroke | .40 | 36-50-2300 | GPMG5290 | SS-100 | Not Needed | GPMG0515 | 6 | Large | 3:1 | 10 x 7E | 12,510 | 61 | 5 cell (3200) |
| Avistar ARF .46 Trainer | HCAA2016 | 2 Stroke | .40 | 36-50-2300 | GPMG5290 | SS-100 | Not Needed | GPMG0515 | 6 | Large | 3:1 | 10 x 7E | 12,510 | 61 | 5 cell (3200) |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avistar select RTF | HCAA16** | 2 Stroke | .40 | 36-50-2300 | GPMG5290 | SS-100 | Not Needed | GPMG0515 | 6 | Large | 3:1 | 10 x 7E | 12,510 | 61 | 5 cell (3200) |
| U-Can-Do 3D .46 ARF | GPMA1269 | 2 Stroke | .40 | 36-50-2300 | GPMG5290 | SS-100 | Not Needed | GPMG0515 | 6 | Large | 3:1 | 10 x 7E | 12,510 | 61 | 5 cell (3200) |
| Superstar .40 ARF | HCAA2020 | 2 Stroke | .40 | 36-50-2300 | GPMG5290 | SS-100 | Not Needed | GPMG0515 | 6 | Large | 3:1 | 10 x 7E | 12,510 | 61 | 5 cell (3200) |
| Twinstar .25 Twin ARF | HCAA2076 | 2 Stroke | .25 | 36-40-3900 | GPMG5265 | SS-60 | Not Needed | GPMG0515 | 6 | Large | 6.4:1 | 9 x 6E | 12,060 | 32 | 5 cell (3200) |
| Cessna 182 ARF .40 | GPMA1228 | 2 Stroke | .40 | 36-50-2300 | GPMG5290 | SS-100 | Not Needed | GPMG0515 | 6 | Large | 3:1 | 10 x 7E | 12,510 | 61 | 5 cell (3200) |
| Combat Corsair ARF | GPMA1470 | 2 Stroke | .25 | 36-40-3900 | GPMG5265 | SS-60 | Not Needed | GPMG0515 | 6 | Large | 6.4:1 | 9 x 6E | 12,060 | 32 | 6 cell (2100) |
| Combat Mustang | GPMA1475 | 2 Stroke | .25 | 36-40-3900 | GPMG5265 | SS-60 | Not Needed | GPMG0515 | 6 | Large | 6.4:1 | 9 x 6E | 12,060 | 32 | 6 cell (2100) |

**Flight Time Estimation**

The following provides a means of estimating flight time available from a particular combination of motor and LiPo battery pack size/capacity (mah = millampere-hour) before the first flight to avoid problems. Once confirmed and refined after first couple flights, it is recommended that a timer always be used to know when you should start setup to land the aircraft.

1. If a wattmeter type device is available that also displays amps, then measure and record current from a fully charged LiPo pack at full throttle. Have someone help to hold the plane during this test.
2. Convert the measured current to milliamps for a Rate value. This will be the worst case.
   **Rate** (in milliamps ) = Amps x 1000
3. **Run time** (in minutes) = ((LiPo pack mah capacity) x 0.8 x 60 to convert to ma-minute) / Rate.
   The 0.8 factor is margin to account for battery variances and state of full charge and fact that ideally LiPo packs should not be discharged on an on-going basis beyond 80% (20% remaining).
4. Example:
   Full power current measurement of 30 amps x 1000 = 30,000 ma rate
   For a 2200 mah LiPo pack x 0.8 x 60 = 105,600 / 30,000 = 3.5 minutes flight time (worst case)

5. Realistically the flight will not be at continuous full throttle. For a first flight estimate use a value of 70% of full current or in this case 30 x 0.7 = 21 amps (21,000 ma) yields a flight time of 5 minutes. Perform a couple flights and monitor how many mah are put back in the battery pack by the charger and then adjust the flight time accordingly by observing how much of the pack's mah capacity remains.

If a wattmeter is not available, it is also possible to make an estimate of flight time as follows:

1. With a fully charged LiPo battery, run the motor stationary (have someone help to hold the plane) for a period of 1 minute exactly at about 70% throttle position on the transmitter.
2. Fully recharge the battery and record the mah (milliamp hour) put back into the pack as shown on the charger display.
3. Multiply the battery mah capacity by 0.8 (for margin) and then divide the result by the mah used during the 1 minute run.
4. Example: 200 mah was consumed during the 1 minute run. A 1300 mah capacity LiPo pack was used. Approximate flight time will be: (1300 mah x 0.8 ) / 200 = 5.2 minutes. Therefore limit the first flight to 5 minutes and after recharging the battery and observing mah put back in, adjust the flight time accordingly by observing how much of the pack's mah capacity remains.