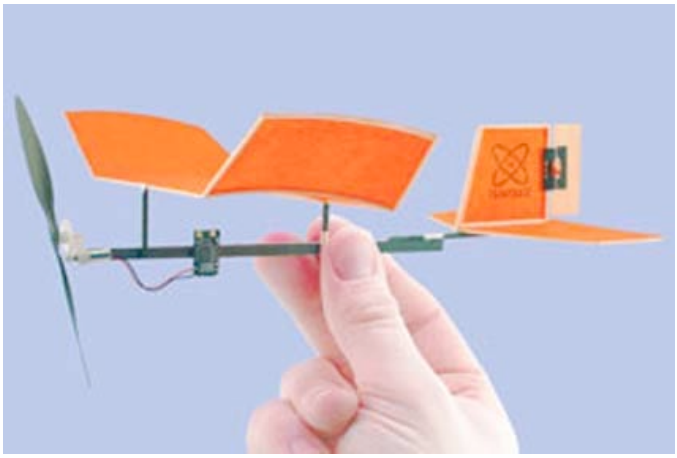
Getting Started in Electric Flight
An Introduction and Some BASICS

By Ken Myers kmyersefo@mac.com

Warning! The many facets of Electrically Powered Flight ARE Addictive



Indoor - living room flyer

Backyard

Park Flyer - Scale

3D

Sport

Scale

Electric Ducted Fan (EDF)

F5B

Electric Helicopter

Race

Old Timer

Thermal Sailplane

Multi-motors

Foamie

QuadCopter controlled by iPhone or iPad

And MUCH, MUCH MORE!

Wing Cube Loading Defines Aircraft Types and Missions

Wing cube loading is a much better comparative number than the commonly used wing area loading.

WCL oz./cu.ft.	Types or Missions
3 or less	Indoor
3 - 5	**Backyard & electrically powered thermal gliders**
5 - 7	3D flying, park flyers, slow & relaxed trainers, some sport planes & biplanes, old-timers, some electric thermal gliders, warmliners
7 - 10	**3D flying up to about 8.5 oz./cu.ft., trainers, sport high and low wing planes, some biplanes, a few light scale planes, some twins**
10 - 13	sport planes, scale planes/Warbirds, some twins, racers, Electric F5B high performance "gliders"/hotliners
13 - 17	**twins, scale planes/Warbirds with the works**
17 or more	twins, scale planes/Warbirds with the works

Wing Cube Loading Table

Online Sources for WCL can be found in the Sources Section at the end of the article.

Recommended First Purchase

The very first item to purchase when getting into electric power is a power meter. It is also known as a wattmeter and Whattmeter (Astro Flight brand and first in the RC market). It is connected between the battery pack and electronic speed control (ESC) and displays the volts at the input of the ESC, amps drawn by the power system, energy delivered over time (Ah – amp hour or mAh – milliamp hour) and the watts input at the ESC.

Watts equals volts times amps.
W=V*A

The purpose of the power meter is to provide the actual information about the power system (battery, ESC, motor & prop). The information provided by the meter allows the user to adjust the prop (load) so that all parts of the power system are within a safe operating range.

The meter is ALWAYS used at full throttle. Partial throttle readings mean nothing. A power meter measures watts in (power in), not watts out (power out)!

The Power Meter by E-flite is NOT RECOMMENDED. It does not display all of the essential information on one screen.

Online sources for the Power Meters are found at the end of the article.

Progressive RC PowerLog 6S

This meter also includes an optical tachometer and has the ability to log data to a file on a computer. It also has a 'Hold' button to keep the information onscreen.

Hyperion Emeter 2 (expensive, but HIGHLY recommended!!!)

P1 from Hobby Partz and similar meter at Hobby King

Watt's Up Meter

BP Hobbies has several choices.

Other power meters can be found online at Tower Hobbies and additional sources.

How to use a power meter:

The manual for the Watts Up meter may be applied to all types and is found on the PowerWerx Web site.

Power Meter Videos:

Three videos about using power meters are located in the Sources section at the end of the article.

When I previewed this information at the December 2009 EFO meeting, everyone one nodded and agreed that this is an **essential** and **highly recommended** first purchase. Get one ASAP!

Hint! If you do not have a power meter with a hold feature, video the data and then record the data when playing back the video.

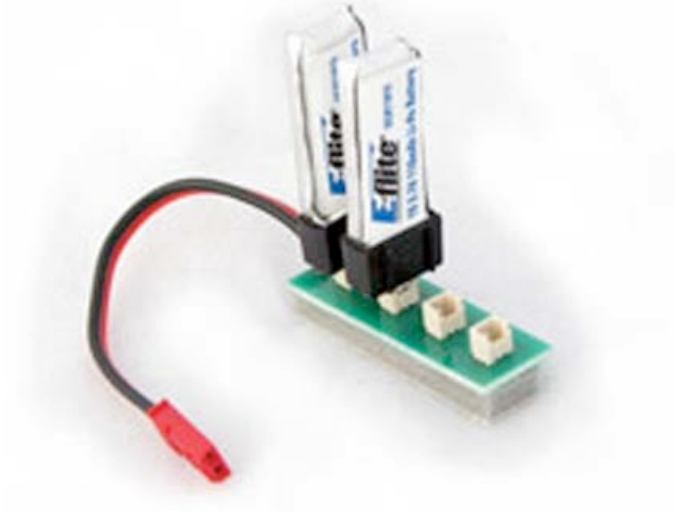
Chargers

A high power, balancing, multi-chemistry charger with discharge function is the 'best' choice. It should charge and discharge Lithium Polymer (Li-Po/Li-Poly), Li-Ion (Li-Io), Lithium Iron Phosphate (LiFe), NiCad, NiMH, and Pb (lead acid).

My chargers - FMAdirect Power Lab 8 (new) & CellPro 10S (well used!)

Progressive RC is a great source for decent chargers.

Another good charger is the TME (Tejera Microsystems Engineering) Xtrema. The Xtrema has a built in wattmeter, so there is no need to purchase a separate wattmeter. TME also has a neat adapter board for charging single Li-Poly cells.

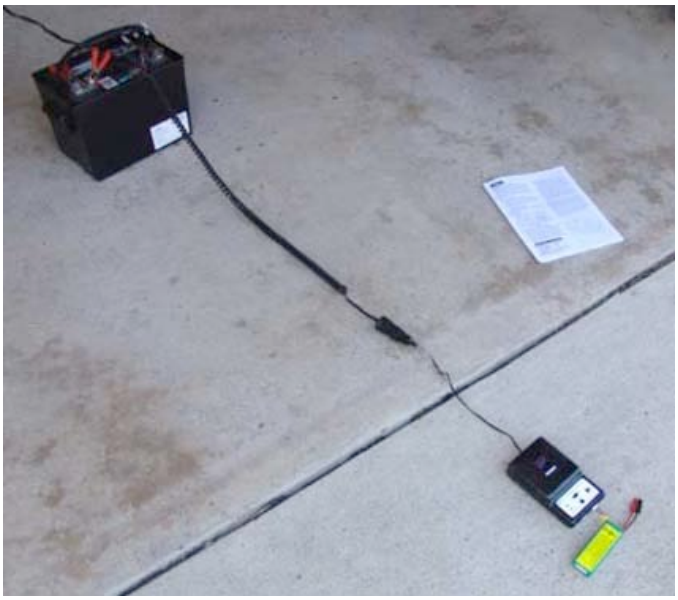


The photo shows a 12-volt Sears DieHard Deep Cycle Marine/RV battery, battery case from NAPA, Walmart 12-volt charger and an Astro Flight Whattmeter.

Decent chargers require an external power source such as a Deep Cycle Marine/RV battery or power supply - NOT a car battery! There are NO decent chargers with a built-in power supply. They are too limited in power to be useful for most purposes.

It is very handy to have a charger that will discharge so that a **storage charge** can be put on Li-Poly batteries when storing for extended periods of time. A **storage charge** is approximately 3.7v to 4v per cell with most chargers. When set to **storage charge**, many chargers automatically charge to 3.85v per cell.

It is best not to plug a charger's input connector into a 12-volt socket in a vehicle. A vehicle battery is not designed for that use. Li-Poly batteries should NEVER be charged in or on a vehicle.



The previous photo shows a safe way to charge a Li-Poly battery with a car plug type connector. The charging is done in the middle of a cement driveway, away from all combustibles. The adapter hooked to the battery is from Radio Shack. The manual was removed from the area before the actual charging took place.

Li-Poly Batteries

Lithium Polymer batteries are the most common type of power battery in use today.

A single cell is not technically a battery, but they are used with some small electrics and called a battery.

How to read a Battery Label or Battery Specifications

Li-Poly cells are said to have a nominal voltage 3.7v per cell. Actually, with a resting voltage of about 3.7v per cell, they are almost empty.

11.1V is the nominal voltage of 3 Li-Poly cells assembled in series (aka 3S). The charged voltage is 12.45v (4.15v per cell) to 12.6v (4.2v per cell) for a 3S pack depending on the charger.

2200mAh (milliamp hours) is the capacity (C) of this battery. 2200mAh is 2.2Ah (amp hours).

25C means that the supplier or manufacture implies that the longevity and performance of the pack will not degrade quickly if the battery is DISCHARGED up to this C-rate. The maximum amp draw for the battery is calculated using the capacity in Ah (amp hours) times the rate multiplier. The rate multiplier is the number preceding the letter C. In this instance it is 25 (rate multiplier) times 2.2Ah (C) or 55 amps. There is no industry standard regarding the C-rate and a manufacturer or supplier may claim whatever they want as the C-rate.

Charge Current

2C normal 4.4 amps (approximately 30 minutes to charge completely discharged pack)

4C fast 8.8 amps (approximately 15 minutes to charge completely discharged pack)

5C max 11 amps (approximately 12 minutes to charge completely discharged pack)

The burst amps really mean nothing.

Charging this battery at 5C requires a charger that can output a bit more than 12.6v at 11 amps. (12.6 * 11 = 138.6 watts) The charger needs to be rated for at least 155 watts or more for a 5C charge.

C-Rate	Minutes
1	60.00
2	**30.00**
3	20.00
4	**15.00**
5	12.00
10	**6.00**
15	4.00
20	**3.00**
25	2.40
30	**2.00**
35	1.71
40	**1.50**
45	1.33
50	**1.20**
60	1.00
65	**0.92**
70	0.86
75	**0.80**

C-Rate in minutes

The chart shows approximately how long it will take to fill an empty pack or deplete a full pack at the C-rate. High charge rate Li-Poly batteries, mated with a good charger, reduce the time spent in the immediate area of a charger. When the charge time is shorter, there is less waiting time for the battery to completely charge.

Li-Poly Storage and Safe Handling

Li-Poly batteries contain a lot of potential energy. They require special attention and care when in use and in storage.

Good charging practices include:
Using the balance connector for all charges, even when using power leads
Charging only out of the airframe
Charging only in an area free of combustibles
Remaining in the immediate area of a charging Li-Poly battery
Keeping the battery and charger under close observation
*High charge rate Li-Poly batteries make staying in the immediate area of a charging Li-Poly battery much easier. The charge time is much shorter.


Li-PoSack Plus

It is best to charge in a REAL Li-PoSack brand charging sack. Some off brands have been known to burn! Really. Distributors of the REAL Li-PoSack can be found on their Web site.

The Li-PoSack Plus is a good storage vessel and can be used for storage and transportation. A fireproof safe, ceramic dish with lid or ammo box make decent storage vessels.

The photo shows my ammo box with charge leads going into the box and a hole for the balance connector.

Another storage and charge safety system is the LiPoLocker. A review of the LiPoLocker.com Battery Charging Security System can be found on RC Groups. It is another Li-Poly safe charging and storage system.

Li-Poly packs puncture easily. Keep them away from sharp objects. Do not allow bolts, screws or other sharp objects to protrude into the battery area of the aircraft. Protrusions will puncture a Li-Poly in a crash. Be sure the battery is secured very well in the aircraft.

Dispose of punctured or puffed packs immediately.

Lithium Polymer disposal instructions are found on the Common Sense RC Web site.
1) Discharge the battery to 0 volts.
2) Puncture each cell and immerse in saltwater for 24 hours.
3) Wrap the battery in a bag and place in an appropriate disposal canister.
4) The pack can now be thrown in the garbage - there are no special disposal requirements for Li-poly batteries.

Put a **storage charge** on Li-Poly packs that will not be used for weeks or months and store in a safe container away from all combustibles.

It is best to purchase Li-Poly packs just before they are to be put into service. They don't have as long a 'shelf life' as other types of batteries.

To **preserve long life for Li-Poly batteries**, they should not be flown to the LVC (low voltage cutoff) of the ESC or too deeply discharged. It is best to use the **"80% of the capacity rule"** to avoid the premature death of a Li-Poly pack.

Here are a few examples of the 80% of capacity rule:

Stated capacity 4500mAh * 0.8 = 3600mAh flight capacity
Stated capacity 3000mAh * 0.8 = 2400mAh flight capacity
Stated capacity 2250mAh * 0.8 = 1800mAh flight capacity

Learning the 80% Capacity Point of a Pack and Flying Style

Step 1: fly the aircraft in a normal manner for 3 minutes using a timer

Step 2: Land, remove pack and charge pack. Note the Ah/mAh returned to the pack

If the mAh/Ah returned to pack is greater than the 80% capacity number, reduce the flight time. Repeat Step 1.

or

If the mAh/Ah returned to pack is less than the 80% capacity number, increase the fight time. Repeat Step 1

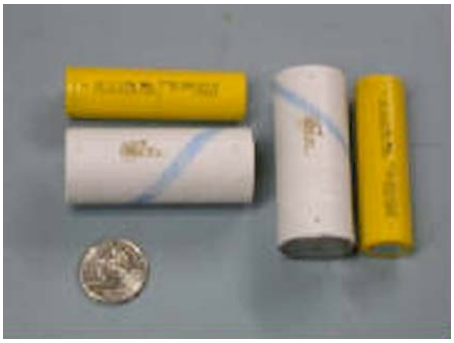
Repeat Steps 1 & 2 until the normal flight time for use of 80% of the capacity is established for the plane, flying style and individual pilot throttle management.

What happens if it is slightly over the 80% point, say 82%?
Nothing, that is close enough.

The actual capacity and manufacturer or supplier's capacity may not be exactly the same. Capacity changes over time. As a battery ages, the capacity decreases. It is important to be aware of this factor.

Online Resources for Li-Poly Batteries can be found in the Sources section at the end of the article.

Other Flight Power Batteries



A123 Cells

Some electric power modelers use power batteries made up of cells from A123 Systems, Inc. The A123 cells are only available in 1100mAh and 2300mAh capacities. They have a nominal cell voltage of 3.3v per cell and a charged voltage of 3.85v per cell. Most people who use them 'harvest' them from DEWALT Lithium battery packs for power tools. A123 cells are Lithium Iron Phosphate ($LiFePO^4$) chemistry. They are heavier than an equivalent Li-Poly cell, but much lighter than NiCads or high-energy NiMH cells. Many people consider them much safer than Li-Poly cells.

More information on these cells can be found on the EFO Web site as well as RC Groups.

Li-Poly Batteries for use in Transmitter

While many modelers are using Li-Poly batteries in transmitters, it is BEST not to use them for this purpose. Li-Poly batteries may require a voltage regulator and the battery must be removed from the transmitter before charging them outside the transmitter. If the transmitter is accidentally left on, the pack will be ruined because it will be too deeply discharged.

The Sanyo Eneloop low self-discharge (LSD) NiMH cells make excellent batteries for transmitters. They come in a 2000mAh capacity. Once fully charged, they'll hold that charge for weeks.

The cells can be purchased at COSTCO or pre-made packs for specific transmitters are available at No BS Batteries.

Ray'O' Vac call their type of LSD NiMH a Hybrid.

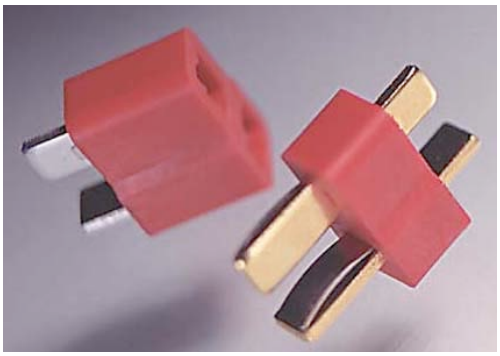
Temperature Effects on Batteries

Batteries work best at room temperature. Operating batteries at a high temperature shortens their useful life. At low temperatures, the performance of all battery chemistries drops substantially. A battery may be capable of operating at cold temperatures, but it may not allow charging under those conditions. The charge acceptance for most batteries at low temperatures is extremely limited. Most batteries need to be brought up to temperatures above the freezing point for charging. Even then, they will not charge well until they are at room temperature.

Connectors

Power lead connectors from the battery to ESC

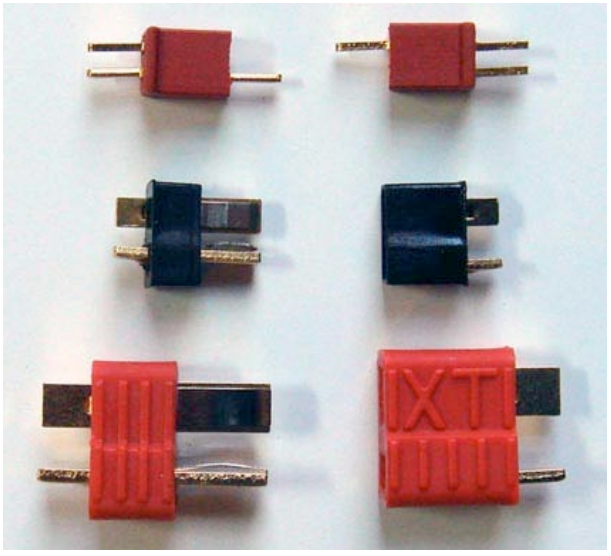
There are many types to choose from. An article by Stefan Vorkoetter gives the statistics and reasons for using many of the connectors discussed here.



The most common power lead connector is the Deans Ultra, which is usually just called Deans. There are Deans Micro Plugs as well.

Handy "Gripper" Covers for Deans Ultra Plugs from HDi

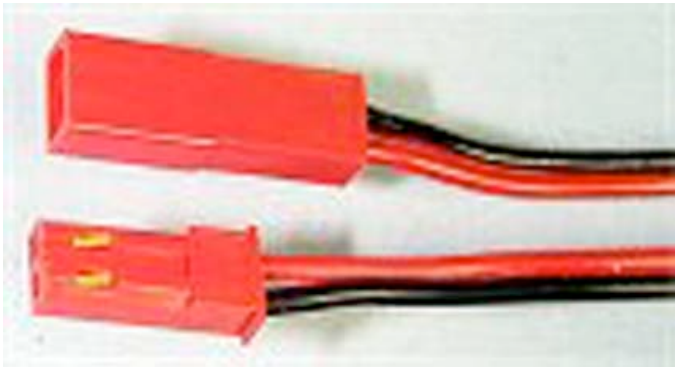
The Deans Ultras are similar to the XT plugs sold by Progressive RC, except that the XT is ribbed for gripping. The Progressive plugs come in three sizes, T-plug, Mini T-plug and Micro. These are NOT Deans plugs.

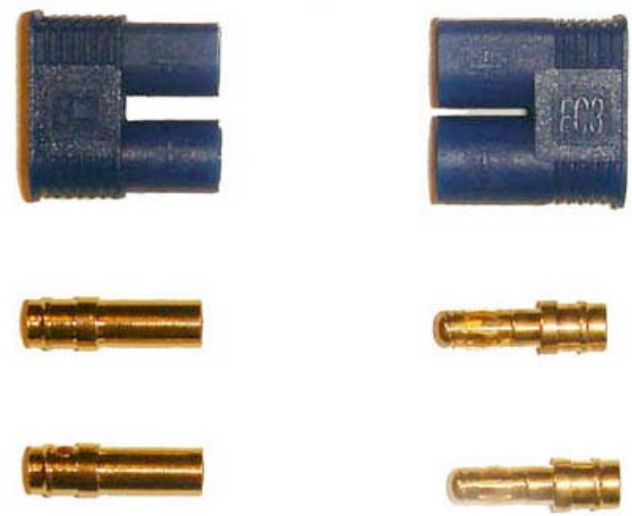


Anderson Power Poles (APP) aka Sermos

Crimper for APP connectors

The JST plug is used for small planes and low current applications. It is also often called the BEC plug or P connector.





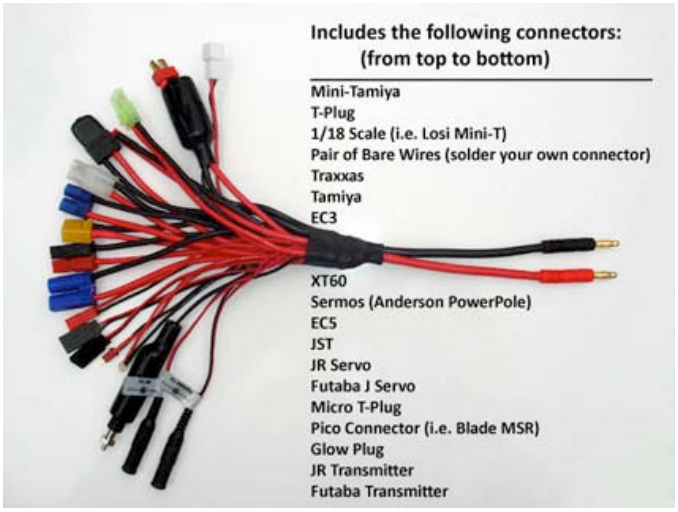
The EC3 and its larger relative EC5 (EC3 shown)

Bullet Type

Bullet connectors are available in various sizes ranging from 2mm diameter and up. The larger ones are used for larger amp loads. They are not really interchangeable by brand. They are used most often for the motor to ESC connection, but they are occasionally used for the battery to ESC connection.

There is often controversy raging on RC Groups as to what is the best connector.

It is a good idea to have an adapter for the various power plugs. It will come in handy at the field someday to help others or yourself when unexpected charger problems arise and you may need to 'borrow' a charge or someone wants to 'borrow' some electrons from you.



Multi power plug adapter from Progressive RC

The 4 Major Balance Plugs, Taps, Nodes or Node Connectors

Please NOTE: The following listing may no longer be current.

Polyquest (PQ) taps are used on: Enermax, E-tec, Extreme Power, Fliton, Hyperion, Impulse, MaxAmps, Pache, Poly RC, Polyquest, True RC and Xcite battery packs

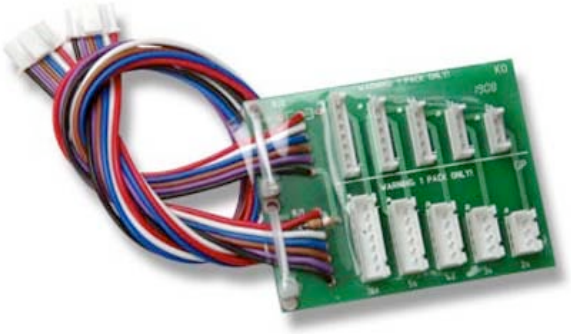
Note that the PQ types use the same connector for several battery configurations and skips pins that aren't required. 2S and 4S packs shown. The 3S also uses the same connector.

Thunder Power (TP) taps are used on: Apex, Danlions, EVO, Flight Power, Kong Power, MPX, Outrage, Tark Power, Thunder Power and Vislero battery packs

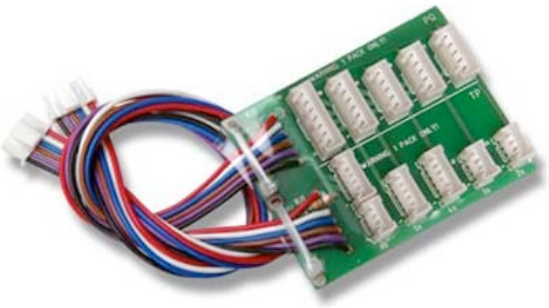
Align JST XH (AL) taps are used on: 3E Models, ABF, Air Thunder, Align, Common Sense RC V2, DN Power, Dualsky, Dynam, E-flight, Electric Power, Electrifly, Energy EC, Esky, E-Watts, Exceed RC Fusion, Fully Max, GE Power, Grayson Power, Hextronix, HI Model, Hobby City, Hobby Loong, Hurricane Flight Systems, Imax, LOSI, Mega Power, Mystery, PowerSource, Protec, Rhino, Tenergy (rev polarity), Tower Hobbies, Trinity, Turborix, Vampower (new), Venom and WOW RC, X-Caliber and Zippy battery packs.

Kokam JST XE taps are used on: Apogee (but you need to remove lock), Core, Graupner, Kokam, New / Neu Motors, Orion Avionics and Vampower (old) battery packs.

Suppliers of Chargers also supply adapter boards for various types balance connectors for use with the chargers they sell. A look at the balance boards shows how the 4 major balance plugs are configured and how many pins each connector has.



Above is the adapter board for a CellPro 10S for the Kokam JST XE (top) and Align JST XH (AL) (bottom) balance taps. Note that each connector size is only used once and has one more connection than cells in the battery.



The photo of the second adapter board is for a CellPro 10S for the Thunder Power (TP) (bottom) and Polyquest (PQ) (top) balance taps. Polyquest uses the same connector for 2S, 3S and 4S packs and different connectors for 5S and 6S. Thunder Power uses the same connector for 2S and 3S packs and then a different one for 4S and 5S packs and double connector for 6S packs.

More balance plug information can be found at RCLipos.com.

Brushless Electronic Speed Controls (ESC) Basics

Many of today's brushless ESCs have three distinct parts or circuits built into them.

The **speed control** - There are a lot of electronic 'things' happening, but basically it is an electronic on/off switch that is turning on and off extremely rapidly. When it is On the voltage and amperage are at maximum. When it is off, there is no voltage or current passing. The RPM is controlled by how long the On cycle is on compared to how long the Off cycle is off.

The **Low Voltage Cutoff (LVC)** circuit was originally designed to stop or reduce power to the motor to reserve battery power for the receiver and servos for a safe landing. It is even more important today because it can save Li-Poly batteries from being ruined by being too deeply discharged. Li-Poly batteries should never be flown to the point where the safety LVC circuit kicks in. Always time electric flights with either the transmitter timer or a typical kitchen timer.

Kitchen timer that I use

The **Battery Eliminator Circuit (BEC)** is another circuit designed into an ESC that allows the power battery to be used to power the receiver and servos. It is basically a step down voltage regulator.

The two types of BEC circuits found in ESCs

Linear (most common, cheap): It works by converting the excess voltage into heat. The higher the input voltage, the more heat generated in the BEC circuit. If there is too much heat, the BEC will either 'fry', or shut down! With a 3S Li-Poly the linear BEC is only able to provide about 0.5A before it overheats. That's only good for about 3 standard servos and the receiver. Many people overstress this type of BEC. Most ESC manufacturers don't recommend the use of a linear BEC with a 4S Li-Poly battery.

Castle Creations' Thunderbird Line

The Castle Creations Thunderbird and Phoenix lines of ESCs contain linear BEC circuits.

Switching (best type, expensive): A switching regulator works by taking small chunks of energy from the input voltage source, and moving them to the output. This is done with an electrical switch and a controller. They regulate the rate at which the energy is transferred to the output. That's why it is called a "switching regulator". A switching regulator can typically have and efficiency of 85%. A switching regulator can easily power heavy loads from a high voltage source.

The Castle Creations ICE line of ESCs contain switching BEC circuits.

Today's Brushless ESCs, with the onboard BEC disabled (easy to do), or Brushless ESCs that do not have a built in BEC can also use NiCad or NiMH receiver packs, A123 Systems Li-Fe receiver packs, and stand alone switching BECs like the Castle Creations BEC or BEC Pro.

Sources for more BEC Information are located in the Sources section at the end of the article.

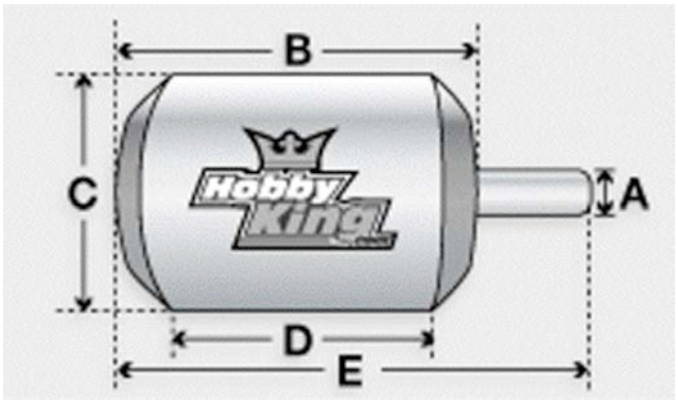
Motors for Electric Flight

Today, brushless inner runner motors are mainly used in electric ducted fan (EDF) applications and helicopters.

Brushed motors are still used in specialized applications, especially very small planes.

One of the main characteristics of the brushless outrunner is that its magnets are housed in a bell. The stator or armature is on the inside of the motor. That is just the opposite of a brushless inner runner. The outrunner provides more torque than an inner runner and the outrunner can turn prop sizes that the brushless inner runner would need a gear reducer to turn.

Outrunners are generally less efficient than inner runner types with a gear reducer, but they are still efficient enough for general use. There are hundreds of different sizes of outrunners from very tiny to massively huge.



Outrunner nomenclature is not standardized. Comparing one company's outrunner to another's is often difficult. Some companies use the outside measurements to describe their motors, as shown in the previous graphic.

TR 35-48-C 800kv

Hobby King has a motor that it calls the TR 35-48-C 800kv weighing 163g. Hobby King uses outside dimensions to designate its motors. The C dimension is about 35mm and B dimension about 48mm. The stator dimensions are 28mm x 26mm. Dimension A is 4mm. Maximum current is rated at 55 amps. Price $14.95

Scorpion has a motor that it calls the Scorpion SII-3020-780 weighing 166g. Scorpion uses the stator dimensions to designate its motor numbers. It has a Kv of 780 (about the same as the Hobby King motor). The C dimension is 37.5mm and B dimension is 45.7mm. The stator dimensions are 30mm x 20mm. Dimension A is 5mm. Scorpion does not give the useless maximum current but does rate this motor at a continuous 40 amps with a continuous power level of 800 watts in. Price $65.95

Hobby King would call the Scorpion motor a Turnigy 38-46 780Kv (they tend to put a dash between the external dimensions, but not always) and Scorpion would describe the Hobby King motor as a Scorpion 2826-800.

Hobby King does not note that the magnets are of the ceramic ferrite type. Scorpion does note that its motors use the N-50EH type of rare-earth neodymium magnets.

The two motors are not the same, but with a similar weight and Kv, they might be expected to perform close to the same level with the same battery, ESC and prop.

The Cermark NEO 25-780 has a similar 780Kv, but it only weighs 149g. Using its outside measurements it would be called a 42-40 780Kv. It has a 5mm shaft. It is rated for a maximum of 460 watts in and 55 amps. While it does use neodymium magnets, it would require a larger diameter prop with more pitch to achieve the same watts in as the other two motors. It is not similar to either of the other two motors, and its performance will be quite different.

Motor weights do NOT include the weight of the prop adapters, motor mounts and their related screws and usually not the connectors either.

Kv or RPM/v

Kv is a motor constant and is directly related to Kt, the motor torque constant. The specific motor's design and construction determine this constant. The Kv motor constant has nothing to do with the applied voltage. It is part of the motor's physical makeup. There are electrical and mechanical losses

in all motors. The voltage in RPM/v is the VOLTAGE OUT not the voltage in.

The only time the input voltage and output voltage are about the same is when there is no load applied to the motor.

The higher the voltage drop through the motor, the lower the RPM will be. The higher the current is, the greater the voltage drop will be. The less efficient a motor is, the higher the voltage drop will be.

More on Kv and how to measure it can be found on the EFO Web site.

Timing and Apparent Kv

Timing affects the apparent Kv. Advancing the timing on a brushless motor using the ESC increases the RPM by forcing the motor to turn at a rate higher than the native or raw Kv. It also increases the current draw and decreases the efficiency.

Power In versus Power Out

The power meter measures the power IN at the ESC. There are electrical losses in the ESC, and there are electrical and mechanical losses in the motor. The majority of the losses are turned into heat. The power out is considerably less than the power in.

If a power meter is showing 10.7v, 27.9 amps and 298.5 watts in, those numbers are input measurements. The motor is not 'making' 298.5 watts! It is not MAKING anything! It is using electrical energy and converting it to mechanical energy.

A useful drive system, using typical outrunners, will be somewhere between 70% and 80% efficient. That means about 209 watts out (70%) to 239 watts out (80%) for the noted system showing 298.5 watts in on the power meter.

How do you know the power out? You don't! There are ways to measure the output, but they are too complicated for most modelers.

Motor/prop/battery computer programs like Drive Calculator can estimate the power out. Drive Calculator is a FREE program and runs on Mac, Linux and Windows.

Power out may also be estimated using something known as prop constants and the measured RPM.

It is not really necessary to know the watts out. When electric fliers and authors use the term watts, they are referencing watts in.

Prop Shaft Rotation

It is easy to change the prop shaft rotation of a brushless motor. Switch the connection of any two leads between the motor and the ESC. The color coatings on the leads from the motor to the ESC mean nothing. Different brands use different colors on the motor leads to the ESC and also different colors on the ESC to motor leads.

Props

The **APC props**, slow fly (SF), thin electric (E), sport and pattern have RPM limits. The limits are listed on their Web site. They all have applications that work well with electric motors.

Master Airscrew standard wood props and G/F 3 series work well with electric motors. The Master Airscrew electric props are not very efficient and should be avoided.

Zinger props are not useful for most electric applications, but make excellent prop blanks, according to Keith Shaw, if you want to create your own props.

GWS has basically two lines of props, RS and DD/HD. The RS (reduction series) are used in applications similar to the APC SF type props. The DD/HD (direct drive/hyper drive) props are used in applications similar to the APC E, but have lower RPM limits than the APC E props.

Selecting the CORRECT Supplier Recommended Props

Many times a supplier will recommend props for a motor and battery combination. It can be confusing.

Recommended Prop Range:	11x8 to 14x7
Voltage:	12–16.8
RPM/Volt (Kv):	870
Resistance (Ri):	.03 ohms
Idle Current (Io):	2.40A @ 10V
Continuous Current:	32A
Maximum Burst Current:	44A (15 sec)
Cells:	3S-4S Li-Po or 10–14 Ni-MH/Ni-Cd

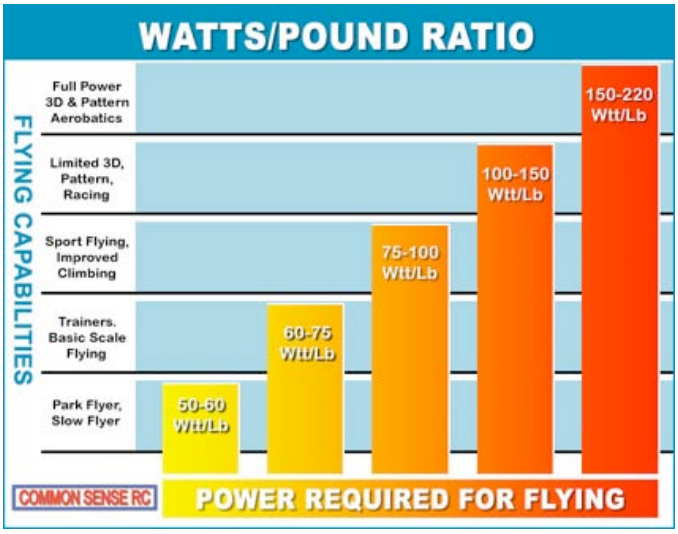
The previous graphic was captured from the specifications for the E-flite Power 25 870Kv BL Outrunner at Horizon Hobby. The props and battery packs (Cells) are listed from 'smallest' to 'largest'. What is NOT apparent is that the largest prop (14x7) is only the largest prop for the 3S pack and the smallest prop (11x8) is the largest prop recommended for the 4S pack. It is not a range at all, but a recommendation for each type of pack with this motor.

A much better way to list them would be
3S up to 14x7
4S up to 11x8

Not all props are created equal. That is another reason for having a power meter! One manufacturer's 14x7 will not be placing the same load on the motor as another manufacturer's 14x7. It is entirely possible that one company's 14x7 will fall within the safe operating limits for the power system while another company's will be outside the safe operating zone. Only flying will prove which prop is best in a given application.

Power Levels for Various Types of Aircraft

This is Common Sense RC's table suggesting power levels based on Watts (watts in) per pound for ready to fly aircraft weight. It is a reasonable guide.

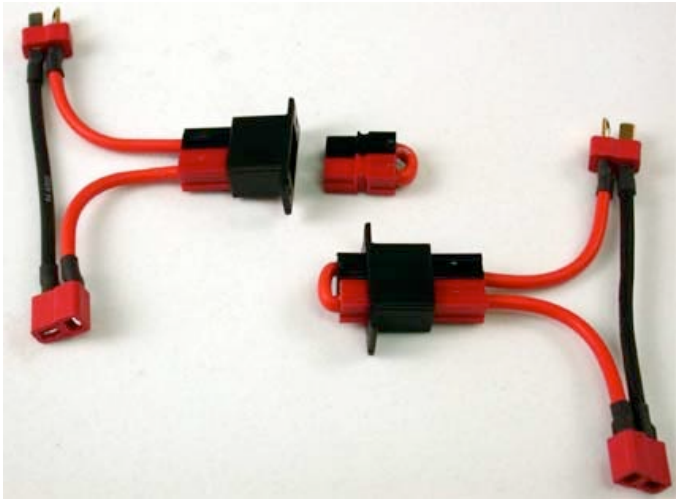


Tips for Being Successful with Electrically Powered Flight

1.) Start out slowly and take the time to learn what you need to know
2.) Avoid impulse purchases - have a specific goal in mind
3.) Glow or gas conversions should be put off until you have acquired the knowledge to do so
4.) When choosing power systems, at first, follow the recommendations of the designers of plans and kits and the recommendations of airframe manufacturers and suppliers
5.) Get the proper equipment to do it right the first time
6.) Ask reliable sources for input and guidance with a project, especially before an equipment purchase – it is best and cheaper not to try to 'go it alone'

Safety Precautions

1.) Store Li-Poly batteries safely and away from combustibles.
2.) Remove the propeller or blades from the motor when working on the radio system and the power battery must be plugged in.
3.) Plug in the power battery just prior to a flight.
4.) Unplug the power battery immediately after landing and returning the aircraft to the pit area.
5.) Be aware that once the power battery is plugged in, the motor may run.
6.) Arming switches and ESCs may or may not keep the motor from running once the power battery is plugged in.
7.) Make or break arming switches, like those sold by Maxx Products International, LLC., are an excellent type of safety "switch", especially for large scale aircraft.



Other Resources:

Online forums:

RC Groups, Watt Flyer, RC Universe and more - be aware that some of the experts on the forums started flying electric RC last week. Most forums contain about 98% 'noise' and about 2% decent advice. There is useful advice to be found, but finding it can be quite time consuming.

An **excellent independent site** is RC Model Reviews. The author has excellent knowledge and is the most unbiased reviewer I've ever read. The reviews and information provided on the site are not just for electric fliers.

Books: The majority of books about electric flight are 'old' and contain a lot of outdated information.

Two books that are not outdated are RCadvisor Model Airplane Design Made Easy and RCadvisor ModiFly. Both are by Carlos Reyes. He also has an excellent Web site known as RCadvisor. Both books are available on the Web site.

The EFO Web site and monthly *Ampeer* electric flight newsletter have a lot of reliable information regarding electric flight topics.

I'm willing to answer, or try to find answers, for questions regarding electric flight at kmyersefo@mac.com

Ken Myers' Modeling Background

1958 Started CL (mostly Cox 0.49) & rubber powered free flight (Guillows, Sterling, Comet)
1960 Started RC with ground based Tx and escapements, small displacement glow & diesel engines
1969 Started using Citizenship handheld TX with pulser and Rand actuators
1972 First proportional 2-ch Cox-Sanwa used with Cox 0.49/0.51, followed by Cox-Sanwa 4-channel and Enya RC engines, then switched to Futaba as Cox-Sanwa (later marketed as Airtronics) became harder to get
1980 Started AMA pattern flying and traveling to meets; Flew Novice, Sportsman then Advanced
1982 First electric, Midwest Sweet Stik 40 with Astro Flight Ferrite 25 and 12 and 14 NiCads
1982 Met Keith Shaw (Mr. Electric) at IMAC meet, both flying glow aerobatic biplanes at time
1984 First 4-stroke, Enya .36 used on small pattern plane
1985 Started Mid-America Electric Flies as CD with Keith Shaw of the Ann Arbor Falcons
1987 Stopped flying glow engines (except when training at Midwest)
1988 Started Electric Flyers Only and *Ampeer* electric flight newsletter
1995 & 1996 CD of electric events at the Nats in Muncie & chairman of National Electric Aircraft Council (NEAC)
1982 - 2005 used mostly Astro Flight cobalt brushed motors in most planes
1996 EFO site started online and the *Ampeer* goes online as well
2003 First brushless outrunner, AXI 2820/10, Castle Creations Phoenix 45
2006 First Li-Poly battery, 4S1P True RC 4000mAh used in Sportsman Aviation Sport Stik - First Li-Poly charger Astro Flight 109
2006 First used E-moli and “A123” 2300mAh cells
2009 First scratch built Foamboard plane, Modifly from Rcadvisor's Modifly by Carlos Reyes - last Li-Poly purchased, only one left in use, rest were given away
2009 Mid-Am celebrates its 25th year

Over the years Ken Myers has authored articles for “Model Airplanes News”, “Sailplane and Electric Modeler”, “Electric Flight UK”, and other magazines.

Ken Myers, President Electric Flyers Only (decades), Editor *Ampeer* electric flight newsletter (decades), Vice-president Midwest RC Society (decades), Editor Midwest Monitor newsletter, President and founder of the Union Lake Flying Organization (now United Flying Organization in Heartland, MI), Contest director (UFO pattern meets 1980-1986, electric meet Mid-Am since 1985), AMA NEAC (National Electric Aircraft Council) SIG chairman 1995 & 1996, Head flight instructor Midwest since 2008, AMA Leader Member (decades)

Major accomplishment in electric flight, learning from and reporting on Keith Shaw's phenomenal Scale electrics.

Main interest - sport and sport scale electrically powered fixed wing aircraft.

Sources referenced in the article in order of appearance:

Indoor –living room flyer:
http://www.microflight.com/Butterfly-Livingroom-Flyer

Backyard: http://www.stevensaero.com/StevensAero-MudBug-Electric-RC-Airplane-Indoor-DiddleBug-SA-KIT-MUDBUG-p-18968.html

Park Flyer – Scale: http://www.stevensaero.com/StevensAero-Pietenpol-Sky-Scout-400-Laser-Cut-Scale-Electric-Park-Flyer-p-20490.html

3D: http://www.speedfreeks.com/reviews.php?service_id=19

Sport: http://electroflying.com/fusion.html

Electric Ducted Fan (EDF):
http://www.nitroplanes.com/f20tijetnera.html

Electric Helicopter:
http://www.nitroplanes.com/6chfacc3daer.html

Old Timer:
http://www.bmjrmodels.com/catalog.cfm?ID=New%20Model%20Kits&ID2=rc

Thermal Sailplane:
http://www.nitroplanes.com/mo16arfrarec.html

F5B:
http://www.airstrike.com.au/New%20Electric%20Models.htm

Race:
http://www.horizonhobby.com/Products/Default.aspx?ProdID=EFL4200

Multi-motor:
http://www.horizonhobby.com/Products/Default.aspx?ProdID=HAN4610

Foamie:
http://www.rcgroups.com/forums/showthread.php?t=681556&highlight=blu+baby

QuadCopter controlled by iPhone or iPad
http://www.ardronehelicopters.com/

WCL

”Cubic Wing Loading: What it is and how to use it.” Also known as - Wing Cube Loading by Ken Myers:
http://homepage.mac.com/kmyersefo/M1-outrunners/M1-outrunners.htm#CWL

“MODEL DESIGN & TECHNICAL STUFF: WING CUBE LOADING (WCL)” by Frances Reynolds, Model Builder - September 1989:
http://homepage.mac.com/kmyersefo/CWL/reynolds.htm" target=_blank>

“Aircraft Performance Parameters Revisited : WING CUBE LOADING”, by Roger Jaffe, Model Builder - June 1994:
http://homepage.mac.com/kmyersefo/CWL/jaffe.htm

“3D Wing Loadings: a Better Way to Scale Models and Compare different size models easily”, by Larry Renger, Dec.1997:
http://homepage.mac.com/kmyersefo/CWL/larry.htm

Electric Flight UK Online WCL Calculator: http://www.ef-uk.net/data/wcl.htm

Power Meters
Progressive RC PowerLog 6S:
http://www.progressiverc.com/index.php?page=shop.product_details&flypage=flypage.tpl&product_id=135&category_id=12&option=com_virtuemart&Itemid=1

Hyperion Emeter 2 (expensive, but HIGHLY recommended!!!): http://www.allerc.com/hyperion-emeter-version-2-and-rdu-set-p-4323.html

P1 from Hobby Partz and similar meter at Hobby King:
http://www.hobbypartz.com/88e-aepm300-p1-watt-meter.html
&
http://www.hobbyking.com/hobbyking/store/uh_viewItem.asp?idProduct=10349

Watt's Up Meter: http://www.powerwerx.com/tools-meters/watts-up-meter-dc-inline.html

BP Hobbies has several choices:
http://www.bphobbies.com/view.asp?id=A0320107

Tower Hobbies: http://www.towerhobbies.com

Manual for the Watts Up meter, but can be applied to all:
http://www.powerwerx.com/techdata/Watts-UP-V2.pdf

Power Meter Videos:
Video 1: http://www.youtube.com/watch?v=kfs4Bs3H7gw
Video 2: http://www.youtube.com/watch?v=_tjEJmq1aB0
Video 3: http://www.youtube.com/watch?v=PiCyDSMOySw

Chargers:
Progressive RC is a great source for decent chargers:
http://www.progressiverc.com/index.php?page=shop.product_details&flypage=flypage.tpl&product_id=5&category_id=1&option=com_virtuemart&Itemid=1

TME Xtrema: http://www.tmenet.com/products/lithium-charger/xtrema-charger

Li-PoSack brand charging sack: http://www.liposack.com

LiPoLocker.com Battery Charging Security System Review:
http;//www.rcgroups.com/forums/showthread.php?t=1333205

Lithium Polymer disposal instructions from Common Sense RC:
http://www.commonsenserc.com/LiPo_v2_new_instructions_warranty.pdf

Li-Poly Resources
Understanding RC LiPo Batteries:
http://www.rchelicopterfun.com/rc-lipo-batteries.html

Proper Li-Poly management:
http://www.rcgroups.com/forums/showpost.php?p=16421261&postcount=1

More Information on A123 cells:
http://homepage.mac.com/kmyersefo/M1-outrunners/M1-outrunners.htm

Sanyo Eneloop pre-made Tx packs at No BS Batteries:
http://www.hangtimes.com/txpacks.html

Killing Tx Li-Poly by leaving Tx on:
http://www.rcgroups.com/forums/showthread.php?t=1358190

Battery Resources regarding temperature
Battery University.com:
http://batteryuniversity.com/learn/article/discharging_at_high_and_low_temperatures

Electric Wingman: Lithium Polymer Battery Guide:
http://www.electricwingman.com/guides/lithium-polymer-battery-guide.aspx

Connectors:
Connector article by Stefan Vorkoetter:
http://www.stefanv.com/rcstuff/qf200001.html

Handy "Gripper" Covers for Deans Ultra Plugs from HDi
http://www.hdiproducts.com/

Crimper for APP connectors:
http://www.westmountainradio.com/product_info.php?products_id=PWRcrimp

Current RC Groups connector thread:
http://www.rcgroups.com/forums/showthread.php?t=1350290

Multi power plug adapter from Progressive RC:
http://progressiverc.com/index.php?page=shop.product_details&flypage=flypage.tpl&product_id=55&category_id=5&option=com_virtuemart&Itemid=1

More balance plug information:
http://www.rclipos.com/Accessories.htm

ESCs

Castle Creations Thunderbirds:
http://www.castlecreations.com/products/thunderbirds.html

Castle Creations Phoenix:
http://www.castlecreations.com/products/phoenix-180.html

Castle Creations ICE:
http://www.castlecreations.com/products/phoenix_ice.html

Castle Creations BEC or BEC Pro:
http://www.castlecreations.com/products/ccbec.html

What is a BEC?:
http://www.dimensionengineering.com/BECFAQ.htm

A beginner's guide to switching regulators:
http://www.dimensionengineering.com/switchingregulators.htm

Lucien Miller, of Innov8tive Designs, provides information of the types of BEC units, and which type is appropriate for which application.
http://www.rcgroups.com/forums/showpost.php?p=16938784&postcount=7580
Innovative Designs: http://innov8tivedesigns.com/

Motors:
Hobby King http://www.hobbyking.com

TR 35-48-C 800kv:
http://www.hobbyking.com/hobbyking/store/uh_viewItem.asp?idProduct=4909

Scorpion: http://innov8tivedesigns.com

Scorpion SII-3020-780:
http://www.innov8tivedesigns.com/product_info.php?cPath=21_25_80&products_id=521&osCsid=fceea02467fa5817d403e784322ae79f

Cermark NEO 25-780:
http://www.cermark.com/products/NEODYM-25-series-brushless-outrunner-motor%3A-KV%3A-780.html

More on Kv and how to measure it:
http://homepage.mac.com/kmyersefo/M1-outrunners/M1-outrunners.htm#KV

Drive Calculator: http://www.drivecalc.de

Props
APC Prop RPM limits:
http://apcprop.com/v/html/rpm_limits.html

E-flite Power 25:
http://www.horizonhobby.com/Products/Default.aspx?ProdID=EFLM4025A#quickSpecs

Common Sense RC's power table:
http://www.commonsenserc.com/page.php?page=howto_DetermPowerRequirements.html

Safety Precautions:
Make or break arming switch, Maxx Products International
http://www.maxxprod.com/mpi/mpi-21.html

Other Resources
RC Groups http://www.rcgroups.com/forums/index.php

Watt Flyer http://www.wattflyer.com/forums/

RC Universe:
http://www.rcuniverse.com/forum/default.asp?fh=1

RC Model Reviews: http://www.rcmodelreviews.com/

RCadvisor Model Airplane Design Made Easy and RCadvisor ModiFly: http://www.rcadvisor.com

Electric Flyers Only (EFO) Web site:
http://homepage.mac.com/kmyersefo

Ampeer electric flight newsletter:
http://homepage.mac.com/kmyersefo/ampeer.html#TOP