The Complete E-power System From Prop-nut to Battery

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What is a "SYSTEM"

Dictionary.com defines a "system" as:
An assemblage or combination of things or parts forming a complex or unitary whole.

An electric model power "system" is a collection of "things" that when properly assembled motivate our models into committing aviation.

What comprises an E-Power system?

(from back to front)

- **A battery**
  - **LI-Poly, NICD, NIMH, Li-Ion**
- **Wire**
- **Connectors**
- **ESC (Electronic Speed controller)**
  - **BEC (Switching or Linear Regulator)**
  - **Opto-Isolated**
- **More wires**
- **More connectors (sometimes)**
- **A Motor**
  - **Brush, Brushless, Inner-runner, Outrunner**
- **A Prop adapter**
- **A Prop**

Why it is important to choose each component with respect to the other.

Choosing a single component without considering the other parts of the system can:

1. ***Cause the failure (mechanical or electrical) of a component immediately.***
2. ***Cause the failure (mechanical or electrical) of a component over time.***
3. ***Not allow the model to leave the ground.***
4. ***Cost the modeler more money than required.***
5. ***Cause a crash!***

Think end to end!

Not one piece at a time!

Thinking end to end!

Thinking end-to-end means to pick components that work and play well together, producing a system that will perform well and last for years.

This is NOT the mindset of many turn-key systems sold to the modeler.

Often a manufacturer/distributor will make a poor choice of a component simply for the sake of cost or something as simple as inexperience.

This poor choice can show up as lack of performance immediately, or can rear its ugly head not long into the life of the product.

Begin the Process

If we do not own any of the components we need to complete the system, the process begins by deciding which of the following class of models are we interested in:

- **indoor (< 8 oz)**
- **indoor/outdoor park/slow flyer/3d (<16 oz)**
- **outdoor sport/3D (1-2 lbs)**
- **outdoor sport/3d (>3 but < 10lbs)**
- **outdoor sport (> 10lbs)**

ELECTRIC CURRENT --- AMPS (DIRECTLY RELATED TO POWER) DRIVES MOST OF OUR DECISI0NS ON COMPONENTS!

Assignment of Power Required

Once the class of model is selected, we make some broad-brush assumptions on how much power we will need:

indoor (< 8 oz) - 20-30 watts
indoor/outdoor park/slow flyer/3d (<16 oz) – 60-150 watts
outdoor sport/3D (1-2 lbs) – 120-250 watts
outdoor sport/3d (>3-6 lbs) – 300-800watts
outdoor sport (> 7 lbs) – 1000-3000 watts

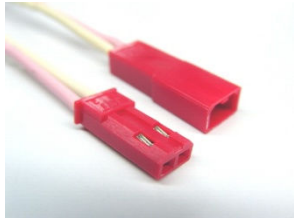
Determination of Current

Since current is our major concern when choosing our e-power system components, we convert the power to current. Using the multiples of 7.4 (2S Lipoly), 11.1 (3S), 14.4 (4S), 18.5 (5S) and so on, we divide the power required by the voltage to get current:

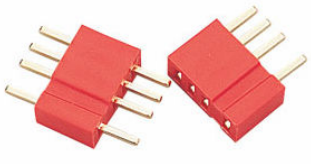
indoor (< 8 oz) - 2-6 amps (usually 2S models)
indoor/outdoor park/slow flyer/3d (<16 oz) – 6-12 amps (2 or 3S)
outdoor sport/3D (1-2 lbs) – 15-30 amps (3S models)
outdoor sport/3d (>3-6 lbs) – 30-40 amps (3-6S)
outdoor sport (> 7 lbs) – 30 to ???? amps (more about this later) (6-12S)

The easy part – picking a battery to ESC connector

Now that we have determined the approximate amount of current we will need to fly the model, the easiest thing to pick is the connectors appropriate to handle that current . Connectors come in many different shapes and sizes and for the most part is really a preference to the modeler.



JST type
For less than 3 amps



Deans 4-pin (use two pins for + and two for -)
For 3-8 amps

APP (Sermos)
For 10 - 45 amps

Deans Ultra plug
For 20-60 amps

Ramifications of making a poor connector choice

Choosing a connector that cannot handle the current……

<u>will</u>:

1. Cause a loss in power

<u>Could:</u>

1. Damage the connector (by overheating)

2. Cause a crash

Picking an ESC

The choice of ESC's is primarily based on current (and motor type – Brush Vs Brushless) but other factors must be introduced.

1. **How many cells will the model be using?**
    1. **Many lower current ESC's only handle up to 10 Ni or 3 Li-Poly cells.**
    2. **Higher current ESC's may go as high as 12 li-poly cells.**
2. **Do I want a BEC (battery eliminator circuit)?**
    1. **Linear BEC regulator –**
        - **Limited number of servos based on battery voltage**
        - **Limited size of servos (torque) based on amperage output of regulator**
    2. **Switching BEC regulator**
        - **Higher servo count (or larger servos) sometimes up to 6 li-poly**

Picking an ESC continued

3. What additional features do I need?
   1. Brake?
   2. Li-poly Vs Ni Vs Li-Ion voltage cut-off?
   3. Timing?
   4. Operating frequency (PWM)?
   5. Sing a song on start-up?

Ramifications of making a poor ESC choice

Choosing an ESC that cannot handle the motor current .....

<u>will</u>:

1. **Create smoke.**
2. **Make you take out your wallet again.**

<u>Could:</u>

1. **Damage the esc (without releasing the smoke) .**
2. **Cause a crash.**

Ramifications of making a poor ESC choice

Choosing an ESC with a BEC that cannot handle the servo current .....

<u>will</u>:

1. **Create smoke.**
2. **Make you take out your wallet again.**

<u>Could:</u>

1. **Damage the esc (without releasing the smoke) .**
2. **Cause a crash.**

Picking wire size

Sometimes we need to extend the reach from our battery to our ESC or our ESC to our motor. We usually do this by soldering on extensions to the ESC.

There has been a great debate on which is better, having long wires to reach the motor, or put the ESC by the motor and run long wires from the battery to the ESC.

For small extension distances it is probably not important, but for any increase in the supplied wire lengths, it is better to keep the battery to ESC wires as short as possible. Always use the same gage wire supplied by the ESC. If the wires coming from the battery are a smaller gage than the ESC, we have a problem..... More to come...

Ramifications of making a poor wire size choice

Choosing wire that cannot handle the current in the system.....

<u>will</u>:

1. Cause a loss in power.

<u>Could:</u>

1. Cause a short, destroying a battery and/or ESC.

2. Cause a crash.

Picking motors

Basic rule:

Unless weight is a critical concern in you model:
Pick the largest (longest, biggest diameter) motor for the class/power of aircraft intended.
It is better to underutilize a bigger motor than to overburden a smaller motor.

With the significant reduction in weight of our models since the introduction of Li-Poly and Li-ion batteries, it is very possible that your model will not balance (will be tail heavy). Don't add lead…. Add a bigger, slightly heavier motor!

Picking motors, cont.

Motor variables to consider:

1. **Diameter (bigger = more power!)**
2. **Length (bigger = more power!)**
3. **Kv (dependant primarily on the above two numbers, wire gage and number of turns on the armature/stator)**
   - **Low Kv…. Bigger prop turning slower**
   - **High Kv…. Smaller prop turning faster**
4. **Inner runner vs outrunner (brushless motors only)**

   Inner runner – fast turning for racing, or requires gearbox to turn bigger prop.

   Outrunner – turns bigger props without requiring a gearbox.

Ramifications of making a poor motor choice

Choosing *too* small a motor (or Kv that is too high) that is not up to the task of flying your model.....

will:

1. **cause poor flight performance (prop too small for the intended flight speed of the model).**

Could:

1. **Damage the battery (from a prolonged duration at a high throttle setting).**

Ramifications of making a poor motor choice

Choosing a motor that is *too* big (or Kv too low) for the model.....

will:

1. **Cause poor flight performance (prop is too small (because of ground clearance concerns) or voltage too low).**

Could:

1. **Cause a crash (if the aircraft even gets into the air!)**

Choosing Batteries
(Li-Poly)

The battery, more so than the motor, can be the weakest link in the chain. Even if all the other choice you made are sound, a poor choice in battery can really ruin your day.

Rule #1:

Never, ever **believe the "C" rating a manufacturer/distributor quotes for their batteries.**

Rule #2:

Use the "C " rating number as a guide and try not to exceed 75% of that rating at full power and better to stay closer to 50% of that number for good life of the battery.

Choosing Batteries (cont)
(Li-Poly)

Rule #3:

Choose name-brand batteries. Don't trust re-labeled batteries. The big names that I have had good experience with are :Enerland (Tanic and Polyquest) and ThunderPower. There may very well be more out there, but I just don't have the time to test them all!

There are hundreds of battery manufacturers in China that will sell anything to anyone. Many of them do not produce a cell that is compatible with the currents we demand for model aircraft flight.

Rule #4

Adhere to rules#1-3 !!!

Choosing Batteries (cont)

(Li-Poly)

Example:

Determine cell count:

Your model requires 300 watts to fly well. You'd like not to draw more than 30 amps as this is the limit of your speed controller. 300watts/30amps = 10Volts. This is approximately 3 Li-poly cells (under load).

Determine capacity:

If 30amps is 50% of the "C" rating then you need a battery that can handle at least 60amps. A battery with a "25C" discharge rating would require a capacity of 2400 mAh (2.4amp) minimum, or a 4000mAH pack with a 15C rating.

Ramifications of making a poor battery choice

Choosing a battery that cannot handle the current in the system.....

<u>will</u>:

1. ***Cause a loss in power (internal resistance of the battery pack causes a greater than tolerable voltage drop under load).***

<u>Could</u>:

1. ***Cause a "bloated" pack , destroying the battery and/or possibly causing a fire.***
2. ***Cause a reduction in capacity in the pack prematurely over time.***
3. ***Cause pre-mature shutdown of the motor when using either a BEC equipped ESC or an opto-isolated version.***
4. ***Cause a crash.***

Choosing Propellers

The propeller, the "legs" of the system, is ALWAYS picked with an ammeter (or wattmeter), not by an organic sentient being!

Even if a motor manufacturer specifies a specific size prop with a specific cell count that matches your models needs, one should always check the current and power in the system with a "watt meter".

Choosing Propellers

(cont)

Propeller types:
Slow flyer Vs "anything else"

The slow-flyer prop such as the similar named APC line or many of the GWS props are meant for just that—— slow flyers; lower powered, lightly loaded models. APC gives RPM/Diameter values that should not be ignored, but a general rule of thumb is that if you an inputting greater than 120 watts into your system , you will be probably better off with a true "electric" prop; one with stiffer blades and a thicker hub.

Spinning a "slow flyer" prop faster than intended usually wastes power by drawing much more current and returning nothing for it (thrust and/or speed)

Choosing Propellers

(cont)

Do I really need to use an "electric" prop?

Props designed specifically for electric flight (typically designed for RPMS that are far lower than glow powered aircraft) are generally more efficient at converting the rotational motion from our motors into useful energy which moves our models through the air. However, using a "glow" wood prop of the proper diameter and pitch on a scale model that had a "wood" prop is quite cool and for the most part, the average modeler will not see the difference in performance.

Choosing Propellers
(cont)

Can I use a 3 or 4 bladed prop?

Yes, but generally at a sacrifice of speed.

Forget the rule of dropping an "inch" in diameter for the same pitch rule (for changing between 2 to a 3 bladed prop). This only works in the 9-10" diameter range.

Power consumption increases approximately 15-20% going between a 2 bladed prop and a 3 bladed prop with only a 10-12% increase in thrust, however the speed of the model will drop by 5-8%!

Choosing Propellers
(cont)

Can I use a 3 or 4 bladed prop?

Yes, but the only good reason to do so is either:

1. **Ground clearance is a problem. (adding blades absorbs watts faster than pitch or diameter).**
2. **I'd like to swing a scale-like prop.**

However, If you cannot get to near the scale diameter prop with a reasonable pitch (based on power consumption limits of your system), a "small" multi-bladed prop on an electric scale model looks just as silly as it would on that glow model and performance WILL suffer!

Choosing Prop Adapters

Little tiny things up front that are often overlooked!
The prop adapter MUST securely fasten your prop to your motor shaft!

Prop adapters come in three basic types:

1. **Set Screw**
   Not found that often for larger shaft motors, thankfully!
2. **Collet**
   My preferred adapter. Solid, no slop attachment (when made correctly!).
3. **Prop Saver**
   Good for low-power applications, those involving slow-flyer props only!

DA END

Fly clean,
Fly quiet,
Fly and
charge safe!