Selecting Electric Power Setups

With the continuing trend towards cheaper and more powerful brushless motors, Electric Power (EP) is becoming more attractive as an alternative to Internal Combustion (IC). However, to the uninitiated, there can appear to be a bewildering array of motors (size and kV numbers), batteries (voltage/cell count, capacity and 'C' ratings) and speed controllers, all of which must be matched to an appropriate propeller to maximise performance and efficiency. This article provides a description of my approach to selecting a power setup for an EP model and will hopefully help others who may be thinking about taking their first steps with EP.

Power

Where to start? The first thing to consider with any new EP model is the amount of power we want our setup to produce. We are looking for a setup that will provide adequate performance without being greatly overpowered for our needs which would just lead to us spending most of the time on low throttle with a resultant loss of efficiency. There is a rough 'rule of thumb', based on the type of aircraft/style of flying and the expected model flying weight that can help us here. The following table gives some approximate power ranges for different aircraft that I have found to provide a good starting point.

Model Type or Flying Style	**Example**	**Power Range in Watts (W) per pound (lbs)**
Trainer/Powered Glider/Scale Light Aircraft/Vintage	Mentor, Habicht, Cub, Junior 60	60 - 100
Sports/Scale Warbird/Bi-Plane	Wot4, Mustang, Gemini	80 - 120
Aerobatic/Pattern Ship/Warm Liner	Yak 54, Angel, Blaze	120 - 200

3D Aerobatic	Shock Flyer, AddictionX	150 - 250
Hot Liner/Pylon Racer	Speedy, Nemesis	200 - 300+

As an example, let's look at my Hyperion Extra 260. This is an aerobatic 1370mm (54 inch) wingspan model with an intended flying weight of around 2.25kg (5lbs). Referring to the third line of the table above, we can calculate the power should be in the range of 600W (120W/lbs times 5lbs) to 1000W (200w/lbs times 5lbs). Lets pick a power in the middle of the spectrum and go for **800W.**

Flying Speed

The next consideration is how fast we want the model to fly. Obviously we want to fly faster than the stall speed of the aircraft with enough on tap to fly in an appropriate style for the aircraft. Again, we can apply a 'rule of thumb' as shown in the following table. Generally, the bigger the model the faster we may want to fly so small models will be at the lower end of the spectrum and large models at the upper end.

Model Type or Flying Style	**Target Flying Speed (mph)**
Trainer/Powered Glider/Scale Light Aircraft/Vintage	30 - 50
Sports/Scale Warbird/Bi-Plane	40 - 70
Aerobatic/Pattern Ship/Warm Liner	50 - 80
3D Aerobatic	25 - 50
Hot Liner/Pylon Racer	80 - 100+

For the example Extra 260, it is a mid-size aerobat so a target speed of around **65mph** should be about right.

Thrust

Next we want to consider how much thrust we need from our setup. Although a model may well fly with a thrust of around 20% to 30% of the model's flying weight, we probably want a bit more than this to allow for the resistance on our grass strip when taking off and also to provide the option of ‘powering out’ in the event of a go-around, tip stall, etc. For easy aerobatics, we will want the thrust to be at least 100% of the model’s flying weight.

For the Extra, let us aim for a thrust of 150% of the model so we should be able to fly unlimited verticals. This gives a thrust of 2.25kg times 1.5 = **3.38kg** (7.5lbs).

Propeller Diameter

Next we must look at the maximum size of propeller that the model can accommodate. This is done by measuring the distance from the prop centre line to the ground with the model at a level attitude. We will want to take a bit off this measurement to allow for grass, uneven ground and the potential for a nose down attitude when taking off or landing.

For my Extra, the measured distance is 9 inches so taking off 2.5 inches as a safety margin gives a maximum prop radius of 6.5 inches and a diameter of **13 inches**. Generally we will want to use the biggest prop that we can as this will be most efficient, as long as we can maintain clearance and don’t end up with a prop that looks ridiculously over/under scale. The exception comes where we are going for all out speed where we might choose a smaller, faster spinning prop.

Battery Voltage

The final consideration is the battery voltage (or cell count). We may find our airframe has been designed with a particular battery size in mind. If not, we need to decide on the best battery based on available space, cost and availability (we may already have a battery that we want to use). The voltage will directly influence how much current we will need to pull to achieve the power we are aiming for. The required current is calculated by dividing the power (in Watts) by the voltage (in Volts) to give the current (in Amps). For the Extra 260, we can calculate the current we would pull for a range of different nominal battery voltages:

On a 2s LiPo (7.4V) we will pull 800W divided by 7.4V = 108 Amps

On a 3s LiPo (11.1V) we will pull 800W divided by 11.1V = 72 Amps

On a 4s LiPo (14.8V) we will pull 800W divided by 14.8V = 54 Amps

On a 5s LiPo (18.5V) we will pull 800W divided by 18.5V = 43 Amps

On a 6s LiPo (22.2V) we will pull 800W divided by 22.2V = 36 Amps

Generally, we will want to limit the current to a reasonable value as more current equals more heat and therefore requires a bigger (and more expensive) ESC to handle this heat. Limiting current to a maximum of around 60A is a good starting point as 60A speed controllers are relatively small and inexpensive and most of the commonly used battery connectors (Deans, XT60, EC3, etc.) are rated to around this current. We always have the option of increase our battery voltage (cell count) to reduce current draw for a given power. This is why high power setups (hot liners, large models) often use high cell count batteries (6s and above).

For the Extra, we will limit ourselves to a **4s** LiPo battery with a nominal voltage of **14.8V** as this will give us a manageable current of 54A.

We now have all the information we need to go and look for a motor and prop combination for the Extra that gives around **800W** of power, **65mph** pitch speed, **3.38kg** of thrust using a **13 inch** propeller and a **14.8V** 4s battery.

<u>Finding a Set Up that Works</u>
There are a number of ways we can now find a suitable EP setup:

1. We could go and buy a range of motors, batteries, propellers and measure the results using a Watt meter, thrust gauge and tachometer - but this will be expensive!

2. We could use a software calculator (such as Castle Creations' Flight Calculator http://www.castlecreations.com/support/flight_calculator.html) to do the testing for us - but this can still be confusing to a new comer and is subject to calculation error.

3. We can make use of motor manufacturer's test data - recognising that some manufacturers may bend the truth a little to make their products stand out from the competition!

Let us use the third of these options and have a look at a motor manufacturer's website to find some test data that meets our needs. I like to use Scorpion Power's website (http://www.scorpionsystem.com/catalog/motors) as they publish full test data for all of their motors. Their S22, S30 and S40 series motors are good for small (under 1kg), medium (1kg to 2.5kg) and large (above 2.5kg) sized models respectively. Below is an example of the tables that Scorpion publish on the website and guess what - this appears to give us a combination that meets our needs for the Extra!

Scorpion SII-3026-710 Motor Propeller Data

Motor Wind	Motor Kv	No-Load Current	Motor Resistance	I Max	P Max (3S)
9-Turn Delta	710 RPM/Volt	Io = 1.56 Amps @ 10v	Rm = 0.022 Ohms	60 Amps	1000 W

Outside Diameter	Body Length	Total Shaft Length	Shaft Diameter	Motor Weight
37.5 mm, 1.476in.	51.7 mm, 2.035 in.	80.5 mm, 3.169 in.	4.98 mm, 0.197 in.	205 gm, 7.18 oz

Prop Manf.	Prop Size	Input Voltage	Motor Amps	Watts Input	Prop RPM	Pitch Speed	Thrust Grams	Thrust Ounces	Thrust Eff. Grams/W
APC	10x10-E	14.8	37.47	554.5	9,030	85.5	1446.1	51.01	2.61
APC	11x5.5-E	14.8	27.43	405.9	9,573	49.9	2033.4	71.73	5.01
APC	11x7-E	14.8	32.18	476.3	9,271	61.5	2140.3	75.50	4.49
APC	11x8-E	14.8	35.86	530.7	9,189	69.6	2072.9	73.12	3.91
APC	11x8.5-E	14.8	38.32	567.1	8,994	72.4	2096.3	73.94	3.70
APC	11x10-E	14.8	44.53	659.1	8,796	83.3	1904.2	67.17	2.89
APC	12x6-E	14.8	36.50	540.2	9,160	52.0	2596.5	91.59	4.81
APC	12x8-E	14.8	45.16	668.4	8,769	66.4	2315.6	81.68	3.46
APC	12x10-E	14.8	52.52	777.3	8,335	78.9	2389.6	84.29	3.07
APC	12x12-E	14.8	58.60	867.2	8,085	91.9	2193.3	77.37	2.53
APC	13x4-E	14.8	31.10	460.2	9,408	35.6	2544.9	89.77	5.53
APC	13x6.5-E	14.8	49.23	728.5	8,545	52.6	3095.6	109.19	4.25
APC	13x8-E	14.8	53.12	786.1	8,358	63.3	3005.6	106.02	3.82
APC	13x10-E	14.8	65.34	967.0	7,582	71.8	2629.9	92.77	2.72
APC	14x7-E	14.8	59.47	880.1	8,026	53.2	3456.5	121.92	3.93
APC	15x4-E	14.8	49.03	725.6	8,528	32.3	3666.7	129.34	5.05

This shows that a **Scorpion SII-3026-710** motor and **APC 13x8-E** prop combination on a **14.8V 4s** battery produces 786 W of power (versus the 800W we specified), 63mph pitch speed (versus the 65mph we specified) and 3.01kg of thrust (versus the 3.38kg we specified), so should be close enough to what we want.

Now, we could stick with the Scorpion motor identified and that would give us a perfectly good set up, the only problem being that Scorpion motors are a little on the pricey side - the SII-3026-710 is going to cost us around £100! What we can do instead is cheat and find an equivalent motor from another manufacturer. What do we mean by equivalent? Well, what we want is a motor that spins at a similar speed (the kV or RPM/Volt figure - in this case 710kV) and has a similar current handling ability. The weight of the motor actually approximates to its ability to handle current as more weight = more copper windings = more current handling, so any motor weighing around **205** grams with a kV of around **710** should do us. For my Extra, that is exactly what I did and found that the **Turnigy SK3 4240** (£20) from HobbyKing is a good substitute with a weight of 195 grams and a kV of 740.

Battery Capacity and 'C' Rating

The final part of the jigsaw is to work out the capacity and 'C' rating of the battery that we are going to use. The capacity is measured in milliamp hours (mAh) and tells us how long the battery will last on a full charge. The bigger the capacity, the longer the flight time but that comes with a corresponding increase in weight. We will usually want the biggest battery we can fit whilst keeping within the specified flying weight of the airframe. For my Extra, once all of the other components were taken into account, I found I could afford a battery weighing up to around **475 grams**. The closest 4s battery I could find was a 4s 4000mAh which came in at 465 grams.

The battery 'C' rating is a measure of how much current the battery can deliver. It is expressed as a multiple of the capacity (C) so as an example a 10C battery with a capacity of 4000mAh would be able to deliver 40,000 mA or 40A (4000mA times 10 divided by 1000). We have already calculated the current draw our setup requires so as long as the battery C rating gives more current than this, we should be fine.

For the Extra, I was going to draw around 55A of current, so I calculated that I needed a battery with a C rating more than **13.75C** (55,000mA divided by 4000mA). In practice, LiPo batteries are now all at least 20C so almost any 4000mAh battery should be able to deliver the current I needed.

Summary

So, I have presented my approach to selecting a power set up that hopefully demystifies the process for anyone thinking of taking the plunge but unsure where to start. The proof of the process is in the flying and anyone who has seen my Extra in the air will know it certainly has all the speed and power needed! The set up I have ended up with in the Extra is:

- Motor: Turnigy SK3 4240 740kV
- Propeller: APC 13x8-E
- ESC: 60A Hobbywing
- Battery: Zippy Flightmax 4S 4000mAh 20C