An Introduction to Radio Control Electric Flight

by Phil Langton

Information and Guidelines for entering the exciting world of Electric Powered R/C Flying

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INTRODUCTION:

The following information is presented to help any R/C Modeller get started in the interesting field of Electric Powered Flying. It is not intended as a scientific or academic treatise but rather a simple compendium of data, knowledge from the authors experience, and helpful jottings from our research of appropriate journals and magazines.

The writer conveys no responsibility nor accepts any liability for the interpretation or use of any of the following information.

ABOUT THE WRITER

Phil Langton is a 30 + year radio control flyer who has had an interest in model flight since early pre-teen years. Like many modern modelers he started in control line modeling transferring to radio in the 1970's when proportional control equipment became relatively affordable. His decades of employment in the Lift Industry and related electrical motor knowledge burnt a deep conviction that "electric" instead of "fossil fuel" powered radio control would one day be a reality. The Australian Lift Industry had a world wide reputation as innovators with one locally owned company developing out-runner motors for lifts in the 1980's.

It's no great surprise that with this background the writer has turned his passion for radio control model flying into a quest for "doing it electric"? After all ***watt*** *alternative is there?!*

If you need help, send an email to phil@langton.biz

RUMORS & MYTHS

My journey into Electric R/C Flight is littered with lessons learnt the hard way. Much advice although given with sincerity and good intent did not always help in the learning experience. So, although I have found the info herein appropriate for me, the reader must test all things for him/herself and use only what is suitable for their own needs.
The following quips and statements characterize how many modelers view this subject!

1. **Electric Flight is only OK for Gliders and slow, small high wing planes**.

Response: Bunkum!! Anything You can do I can do as well and maybe better!

2. **Electric Flight is expensive**.

Response: It can be, but it doesn't have to be. IC Pylon Racing and Competitive Aerobatic flying can cost "an arm and a leg"too if that's your bag.

3. **Electric Flight isn't up to Sport aerobatic, competitive aerobatics or helicopters**.

Response: Just plain wrong. There is a growing E.F. presence in all areas. In fact it is reported that an electric model won one section of the World Scale Competitions in the USA, in 2002. Since then many electric powered models have been "placed" in World Competitons.

4. **I've always been afraid of electricity**.

Response: Fair enough, high capacity, high discharge battery packs must be treated with much care and respect. Any fuel cell whether fossil or electrically based is a potential safety risk. It's a good illustration of the saying "Fire is a good servant but a bad master." However, proper care and safety ***is*** *vital. It's important to say right here that charging of any battery of any type inside motor vehicles is dangerous and should not be done.*

5. There isn't much equipment, kits or ARF's for electric.
Response: Wrong, wrong, wrong! It's the fastest growing section of the hobby, just take time to notice all the gadgets and gizmos appearing on the local Hobby Shops shelves and walls.

6. There aren't very many people into 'electric'.
It's only for the fringe technocrats!
Response: There are more people learning to fly using electric powered trainers today than the traditional IC powered Trainers. Trouble is, they are buying the cheap park flyers and bypassing the proper "Club Scene".
But at the club level a growing percentage of members are including electric models in their fleet. At some clubs we are seeing large scale permanent charging stations powered from the 240 volt mains supply.

7. All batteries are the same!
Response: No they aren't, and this is an area we need to learn a lot about. Take the time to study the available material. Join a like interest group and associate with the 'experts' in this field.

8. What happens if I try to charge my plane from my car battery? Will it catch fire?
Response: You can, and many people do but there are risks like flattening the car battery and not being able to start the car. Yes fire is possible, but that can happen with methanol fuel too.

9. **It all comes down to Common Sense.**
It's true, but it's a rare commodity these days. There are basic rules of flight that must not be ignored.
The Location of centre of gravity, power requirements, wing loading, battery condition, state of charge and all the usual principals are just as relevant as with any other model flight etc.

RULES OF THUMB & GOOD IDEAS:

The following guidelines will help the reader arrive at a satisfactory beginning in the exciting and challenging new field of Electric Model Flying. We've tried to use everyday language where possible, but the units of "Power" "Pressure" and "How much Fuel there is in the tank" end up being expressed as Watts, Volts and Amp Hours or derivations thereof; Sorry!

1. How much Power do I need for a given model?

Response: There are many ingredients in this equation, but here are a couple to get us started.

Power, is expressed as Watts and when related to the weight of the model can give the modeler their first check on whether a certain electric power combination will achieve the flight performance they expect. So, here are some statistics that are somewhat universally accepted.

50 to70 watts per pound for a slow hand launch floater.
70 to 100 watts per pound for fun aerobatics & ROG.
100 to 150 watts per pound to easily ROG off grass.
150 and above for competition, prop hanging etc
200 to 250 watts per pound for electric flan jet models.

2. Current limits for typical 'can' type brushed motors.

These are guidelines not rules. The following suggestions are MAXIMUM Amps that should be used by each motor, if you want to get a reasonable life out of your motor. Please appreciate that electric motors powered by DC will try to perform to the load placed on them, even if it means destruction!! They can be exceeded but there are consequences! For example the Speed 400 motor is quite good for a class of pylon racing and some pilots are quite happy to burn up a motor like this in one days racing. (After all, as the cost only $12 – 18 it's not a big expense.) But to apply this approach to everyday sport flying will only result in disappointment.

So, here are my suggestions for sensible upper limits for some of the popular 'can' type motors:-

Speed 400	*10 Amps*
Speed 540	*20 Amps*
Speed 600	*25 Amps*
Speed 700	*30 Amps*

Other brush type motors, especially those with adjustable timing etc can be run at much higher currents but mostly the manufacturers of these motors will give relevant instructions.

3. Current checks for typical brushless motors.

Brushless motors have introduced efficiencies in energy usage some say from as much as 10 to 20%! This is an enormous benefit to the quest for satisfactory electric flight. To give an idea of how important this is, take the simple 380 can motor, now generically known as the Speed 400. One can buy a outrunner brushless motor that will give the output of the Speed 400 but is 20% more economical to run and may be even 20% lighter as well.

Alternately, A motor of similar physical proportions to a Speed 400 motor can give the output of a 480 can motor, also without much of a weight penalty.

Rules of thumb are not so appropriate here as there is so much variation in brushless motor construction and performance, e.g. They can be "inrunner or outrunner" type motors and each of particular flight performances.

The wisest course of action here is to consult the makers data either from original instruction manuals or by searching the world wide web. You can, of course copy the combinations of your modeler friends who have successfully done ***exactly*** *what you propose to do.   AND, this vital:-*

Always, yes, always make up a testing stand and set up your propeller/motor/battery/speed controller combination and do actual amps/volts/watts checks before even thinking of bolting the gear in you model.

Obviously, then compare your results against the requirements of your model, always keeping within the parameters of your equipment.
<u>Most "would be" electric flyers' errors occur because they short circuit this checking. They do so often at some considerable expense and grief!!!!</u>

3. Batteries and how many cells do I need?

The selection of battery type and cell count is a bit tricky, but it often comes down to "What battery packs do I have " and what current <u>will they allow</u> the motor to draw, when the selected propeller is fitted. And, does this give me enough power to achieve the required flight characteristics?

Whilst the public euphoria almost demands the use of Li Poly battery packs, there are some good reasons why the use of tried and tested Nickel cadmium and Nickel metal hydride battery packs are a good starting point. Why, yes, of course they are heavier and not much cheaper than Li Poly packs, but they are very much more robust in every sense. They take a lot more abuse than Li Po's and anyway, you have a lot of other technology to get to know without adding the vaugeries of new batteries too! So this is my suggestion for a good starting point.
I've found that 8 to 10 cell packs of Ni Cad or Ni MmH of the various types and capacities are quite a workable starting point. You see, if we need more power (Watts.) we can add an extra cells, because extra cells means extra volts and probably extra amps both will give increased power.

Obviously, there is a limit to the number of cells your speed controller is rated for and just as importantly, your chosen model will carry and still have an acceptable wing loading. However, that's the subject of a later paragraph!

But here are a few ideas.

For a High Wing Trainer – one cell for each 50 square inches of wing area.

For a low wing sport aerobatic Model – one cell for every 35 square inches of wing area.

Another rule of thumb for cell count relates to the IC engine capacity we are used to and is as follows:-

15 Size	*7 – 8 cells*
25 Size	*10 – 14 cells*
40 Size	*16 – 28 cells*
60 Size	*29 – 40 cells*

Above this, your on your own. Get help!!!

4.Which Batteries are right for me?

Unfortunately, not all cells are OK for electric flying. This is due to the simple fact that we need fast Charging AND Discharging performance, without ruining the cells. The cells I have chosen give reliable performance and will take fast charging over and over again. Reliable performance to me is:-

1. *A discharge rate of 15 to 40amps dependant upon the requirements of your model.*
2. *A recharge in about 30 to 40 minutes.*
3. *Hundreds of cycles before I have to buy new cells.*

Some say these cells will cycle up to one thousand times but I personally doubt this claim when we treat them so aggressively.

When I use Ni Cad or Ni Mi cells I mostly used Sanyo & Gold Peak and I have listed my choices below.
Lithium Iron & Li Poly Cells are also now well established on the market and they do have excellent energy density potential; but again, the reader is cautioned to get lots of good advice before buying a large number of these packs.

So, what cells DO work for us? I suggest the following:-
Nickel Cadmium & Nickel metal Hydride types:-

Sanyo N500A
Sanyo KR600AE
Gold Peak GP1100
Sanyo CP1300SCR
Sanyo CP1700SCR
Sanyo N1700SCR
Gold Peak GP2200
Sanyo CP2400SCR
Gold Peak GP3300 to GP4700
(Intellect Brand are comparable to GP)

The price of cells whether NiCd or NiMh multiplied by the number you need for a given model can be quite expensive. Doubled, of course if you decide to have a second pack for more frequent flying. So, get advice BEFORE you make the purchase. These packs will be with you for a long time some experts say up to 500 cycles. Therefore, it is obviously no good buying cells that don't suit your particular needs, even though in another application they may be perfectly suitable.

Lithium Polymer and other new light weight battery Packs.

Like cylinder battery cells there are many Lithium Polymer (Li Po's they are usually referred to) on the market. These cells carry dire warnings that you need to become very familiar with, however, with intelligent use and correct selection they are fantastic!

The biggest advantage of Li Poly's is that they weigh around one third, yes 1/3 rd of the weight of a similar capacity pack of cylinder batteries. This means you can build light, fly longer and your fuel cell will probably be smaller than the older types of batteries.

BUT, there are some very important things to know about Li Po cells, and here are some of the most significant pointers you need to know all about:-

1. *Cell Voltage is usually 3.7 Volts not the 1.2 volts you may be used to.*
2. *Li Po's are very susceptible to over charging and over discharging.*
3. *You must always use a dedicated Li Poly charging device operated from either a suitable car battery or good quality regulated power supply.*
4. *Always charge the Li Poly pack with it resting on a non combustible surface, like the garage concrete floor.*
5. *Install a smoke detector above the location where you normally charge your packs.*
6. *Never, cause uncontrolled discharging by shorting out the battery pack leads. An instant short circuit can render your brand new pack useless.*
7. *Never store your packs in a deep discharge state. Store at at least 60% fully charged state.*
8. *Do not connect packs of dissimilar capacity together because it may lead to over charging or discharging of individual cells and subsequent ruin of the pack.*
9. *Occasionally use a cell balancer in conjuction with your charger. Follow the instructions carefully.*

<u>Lithium Manganese and other new light weight battery Packs</u>.

Two new technologies have been introduced into our market recently. Both are showing promise as a development of light weight battery packs, but neither has the capacity or discharge characteristics that Li poly packs now provide. Here is some information about them:-

Lithium Manganese: These cells are a bit heavier than the Li Po's we are now using, are physically larger and have less capacity. I haven't seen any of them at our local hobby shops, so don't rush into purchasing these on the internet as there will be no local after sales service.

Lithium Nanophosphate called A123's: These cells are now available through one local internet based Electric flight specialist shops. These cells are 3.3 volts nominal and are supplied in iron cans like other technologies. Whilst there is a substantial weight saving over NiCd and Ni Mi cells, these too are only currently sold in 1300 to 2300mAhr cells. Further they are larger that the sub-C cells we had gotten used to. The good news is that the manufacturer is supplying this technology to domestic car hybrid and government road, air and military applications. The USA is gearing up to be far less dependant on fossil fuels in the years ahead which can only help us with our need for high energy dense light weight fuel cells.
There is just one other thing to be aware of, if you go for A123 cells, your charging system will need to accommodate the different charging requirements of Lithium Nanophosphate. Some existing chargers like Schulze can be upgraded with a OEM supplied upgrade chip. The abbreviation for A123's is Li Fe.

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How would you know this without asking someone more experienced than yourself? **Check with other experienced electric flyers before committing to buy a certain type of Battery pack or cells.**

5. Wing Loading:

Much can be written about this subject and not many are qualified to do so, self included. But as a guide, for a forty IC size model around 22 oz per square foot of wing area is a start. My models are usually higher than this because I am always searching for aerobatic performance. Many of my models land really fast as a result.
The following table may be of use:-

Small models (Under 36 inch span)	*2 to 15 oz/sq foot.*
Medium size (36 – 48 inch span)	*15 – 19 oz/sq foot.*
Large size (48– 54 inch span)	*19 -26oz/sq foot.*

6. Build Light, not for Crashes:

The excellent power to weight ratio of our modern IC engines has allowed us to ignore the weight "cost" of adding more stiffening/weight etc than necessary in the attempt to crash proof our models. In a lot of situations this is a fallacy. All we achieve is greater wing loading and higher landing speeds and stalling point.

With electric flight much lighter structures are satisfactory because there is less vibration produced by the rotating mass, the motor.

As a rule of thumb, we like to aim at the air frame weight being no more than 50 % of the flying weight of the aircraft. This means the electric motor, speed controller, radio gear and servos would also be 50% of total flying weight. This R of T does not recognize wing area, or type of plane or desired flight characteristics. So don't take it as gospel.

7. Associate with other Electric Flyers.

The parameters for flying electric are somewhat different to IC R/C model flying. You can do what I did; muddle around for years making your own mistakes and learning your own lessons, or, you can join a group of electric flyers and watch what they do, listen to their conversations AND ask questions!

Some18 months ago I joined the Australian Electric Flight Association and I have learned more in that time than all of the previous 10 years!

The AEFA have terrific meetings, lots of show & tell, competitions for all levels and a culture of helping one another. I highly recommend you go to your nearest local Chapter.

RULES & TOOLS:

Obviously there are many rules and tools that are applicable to radio control model flight, however, we mention only those that to us are pertinent to electric flight. We may have omitted some but here are a collection we think you should know about:-

1. Ohms Law *When I went to school there was a formula that started as … I = E divided by R where I was current, E was Volts and R was, (you guessed it!) Resistance. But, for us it may be easier understood as:*

$$\text{The flow of current} = \frac{\text{Pressure measured in Volts}}{\text{Resistance in Ohms}}$$

2. Another part of Ohms Law is *… Watts = E multiplied by I*

Or, Power = Pressure in volts multiplied by Current in Amps

This is a very useful rule. You may remember in Section Rules of Thumb, Point No.1 we made reference to certain quantities of power (Watts) are needed for certain types of planes and for certain levels of performance! Well, this is the formula you need to use to calculate the power output of a selected motor/propeller/battery combination. It's quite easy really.

How long will it Fly?

The Rule is 1 milliamp hour equals 60 milliamp minutes.

The formula is:

$$\text{Time of flight in minutes} = \frac{\text{Capacity of battery times 60 minutes}}{\text{Amps consumed by motor, radio etc}}$$

Example: Take a 1700MiAh battery pack and motor, radio etc current of 10 amps. Flight time = $\frac{1.7x60}{10}$

=10.2 minutes.

Realize this formula is theoretical and doesn't take into account throttle useage or other factors, but it is helpful in deciding what battery pack will be suitable for your project.

TOOLS & EQUIPMENT:

There are some special items you can use that will help you master the exciting challenge to fly your favourite models by radio control, using batteries for the fuel cell rather than a plastic tank with a liquid fuel therein. So here are some suggestions:-

1. ***An enquiring mind**. Yes, you will have to do some thinking, but it's worth it.*
2. ***A Digital Multimeter**. Electronics Shops sell one for around $15.00. I've got a couple of them and they do the job well enough to get started.*
3. ***A Watt reading meter of some kind.** I started with an Analogue Voltmeter and an Ammeter in a box, which I made up myself. But digital instruments that read amps and volts simultaneously are much better. Some even do the Ohms Law calculation for you as well. Clamp meters are better but expensive. These days you can afford an MPI MX 8100 or an E Flight Meter from your local Hobby Shop. Better still, go for the best and save up for an Hyperion E meter which stores data, programmes speed controllers as well as a host of other useful things..*
4. ***<u>But you must have some of this gear to do it right.</u>***

5. ***A good set of scales**. You can purchase digital kitchen scales that measure in one gram increments up to 4 kilograms for about $30.*

   I also have a simple little spring type unit that measures up to 100grams that fits in my pocket. It's great for selecting balsa in the hobby shop. In case you think I have gone "tropo" yes I've started to measure the weight of each sheet of balsa I use. Do you know some sheets can be more than twice the weight of another otherwise identical sheet!

6. ***A soldering iron of around 40 watt power** and rosin cored solder.*
7. ***Access to the Internet**. It's a marvelous source of information. I'll include a list of sites you will find useful.*

8. ***A Mentor.*** *Just as you appreciated an older or more experienced R/C Flyer helping you until you went "Solo" so it is with the transition to Electric Flight. Don't be proud, make contact with some one you know and respect, who is a competent electric flyer and seek their help. You'll find they are only too willing to assist.*
9. ***Join an Association of like-minded Electric Flyers*** *such as the Australian Electric Flyers Association.*

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Conclusion: *So, that's my introduction to Electric Powered Model Flight. It's not so hard but you must get an E Meter or something that will give you at least amps and volts.*
You can do it… have a go.

Do ring me on 0411 038 207 if you need help. I charge you, (or is it challenge you) to get started.

If you need help, send an email to phil@langton.biz

Books, Associations and Internet Sites Of Interest to the Electric Flyer

Books, Magazines and Associations:

Entering Electrics By Harry Higley(An extremely useful reference.)

Quiet & Electric Flight International Magazine

R C M & E Magazine from the UK.

Australian Electric Flight Association   Annual Subs only $20

Internet Sites of Interest:

AEFA	www.aefa.asn.au
BEFA	www.ndirect.co.uk/~befa
E Zone	www.ezone.com

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