Some thoughts on Model Airplane Electrocution – or -

Selecting a Power System to Convert Glow Powered Planes to Electric

NVRC

~~November 15, 2012~~

April 25, 2020

Balance

- The key to converting glow airframes to electric power is to achieve a balance between:
  - Overall aircraft weight
  - Power available
  - Estimated wing loading
  - Projected speed of aircraft
  - Desired performance/flight time

Simplest Method

- Compare the airplane’s desired size and weight and performance with a comparable electric aircraft you are familiar with.

- Select a proposed motor/ESC/battery similar to the one in the familiar airplane & install it.

Next Simplest Method

- Estimate weight & performance target

- Pick a motor & prop that will deliver thrust in the right range

Flying Capabilities	**Power to Weight Ratio (W/lbs.)**
Electric Glider, Park Flyer & Slow Flyer	30-60
Trainers & Basic Scale Flying	60-75
Sport Flying & Improved Climbing	75-100
Limited 3D, Pattern & Racing	100-150
Full Power 3D & Pattern Aerobatics	150-220

“Less Simplest” Method

- Determine what prop size, pitch, and max RPM the designated glow engine would run.

- Find a motor/ESC/battery that will drive a prop of the same size and pitch to the same max RPM without overloading the components.

Electronic Conversion Aids:

- Moto Calc
- Electric Calc
- Web sites such as
  - Castle Creations
  - Great Planes Electrify glow to brushless rec.
  - RC Groups
  - Hobby Lobby

For more Refined Efforts

- We can manipulate the equipment to achieve very balanced conversions
- It does require careful thought and sometimes iterative calculations
- Test the equip. with a Wattmeter to confirm
- This is what most electric ARF manufacturers have done for us on their ready made electric flyers.

Wing Loading

Wing loading is a major performance factor in conversions -- weight / wing area

- Higher wing loadings increase stall speed but should permit faster top end flight
- Lower loadings usually bring greater agility and slower stall speed

Watts !

- Watts are a measure of power/work
  - Voltage X Amperage = Watts
  - 746 watts = 1 horsepower

- Knowing the number of Volts, Amps and Watts to be used is Key to balancing a conversion

Power levels needed for Approximate performance of various applications

General guidelines of Watts for each pound of aircraft Weight:

- Basic/Trainers/Gliders approx. 50 W
- “Normal aerobatic” performance 70 – 80W
- Strong aerobatic performance 100-125 W
- 3D performance 175 W or more

KV and Speed, why is it a factor?

- KV is an abbreviation that identifies how fast an unloaded motor (no prop or fan mounted on the motor) will run for each volt of power fed to it. The higher the KV the faster a motor will turn for a given voltage supplied to it.

- Example: a motor rated at KV of 1,000 should turn 1,000 rpm per volt, ex: KV 1000 X 12 volts = 12,000 RPM

- When loaded with a prop the RPM will be less – I expect a 10% to 20% drop off --- depending on quality of the equipment

Motor Winds, KV and Speed

- The number of “winds” in a motor determine its KV and speed/torque.
- More winds = lower speed & more torque
- Fewer winds = faster speed & less torque
- Many manufacturers include # of winds in their technical specs for their motors.

Motor Efficiency

- Motors run better above 50% of their maximum speed, and usually are best at 80 – 95% of their maximum RPM.
- If possible, try to select a motor that will run at this rate for most of your flying time.
- Note: Gear drives can add flexibility to your system to help achieve max motor efficiency

Speed – Thrust

- All other things being equal:
- If you want more speed – increase voltage and/or use an “inrunner” { think of a 2 stroke glow} & smaller prop
- If you want more thrust – increase amperage and/or use an “outrunner”{ think of a 4 stroke glow} & larger prop

Aircraft Speed

- Projected Aircraft Speed is important because your power system must provide enough difference in speed between your stall speed and max speed to fly comfortably. (ie. If your stall is at 20 mph and your max speed is 25 mph you have a problem.)

RPM Pitch & MPH conversions

- To get miles per hour from RPM & pitch
  - RPM X Pitch divided by 1056 = MPH
    - (Pitch is in inches)

- To get RPM from miles per hour & pitch
  - MPH X 1056 divided by Pitch = RPM

- To get Pitch from miles per hour & RPM
  - MPH X 1056 divided by RPM = Pitch

Motor/ESC/Battery Loadings

- Every motor, ESC, and battery has limits on their working voltage and amperage. You MUST choose your ESC & Battery to meet or exceed the max volts and amps your motor/prop can draw. (otherwise the magic smoke may escape.)
- I recommend you size your motor/ESC/battery to deliver your desired MPH and prop disc area at 80% to 90% of the ratings of the motor/ESC/battery
- Manufacturers provide ratings for their equipment – it's a great reference

Mechanical Considerations

- **<u>Include a “SAFETY PLUG”</u> to externally disarm the motor.**
- **KEEP YOUR BATTERY TO ESC WIRES SHORT!!! (<12 inches) You can fry your ESC if you don’t. Longer wires are OK from ESC to motor.**
- **Electric motors, and especially ESCs and batteries like lots of air flowing through/around them. Include air intakes and EXITS in the airframe.**
- **Include some type of easy battery access to reduce battery switching aggravation.**
- **You can Build Lighter! Electrics don’t need as massive an airframe because they don’t vibrate like a glow powered unit.**

Battery Cost vs Fuel Cost

- Battery costs have dropped dramatically in the last 2 years.
- Battery costs occur up front, glow fuel more slowly over time.
- Glow Fuel costs are actually higher for the same number of flights than battery costs for the same number/length of flights.

Conversion example #1

- Trainer type performance
- 5 ft wingspan & 5 sq ft of wing
- Target max weight 5 lbs, wing loading 16 oz/sq ft.
- Target top speed ~ 50 mph
- Power level desired: 50 watts/lb. on a 10 X 6 prop at about 12,000 RPM
- Bare airframe weighs 3.2 lbs or 51 oz.

Conversion example #1 Continued

- Axi 2217/16 motor weighs 2.5 oz & is rated for up to 3s LiPo at 22 amps for ~ 250 watts and is rated to run up to a 11X5.5 prop.

- For ~ 12,000 rpm I need a 3S LiPo battery (1050 KV X 12 volts = 11,000 – 12,000 rpm)

- ESC weighs ~ 2 oz, 3 S battery weighs~ 8-10 oz
- All up weights is ~ 65 oz or 4 lbs
- This is 250 watts/4 lbs or 62 watts/lb

- Max speed will be between 62 and 68 mph

Conversion example # 2 – Giant Scale

- Sport type performance 6.5 ft wing Biplane
- 13 sq ft of wing
- Target max weight 24 lbs, wing loading 29.5 oz/sq ft.
- top speed ~ 60 mph
- Power level desired: 100+ watts/lb. on a 22 X 8 prop at about 7 or 8,000 RPM
- Bare airframe weighs 15 lbs

Conversion example #2 Giant Scale - Continued

- Great Planes “50cc Rimfire” motor weighs 44 oz & is rated for up to 12s LiPo at 110 amps for ~ 5280 watts and is rated to run up to a 26X10 prop.
- For ~ 8,000 rpm I need a 10S LiPo battery (230 KV X 40 volts {less 10%} = 8280 rpm)
- ESC weighs ~ 8 oz, 10 S battery ~ 48 oz, RX & Servos etc ~ 2.0 lbs
- All up weights is ~ 24 lbs
- This is 5280 watts/24 lbs or ~200 watts/lb
- Max speed estimate is about 70 mph
- I strongly recommend a separate battery or separate ESC to run the RX & servos on medium/large planes.

FF “Gummy Band” Conversion Example # 3

- Trainer performance
- 30 inch wingspan ~ 0.9 sq ft of wing
- Target max weight 7 oz, & prefer a wing loading 5-6 oz/sq ft.
- Target top speed ~ 30 mph
- Power level desired: 70 watts/lb.
- Bare airframe weighs 4.0 oz.

FF “Gummy Band” Conversion Example # 3

- Generic outrunner motor weighs 0.3 oz & is rated for up to 3s LiPo at 6 amps for ~ 60 watts and is rated to run up to a 5 X 3 prop.
- For ~ 5,000 rpm I need a 2S LiPo battery at 4 amps for 30 watts
  - (750 KV X 7.5 volts = ~ 5,000 rpm)
- ESC weighs ~ 0.25 oz, 2S battery ~ 1.0 oz
- All up weights is ~ 5.55 oz or 0.35 lb
- This is 30 watts/0.35 lbs or 85 watts/lb
- Max speed will be ~ 20 mph

Questions ?

- If you have questions, call me at home: 703-408-9434

carl