

GLOW TO ELECTRIC CONVERSION

by Al Montalbano

INTRODUCTION

Today, more than ever, the growing trend toward electric flight has introduced a flood of new electric powered RC airplanes in the marketplace. Many of these models fall into the category of “Park Flyers” and are very light weight, constructed from foam, thin balsa and ultra thin covering or a combination of both. Some of these offerings fly rather poorly, however, an increasing number fly surprising well. Because of their light weight they are very susceptible to damage in handling. Crash damage, however, is usually easy to repair. Profile models are so light and over powered that 3D flight is definitely in order, but any resemblance between these cardboard and foam crates and a real airplane is purely accidental. These aircraft generally have several things in common. Most have “The Electric Look”, while some even look like children’s toys. The other thing I have experienced is that during flight most of them seem to have “The Electric Feel”. Lastly, the performance usually doesn’t quite match up to fuel models and their small size and light weight make them susceptible to the slightest wind.

MISSION

Almost any glow plane can be converted to electric if cost is not considered a deterrent. In my quest to find and build the ideal electric conversion, consistent with my budget, I prepared a search criteria based upon practical limits. A search of currently available components (as of this printing) reveals that modestly priced equipment is available if motor selection is limited to fractional horsepower motors. Motors with input power of 400 watts or less are available for under \$100.00. Electronic Speed Controls (ESC’s) and Lithium batteries required to operate these motors are also quite affordable. Keeping this in mind and using the rule-of-thumb of 100 watts per pound for high performance aerobatic model, I decided that the flying weight should not exceed four (4) pounds. Four

pounds narrows down the field of available Almost Ready to Fly (ARF’s) to RC airplanes designed for .25 to .40 cubic inch engines. I acknowledge that new products hit the marketplace every day, but at the time I did my search I found very little that would meet my criteria. Frustrated, I finally stumbled upon a model that seemed to be an ideal candidate. The model I chose was an Ultimate Bipe offered by eGRANDBUY.com located in El Monte, California. The Ultimate was designed for a 2-cycle 0.40 cu engine, the published flying weight was 4.5 lbs. and it cost \$119.00. I felt that I could trim a little weight off and it would be just right. I have since found two other mail order houses that offer the same model.



The Ultimate

CONVERSION

Upon inspection of the new Ultimate Bipe, I was very impressed with the quality of construction, finish and attention to detail that had gone into this airplane. I immediately weighed all the parts from the kit that I intended to use and measured the total wing area. Before actually going to work on the project, I entered all the required data into “MotoCalc”, a computer program capable of predicting the static and dynamic flying characteristics of this combination. Numerous configurations were entered into the program and the optimum power system, i.e. motor, ESC and battery was de-

terminated. For this combination a 10-7 prop was selected since it limited the peak motor current to 38.6 amps, just under the 40 amp maximum limit of the ESC and still gave impressive performance. The results of these calculations were very encouraging. The total weight including motor, speed control, servos and batteries was computed to be 62.1 oz. or 3.88 lbs. Peak power predicted was 399 watts or 102.8 watts/lb. Stall speed was estimated at 22 miles/hr, the maximum airspeed estimate was 55 miles/hr. For a performance summary output from MotoCalc see Figure 1 MotOpinion.

MOTOR AND SPEED CONTROL

Motocalc selects appropriate power system components from its built-in database, as identified in Figure 1. The user may accept Motocalc's recommendations or select equivalent items. In this case, the recommended AXI motor was employed, and the recommended speed control's properties were used to select a comparable, but less expensive, JETI 40 Amp controller. Battery selection is discussed below. The alternate components' specifications could be entered into Motocalc to verify system performance with these items.

MotOpinion - Ultimate Biplane

Sea Level, 29.92inHg, 59°F

Motor: Model Motors AXIAC2820/10; 1200rpm/V; 2.3A no-load; 0.039 Ohms.

Battery: Kokam 2100SHD; 3 series x 2 parallel cells; 21 OOmAh @ 3.7V; 0.0114 Ohms/cell.

Speed Control: Castle Creations Phoenix 45; 0.0026 Ohms; High rate.

Drive System: Direct Drive; 10x7 (Pconst=1.31; Tconst=0.95) direct drive.

Airframe: Ultimate Biplane; 554sq.in; 62.1 oz; 16.2oz/sq.ft; Cd=0.046; Cl=0.03; Clopt=0.37; Clmax=0.92.

Stats: 103 W/lb in; 72 W/lb out; 22mph stall; 34mph opt @ 63% (22:31,118°F); 127mph level; 981 tt/min @ 19.2°; -560tt/min @ -10.9°.

Power System Notes:

- The full-throttle motor current at the best lift-to-drag ratio airspeed (38A) falls between the motor's maximum efficiency current (18.9A) and its current at theoretical maximum output (79.1 A), thus making effective use of the motor.

Aerodynamic Notes:

- The static pitch speed (61 mph) is within the range of approximately 2.5 to 3 times the model's stall speed (22mph), which is considered ideal for good performance.
- With a wing loading of 16.2oz/sq.ft, a model of this size will have trainer-like flying characteristics. It would make an ideal trainer, for use in calm to light wind conditions.
- The static thrust (44.2oz) to weight (62.1oz) ratio is 0.71:1, which will result in very short take-off runs, no difficulty taking off from grass surfaces (assuming sufficiently large wheels), and steep climb-outs.
- At the best lift-to-drag ratio airspeed, the excess-thrust (23.9oz) to weight (62.1 oz) ratio is 0.39:1, which will give strong climbs and rapid acceleration. This model will most likely readily loop from level flight, and have sufficient in-flight thrust for many aerobatic maneuvers.

General Notes:

- This analysis is based on calculations that take motor heating effects into account.

Figure 1

ASSEMBLY

After the normal assembly of the control surfaces,



FIGURE 2

push rods and servos, I returned to my computer to design a custom motor mount to accommodate the electric motor. I decided that I would modify and use the original motor mounts and machine a set of

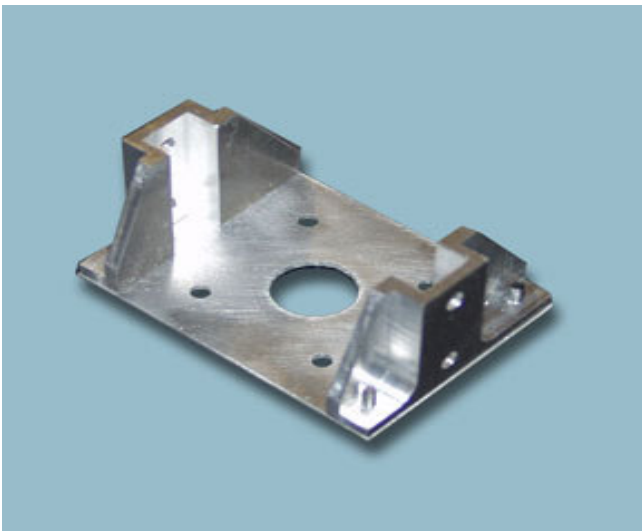


FIGURE 3

brackets and an aluminum plate on which to mount the AXI 2820/10 motor (See figures 2, 3 and 4). The instructions that came with the kit places the face of the propeller thrust washer at 4-1/2 inches from the firewall. This is but one of many methods. The mount could be made from formed sheet aluminum or built up from thin plywood. After assembly, the mount must be aligned to the firewall, allowing for accurate positioning of the centerline

of the motor prop adapter with the centerline of the



FIGURE 4

cowl. Since the firewall is angled to provide proper thrust offset, a self leveling laser was used for this alignment. After the motor was installed, the ESC was connected and mounted to the firewall with double sided tape (See figure 5). The recommended full size servos were substituted with Hitec HS-255BB Mighty Mini servos. Not only are the HS-255's lighter, but they also deliver about 30% more

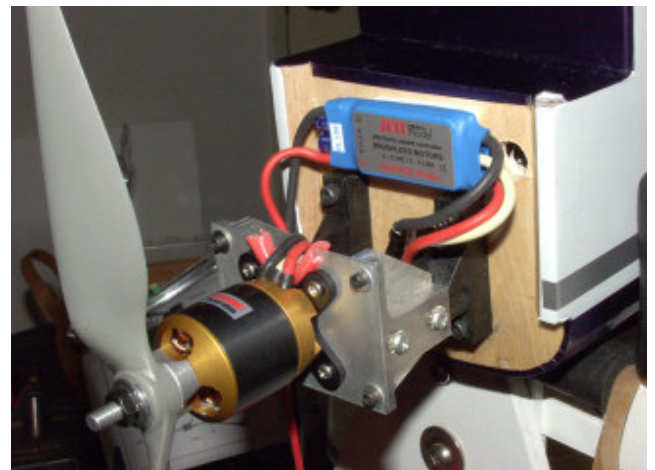


FIGURE 5

torque. This is a significant improvement since one servo must drive four (4) ailerons.

BATTERY SELECTION

Since the AXI 2820/10 motor can draw almost 40 amperes, the battery must be capable of supplying this demand. A quick check of a 10C battery (40 amps/10C) = 4amp hr., therefore, any battery having a rating of 4000 mahr or greater and an average discharge rating of 10C minimum should handle

the current requirements. A search for inexpensive Lithium batteries matching this requirement yielded the APEX12cLipoly225011v, available from GWS Expert. This is an 11.1 volt, 2250 mahr, lithium with an average discharge rating of 12C and costs only \$40.00 each. Two of these Apex batteries wired in parallel will supply $(2250\text{mahr} \times 2) = 4500\text{mahr} \times 12\text{C} = 54$ amperes. These batteries will furnish the required maximum current with a thirty-five (35) percent reserve.

When replacing the engine with a lighter electric motor, fuel models often become tail heavy and difficult to balance. I have found that locating the battery as far forward as possible goes a long way in helping to adjust balance. Also, if balance weight is needed, it is much more desirable to add more battery than adding lead. The problem with conversions is that they have no battery compartment or battery access hatch and since the ARF is already covered they are generally difficult to add. After

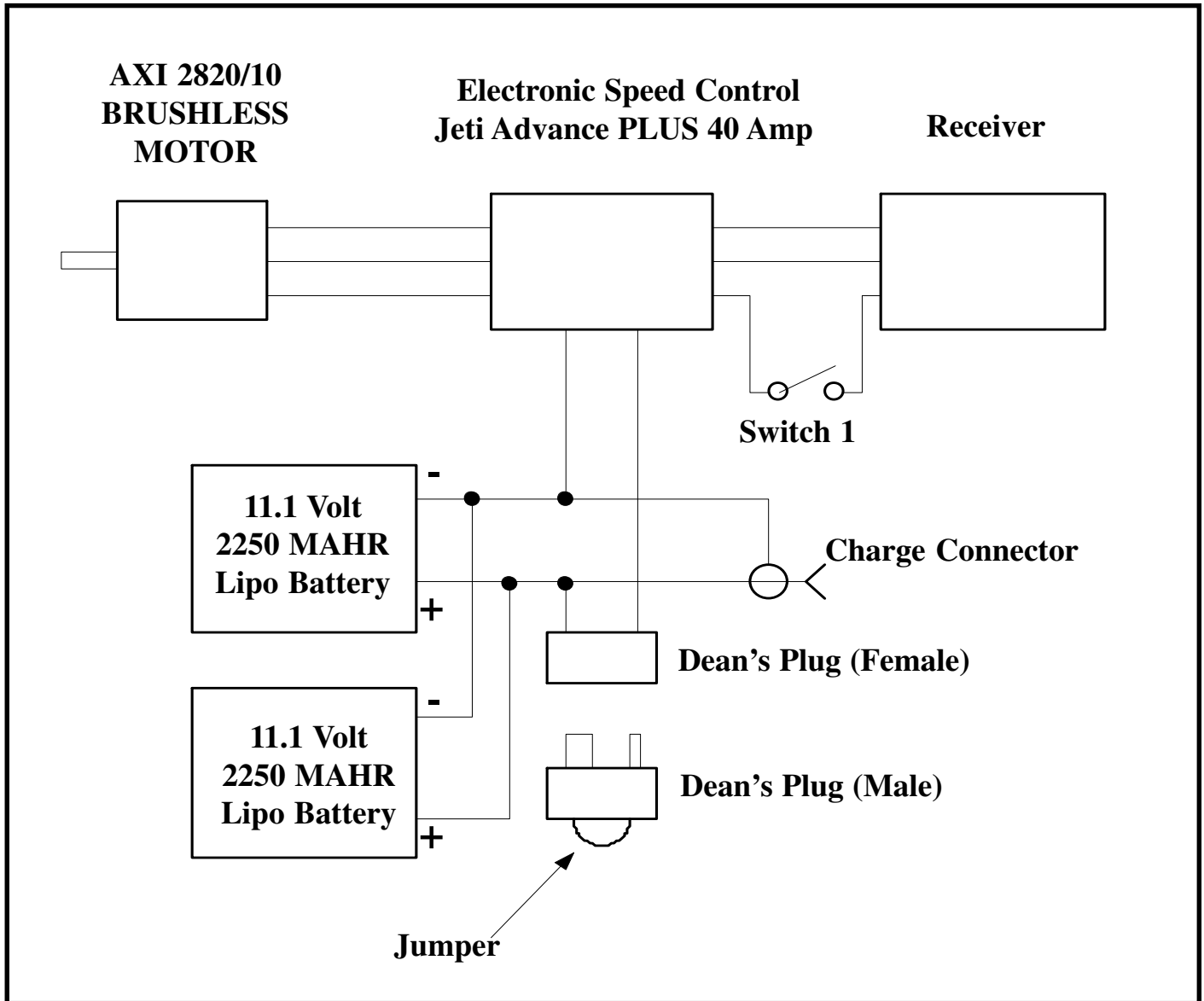


Figure 6

WIRING & BATTERY INSTALLATION

Conversion of fuel to electric often poses a balance problem. Often the combination of Engine, fuel and fuel tank aids in shifting the balance forward.

careful study, I found that both APEX batteries will fit snugly between fuselage formers #1 and former #2 with a small piece of foam wedged above them to take up the remaining space. After completing assembly, I measured the balance using the

manufacturer's recommendation and, what a surprise, found that it was perfect, it couldn't have been better.

WIRING

I have installed toggle switches in series with the batteries on all of my smaller 400 size planes to prevent discharge during periods of non-flight or even during transportation. This is possible since the 400 motors draw current within the rating of the switch, providing that the switch is only activated while the motor is stationary. These switches would melt with the 40 amp current required by these large motors. The solution is to insert a very short jumper, made from a set of Dean's Ultra plugs and a small piece of 20 AWG buss wire wrapped several times around the terminals and soldered in place. A piece of shrink sleeve shrunk around the rear of the male plug is then filled with 5 minute epoxy to provide good electrical insulation. (See figures 6 & 7). Since the batteries are not easily removed, a charge connector was added to the right side of the fuselage so they may be charged in place (See figure 8). The switch, S1, is provided with some ESC's to remove power to the receiver for short periods. This switch does not provide long term battery isolation since the idle current of the motor controller is ever present.

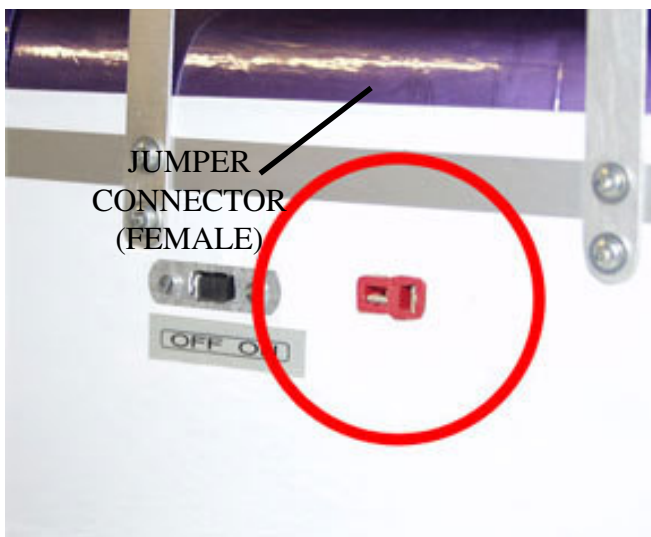


FIGURE 7

FIRST FLIGHT

Somewhat nervous about taking this concoction up for the first time, I thought I'd recruit a veteran pilot, one who's flying skills far exceed mine. For this I turned to Les Holland, a true professional and highly skilled pilot. After inspection and pre-flight we carried her off and set her down on the runway. Les taxied her back and forth a few times and when all seemed well he pushed the throttle to the wall. We all watched as she headed down the runway, straight as an arrow without a hint of an attempt to veer from a perfect run. Just at the right moment for rotation, Les drew back on the elevator and she raised her nose and lifted off into a powerful climb. A 180 degree climbing turn and she streaked across the sky directly in front of us... two notches on the elevator trim and she was in perfect trim. After a complete shake down, Les lined her up for an up wind approach and she began to slowly sink as he greased her in from final. Her touch down was as slick as could be. She flew



FIGURE 8

just as MotoCalc had predicted. She was gentle, but she was strong. She flew with the grace of an eagle and the authority of a lion. She is destined to become my favorite bird.

End