X4MR Manual

(See our website www.mexairrc.com for our upcoming video series on X4MR Construction))

Introduction

Congratulations on your purchase of the MexAir RC X4MR 250 FPV Race Quadcopter. This quad has some very unique design features that allow for advanced flight characteristics. The built-in configurations enhance maneuverability, speed and load handling capability. Some of these are described below and throughout the build sections of this manual. Besides the advantages described below are the less obvious materials making up the airframe. Most quality multirotors use some form of carbon fiber in their design. We have chosen the more costly but highest quality aerospace ***quasi-isotropic*** carbon fiber. Rather than describe the benefits of this material, especially when used in conjunction with a light-weight core, you may wish to simply "Google" the terms to find the vast amount of technical data supporting the use of this grade of carbon fiber in light-weight rugged, rigid, and strong applications.

MexAir RC, located in Central New York, is the designer and manufacturer of the X4MR 250 Class Racing Quad airframe. We specialize in the design and construction of the airframe. Since the various electronic components and peripherals are widely available through many sources, our focus is on providing a unique platform for the already available devices. The experienced builder will already know much of the information – but we decided to cover details not always found in build manuals – especially considering some of the unique features of the X4MR.

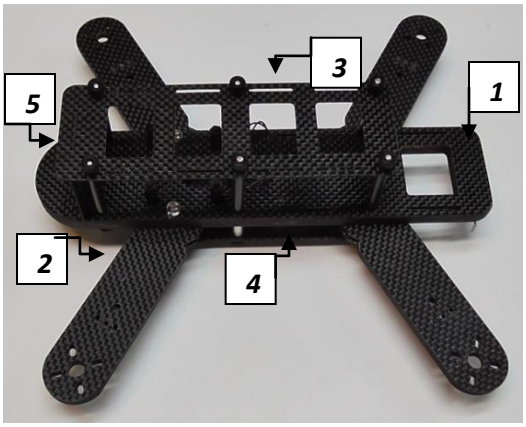
The X4MR carbon fiber laminated airframe design, materials, and methods of construction create an assembly that allows for:

- Enhanced aerodynamics due to the ability to embed wiring within airframe structural components thus reducing turbulence and drag
- Elimination of the typical "lightening holes" in areas of the airframe to improve strength and rigidity, additionally reduce turbulence, while at the same time reducing airframe weight when compared to typical solid carbon fiber frame materials used in many other multirotor copters
- Reduced induced vibration through use of vibration damping body & arm core material – resulting in better video quality
- Electronic component placement flexibility due to:
    - ease of mounting additional accessory items to the CF frame using simple self tapping screws

  - additional space on certain surfaces of the frame when using embedded wiring
- Top and bottom plate mounting using thru-layer tie-rods and fasteners creating a rigid structure required by high power motor systems
- Variable motor arm positioning that allows for
  - Fine adjustments to center of gravity
  - variable motor placement to enhance maneuverability
  - motor arm "swing away" deflection on a hard-hit thus reducing crash damage potential

The **X4MR** 250 kit includes all the frame components and fasteners necessary to construct a 250 class racing quad using electronics of your choice. You will receive the airframe in an already assembled state. We have done this for you so that you can see how the frame should look when completely assembled. It is expected that you will disassemble some of it during the build. The instructions that follow assume that you simply received the kit in a completely disassembled state.

The airframe comes configured to mount the supplied Power Distribution Board with the included PDB standoffs and predrilled main frame mounting holes. This PDB mount allows for "piggy-back" mounting of a 30.5mm controller board using additional standoffs. The frame body already has embedded wire leads to solder the included LEDs to both the front and rear to assist in visual orientation during flight. The motor arms have internal wire cavities that allow for embedding the motor wires up to the main frame and the speed control bottom plate.



X4MR Kit Contents: (See Accompanying Pictures)

1. Main Frame Body w/preinstalled LED wiring
2. Motor Arms (4)
3. Top Plate [To mount FPV Gear]
4. Bottom Plate [To mount ESCs]
5. Camera Plate [To mount forward looking camera]
6. Landing Gear Legs, Boots, and Mounting Hardware (4 sets)
7. Power Distribution Board [3oz copper PDB for higher current applications]
8. LED Boards, 4S LiPo Capable (Front & Rear)
9. PDB Mounting Standoff Set
10. Plate Mounting Standoffs/Hardware Set
11. "Hook & Loop" Battery Strapping Material
12. Alternate 3mm motor mounting screws (16) if your motor screws will not fit properly
13. Double Backed Insulating Tape

Other "stuff" typically installed on a racing multirotor frame includes:
Flight Controller Board
Motors
Propellers
Speed Controls (ESCs)
FPV Gear and cameras
Batteries and Battery Connectors

In some frame designs, including the **X4MR**, there are varying options for positioning and mounting components. We listed options for those that have shown to be useful and tested successfully with the **X4MR**s we build in-house.

Recommended Options:

- Voltage Regulator(s)
    - Note: If you do not have 5V and/or 12V supplies that may be necessary for your camera systems, these can be handy add-ons wired direct to the supplied PDB.
- Satellite receiver vs. standard receiver?
    - Testing with a Spektrum satellite receiver showed no adverse effects on range or signal reception. It is a good lightweight alternative to traditional receivers due to small size and less wiring as might otherwise be necessary. It can be mounted almost anywhere on the **X4MR** airframe.

General Guidance to make assembly faster, easier and safer:

1. Read through the assembly instructions completely PRIOR to beginning construction.
2. Inventory all kit supplied parts, your electronics and tools, organizing them according to your intended build. Do not forget about any general supplies such as solder, heat shrink, small tools, etc.
3. Use small amounts of blue loctite thread locker on all metal-to-metal screw contact surfaces, especially motor mounting screws.
4. "Dry-fit" and test all electronics and FPV gear, to the extent possible during the build, so disassembly will not be required after you have completed the frame assembly.
5. Pre-plan purchase of motors that have sufficient motor wire length and diameter to allow for embedding the wires into the motor arms. The minimum length of the leads should be 4 inches. The wire diameter, including insulation, should be a maximum of 1/16" (~20 gauge) to fit into the arm holes. If larger, the holes can be widened as described in this manual. Alternately, any wire length or diameter can be used by surface mounting them.
6. Take care in soldering components to prevent shorting between solder pads or overheating any sensitive electronic components.
7. Although the skills, techniques, and "hazards" associated with this build are typical for many hobby related activities, we always strive for safe and efficient construction techniques. We therefore repeat here what you have likely learned from your previous experiences:
    a. The **X4MR** airframe kit does not require any drilling for the typical build. If drilling holes in the carbon fiber (CF) for self tapping screws or larger component attachments use a sharp drill bit and work with light pressure and a relatively high speed drill. CF can not be "punch marked" for drilling. A small electric rotary tool or drill press is recommended to prevent the bit from "wandering" as you start the hole. Wear appropriate safety gear, including air mask/filter, if creating carbon dust.

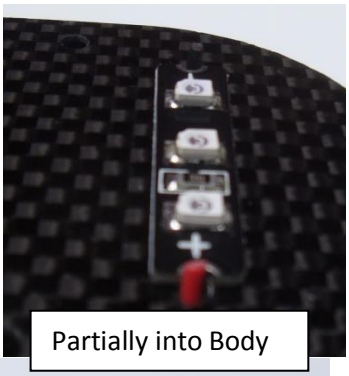
b. Always wear appropriate safely gear or take other precautions during any operation that could create a hazardous condition – including soldering, drilling, cutting and grinding.

8. ***Carbon fiber is a conductive material. Never allow bare battery terminals or other powered connections to physically come into contact with the carbon fiber or metal components of the frame. Contact may create short circuits that may damage electrical components and/or become a fire hazard. Always insulate powered terminals from the frame using nonconductive materials such as electrical insulating tape, heat shrink tubing, or plastic/nylon standoffs or mounts.***
9. ***NEVER attempt to screw any component into the carbon fiber frame without first carefully drilling the appropriately sized hole at the fastener location. Self tapping screw/bolt hole sizes are slightly larger than the <u>inner</u> diameter of the threaded portion of the fastener. When tightening a self tapping fastener, it may be necessary to start tightening it, back it out slightly, repeating this process until the fastener is threaded to the proper depth. This creates a threaded hole that should hold firmly without any other aid. For added assurance, use the time-tested technique of "hardening" the laminate core material AFTER you create the threads using the self tapping fastener. Remove the fastener from the hole and carefully drip 2 – 3 small drops of thin CA into the hole. The CA will "wick" into the core thread area and harden the core material. Allow sufficient time (usually only a couple of minutes) for the CA to completely dry prior to reinserting the fastener. You do not want to glue the fastener permanently in the hole! Hardening the laminate core material, although not typically necessary, is only done if you intend to insert a threaded fastener that will be tightened across the laminated surfaces causing significant compressive forces on the laminate structure. Hardening reduces "dimpling" the surface when compressed. The laminate structure is sufficiently strong and some dimpling is not a bad thing – it actually acts to further reduce the possibility of fasteners loosening. Excessive tightening is unnecessary.***

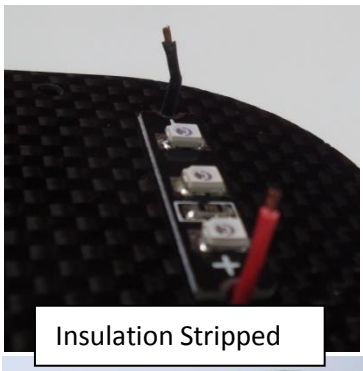
Construction of the X4MR Airframe

1. LEDs (LED Boards supplied with this kit can be run direct to 4S LiPo power without any voltage regulator)
    a. The preinstalled LED power leads feed through the body of the frame and exit the frame conveniently below the PDB position. Do not permanently connect the power side of the leads to the PDB or power source at this time. Permanent installation should be done after final placement of the PDB, any necessary voltage regulators, and speed controls.
    b. Place the main frame body upside down. First, gently push the LED wires a slight amount into the wire exit hole and then pull gently to see how much slack wire you have to work with. Note the slack amount. Strip the remaining insulation leaving the amount of insulation you determined as slack.
    c. Cut the excess bare wire leaving about ¼" bare. Tin the bare end.
    d. If your kit was supplied with single color wires, trace the wire from the LED location to the planned source end with an ohm-meter. Mark both the positive (+) and negative (-) wire ends at the main body hole (the large elongated hole). You can always trace the polarity later during the build if you forget to do it now. If supplied with colored wires, the red (or white) wire will always be intended as the positive (+). The other wire is the negative (-).
    e. Solder the LED board to the wires paying attention to the proper polarity. Measure and cut a small strip of supplied double backed tape the same size as the LED board. [This is very sticky stuff! You may want to handle it with the tip of a small hobby knife blade rather than your fingers.] Apply the sticky side between the wire holes on the body underside. Remove the remaining tape backing.
    f. At this time you should be able to push the soldered wires of the assembly slightly into the body so the board will lay flat to the tape. Readjust as necessary.
    g. Verify that the bare metal of your solder joint is not touching the carbon frame body and the board is fully insulated from the body by the tape.

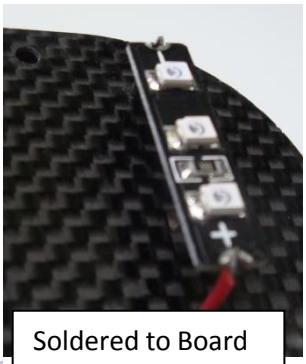
Wires Fully Extended



Partially into Body

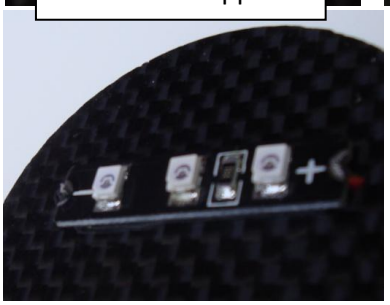


Insulation Stripped



Soldered to Board

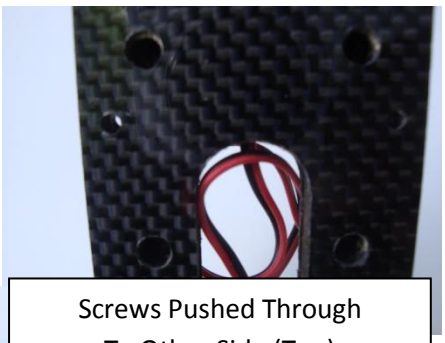
Double Backed Tape Applied to Bottom of Board or Frame



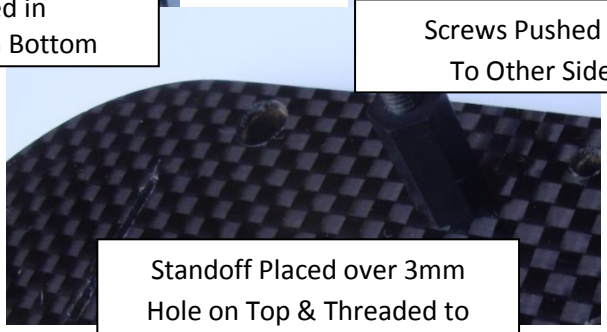
Tape Backing Removed, wires pushed into holes & LEDs Pressed Into Place

2. There are two possible locations to mount the PDB and/or controller board. Note that there are six standoff hole locations. Use either the forward or rear sets depending on your needs. The rearward set places the controller more toward the center of the body – closer to the center-of-gravity. Flight testing using a Naze32 in both forward and rearward positions did not seem to affect performance – so it becomes a matter of personal preference. Install four PDB standoffs "upside-down" as shown in the accompanying figure. The nylon screw is hidden within the frame body minimizing any possibility of interference with motor arm placement. The female end of the standoff is placed over the 3mm hole on the main frame top and the screw is inserted into the frame 5mm hole from the underside. Hand-tighten the posts to their respective screws by holding the screw in place with a screwdriver. Complete tightening using the screwdriver while holding the standoff in place. Take care not to over-tighten the standoff and shear off the screw. For added assurance to prevent the screw from ever backing off, a small dab of RTV/Silicone Seal can be placed on the threads using a toothpick. The screw can be removable if necessary. Alternately, a drop of CA can be used while the frame is held upside-down. This will be permanent and any future standoff removal will require breaking off the standoff and replacing it with a new one.

Screws Placed in 5mm Holes From Bottom



Screws Pushed Through To Other Side (Top)

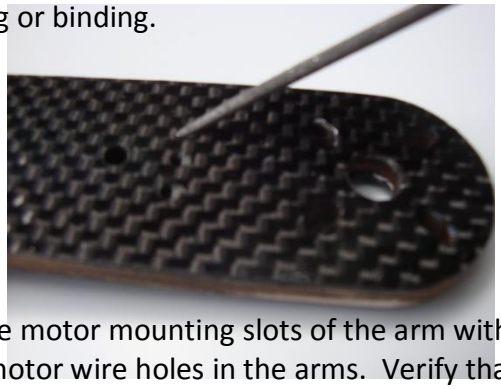


Standoff Placed over 3mm Hole on Top & Threaded to Screw

3. Installing the motors
    a. Verify the appropriate length of your motor screws and always mount them so there is sufficient thread into the motor frame, but not so much as to touch the internal components. Doing so will damage your motor. If your screws will not work and you have motors with 3mm mount threads, the set of 3mm motor screws included in the kit will likely work for you.
    b. For screws less than 3mm diameter you may need to install the screws with a flat washer to increase their contact surface area against the CF skin.

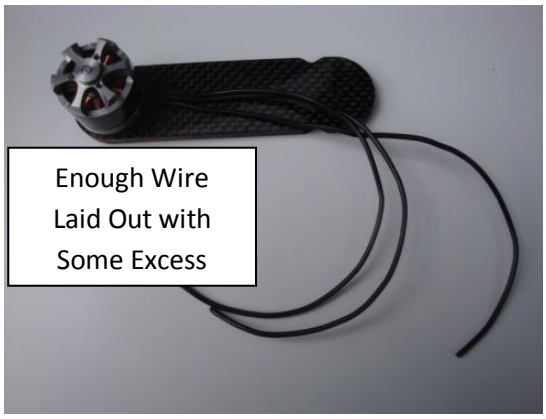
c. When initially dry-fitting the motor in the following sections and on final tightening of the motors, verify that the motor shaft is centered in the arm shaft hole and that there is sufficient clearance from any shaft hardware. Some motor shafts have a clip or setscrew that secures the shaft in the motor. Visually verify that the clip/setscrew will not contact the edge of the hole. Turn the motor rotor by hand and again verify sufficient clearance all the way around.
d. Embedded Wire Option (for typical 20 gauge motor wires – size for many high power 2000KV motors)
    i. It is possible to widen the three motor wire holes for wire sizes greater than 20 gauge using a small, round needle file inserted at an angle toward the arms body end. The hole is already predrilled at an angle to allow pushing the lead through and toward the body without binding. The intent here is to ultimately thread the leads into the three holes and into the arms cavity and out to the body end leaving sufficient wire to reach the solder pads or connectors with some excess. The excess allows the arm to pivot to its maximum angle without tightening or binding.

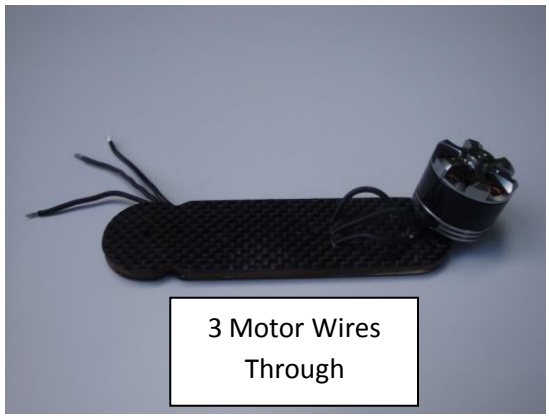
Needle File to Open Motor Wire Holes ONLY if Necessary



    ii. Align the motor mount holes to the motor mounting slots of the arm with the motor wires facing the three motor wire holes in the arms. Verify that there will be sufficient wire to reach your intended ESC solder pad locations or connector. A minimum wire length of about 4 inches is necessary. If not, use the “Surface Wire Option” described below. A solder joint will not fit through the hole unless the hole is widened as described above.
    iii. If your wires have pre-installed connectors, they must be removed. If the wire insulation is not uniquely colored, note which wire is threaded into each hole by tagging or marking the bare end after each is pulled through. This will aid in attaching to the correct pads on the ESCs for proper motor rotational direction. This step may not be necessary should your ESCs have a reverse motor option and you plan on setting direction using this ESC feature.
    iv. Avoid kinking the wire/insulation while snaking the motor wires into the holes and out the other end. There is a curvature to the channel so it may be necessary to give the end of the wire a slight bend to follow the curve near the exit of the channel. First insert the outermost motor wire into the corresponding hole. Gently push the wire through the arm until you can pull it out at the body end. The middle wire is next then the third. It may take a couple of tries until you get the hang of it – and yes – it can be done! You may need to manipulate the wires past the leg hole in the arm if it hangs up there. You will be able to see the wire through the leg hole and manipulate it

from the outside with a thin/blunt pointed object. Do not cut off any excess motor lead at this time.



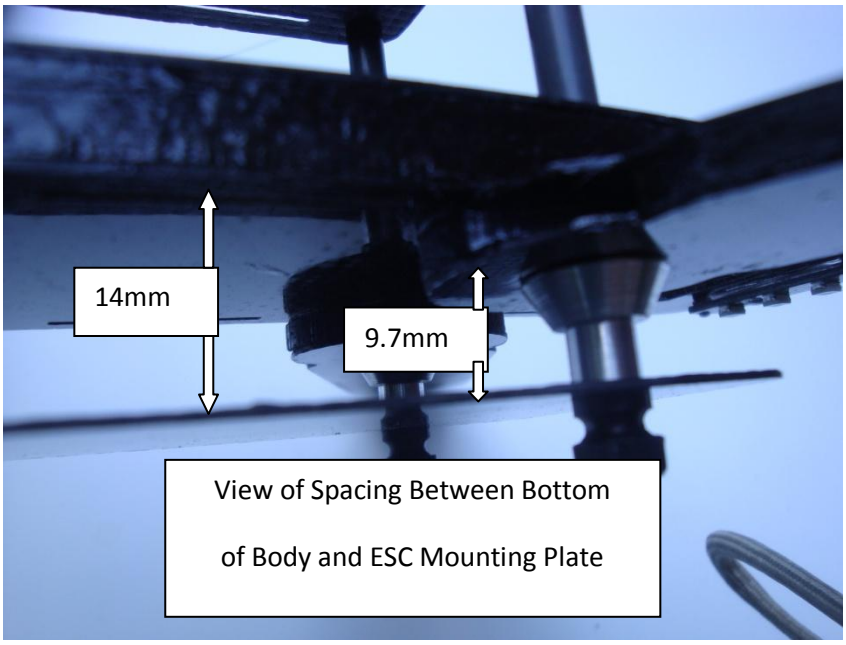


v. Bolt your motors to the arms while carefully pulling from the body end any excess wire loop at the motor.

e. Surface Wire Option – easier to install , but less aerodynamic
   i. Lay out your wires as described above to determine where you will fasten the wires to the arm. Drill small holes all the way through the arm on opposite sides of the wires to securely mount them to the arm using small “tie-wraps”.
   ii. If using this option, you may also consider surface mounting your motor ESCs directly on the arm surface. Again, this will additionally increase drag and turbulence and expose the components to possible unprotected crash damage.
   iii. Bolt your motors to the arms and fasten the wires as appropriate for your configuration.

4. ESC installation
   a. Prior to permanent attachment, note the depth of the bottom plate below the main body frame. The depth below the mounted motor arm and the bottom plate will be about 9.7mm. The depth between the main frame and bottom plate is about 14

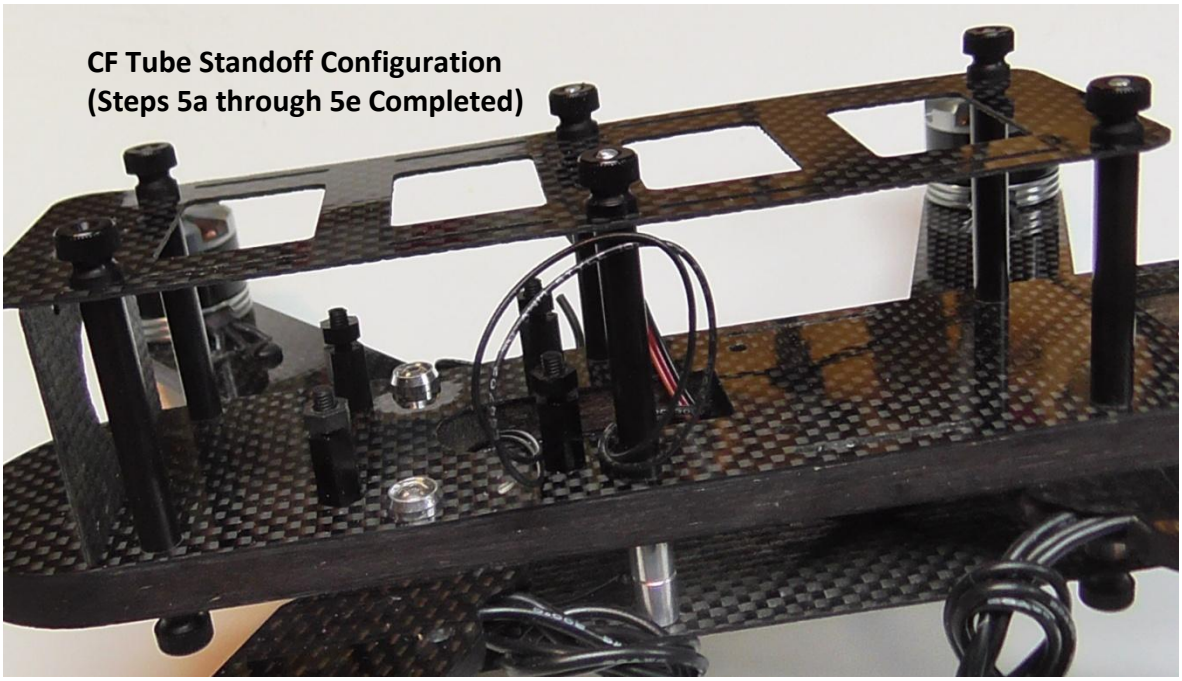
mm. This allows ample space for ESC mounting. If not already done, dry-fit the arms and bottom plate to the main frame should there be any doubt.



b. For unwired/bare ESCs, with the exception of the motor wires, pre-wire your ESCs. Use enough wire to reach their intended termination. A bit of excess length is recommended until the PDB, flight controller, and other peripherals are fitted in-place.
c. Slip the appropriate length of heat shrink over the ESCs and beyond the ESCs over the input power leads and signal/ground leads PRIOR TO SOLDERING the motor wires (to be soldered on later). This will allow for soldering the motor wires later and THEN moving the heat shrink over the ESCs prior to final shrinking.
d. TEMPORARILY place the ESCs onto the bottom plate so that the motor pads face the side of their intended motor arm. [There are other options available including PDBs intended for ESC mounting.] You may solder the motor leads to the ESCs at any convenient point during final frame assembly. After soldering the motor leads, move the heat shrink tubing completely over the ESC to cover all exposed bare wiring and solder joints. Shrink the tubing at this time.
e. Firmly mount the ESCs to the bottom plate using double backed tape (“servo tape”) supplied with this kit or mount using any other suitable method.

5. Frame Assembly
    a. Assemble the balance of the frame as you complete the final wiring of your electronics. See the accompanying photos for airframe standoff placements. Note that the upper standoff CF tubes are embedded into the main frame. They insert into the upper side of the main frame body and rest on the lower skin surface. Prior to insertion, check that the hole is clear of any obstruction. When finally tightened, this creates a very rigid frame. Temporary and partial frame assembly may be desired as you progress through assembly.

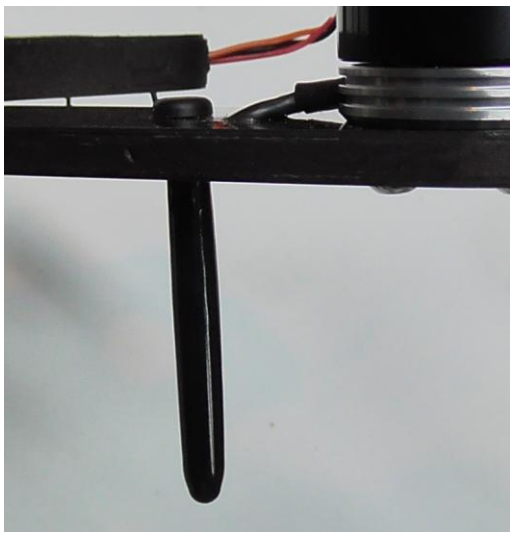
CF Tube Standoff Configuration
(Steps 5a through 5e Completed)



    b. Final tightening of the frame standoffs is done after all soldered / permanent equipment is installed. The camera plate must be inserted into the front upper and lower slots completely while the forward standoff fasteners are loosely fitted. The camera plate should rest squarely on the main frame body and top plate surfaces.

Camera Plate Configuration

c. With the motor arms held loosely in place, thread the aluminum cone nuts onto their respective threaded rod (rear arm) and 4-40 SS screw (front arms). The cone nut should be threaded on so it will leave sufficient thread for spacers and engagement with the knurled nuts. See the preceding pictures. All standoff knurled nuts should then be tightened snugly by hand. Note that the supplied cone nuts holding the rear motor arms in place are tightened by turning the top knurled nut. The front arm set is tightened by turning the supplied 4-40 steel screw. Do not over-tighten.
d. Attach the bottom plate using the aluminum spacers and nylon thumb-nuts. Each motor arm uses a 5mm spacer and the middle spacers are made up of two 7mm spacers each or a 9mm plus 5mm spacer (depending on what is supplied in your kit). Tighten the plate firmly. Readjust the hardware placement if necessary.
e. Take the main frame by hand and apply a moderate twisting force to the main frame. The frame should feel solid as if it is one piece. If there is any noted slipping or twist, verify that all standoff fasteners are properly tensioned.
f. Landing Gear Installation [Note: Nylon landing gear can be cut to desired length]
    i. Embedded Motor Wires
        1. Looking through the landing gear holes you will likely see that the motor wire(s) may interfere with the landing gear (LG) installation. Using any thin blunt object simply move the wires to the side and out of the way. There is enough space in the cavity to make room for the LG. Install the LG screws.
    ii. Surface Mounted Motor Wires
        1. If the wires cover the landing gear (LG) holes, move the wires apart to make room for installing the LG and prevent pinching a wire under the LG head. Install the LG screws. The wires may be moved back and rest on top of the LG head.
    iii. Slide the plastic boot over the leg. The boot may fit tightly and may need to be “worked” onto the leg. When installed, it should not come off easily. If loose, remove the boots and place a small amount of RTV / Silicone Seal or similar pliable glue to the lower threads of the legs. Fit the boots back over the leg and stand the completed airframe on a flat surface until the glue hardens securing the boots in place.



Landing Gear Screw and Boot Installed

g. Final Adjustment of Motor Arm Position & Tension
   i. The motor arms are designed to intentionally pivot at the single mounting point.
   ii. The motor arm is typically mounted at about 60 degrees from the main frame (see picture below). This is a good starting point for most applications. Verify that your propeller will not interfere with the main frame standoffs. The arm length is designed to accept a 5 inch prop without interference. There should be no noted "slop" and the arms should feel firmly seated in position, yet should pivot with moderate force. Tighten/loosen the arms as necessary so that they are firmly seated but can pivot with moderate force. **Do not over-tighten** to cause excessive dimpling of the laminate or possibly sheering the aluminum threaded rod.

PROPER ANGLE AND ANGLE TEMPLATE

   iii. Repeat the above steps when realigning the arm(s) after a crash. Inspect for damage to the arm or frame. Always repair or replace broken structural parts prior to use.
   iv. The positioning of the motor arms can be varied from 60 degrees to affect flight characteristics, including the location of the center of gravity (CG).

Happy Racing!

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