Web Site: www.parallax.com
Learn: learn.parallax.com
Forums: forums.parallax.com
Sales: sales@parallax.com
Technical: support@parallax.com

Office: (916) 624-8333
Fax: (916) 624-8003
Sales: (888) 512-1024
Tech Support: (888) 997-8267
EDU Hotline: (916) 625-6801

Multirotor Flying Guide - ELEV-8 V2

New to flying multirotor aircraft? This guide for the ELEV-8 V2 Quadcopter is a perfect place to start learning. Topics include RC transmitter controls, safety guidelines, arming and disarming your flight controller, beginning and advanced flying techniques, and optimizing your multirotor performance.

The first thing you need to know is:
If you have an ELEV-8 Quadcopter **you must register it** with the Federal Aviation Administration's UAS Registry before flying outdoors.

Multirotors Are Not Toys.

You will not be capable of safely handling and flying a multirotor, including the ELEV-8 Quadcopter, unless you have respect for the dangers they present. In the worst case scenarios, multirotor misuse can cause grave bodily injury and damage to property, in addition to significant legal fines, jail time, and insurance payments. However, if you follow all instructions, guidelines, and safety warnings, and use a healthy dose of caution and common sense, piloting and interacting with multirotors is not a particularly dangerous activity. Unfortunately, far too many individuals — especially beginners — do so only after they have a near-miss or incident. Please don't let that happen to you.

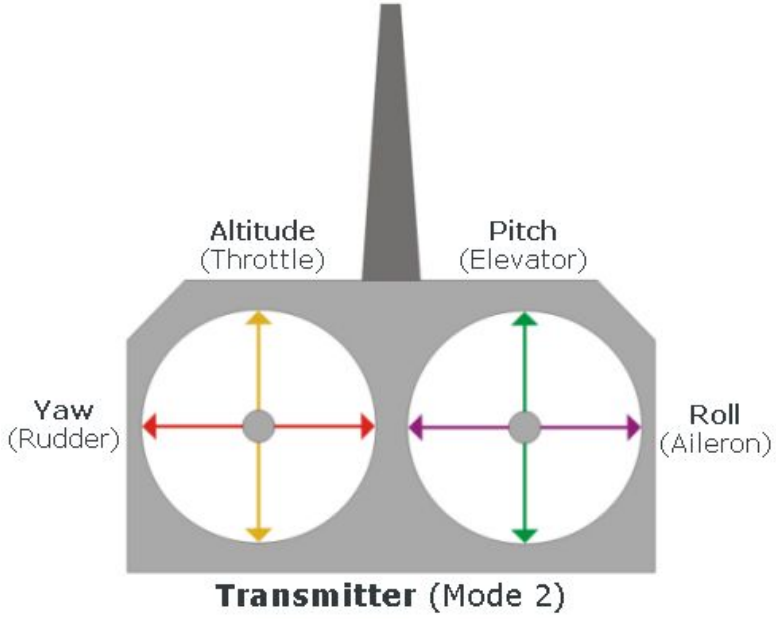
"Don't be a show-off. Never be too proud to turn back. There are old pilots and bold pilots, but no old, bold pilots."
– E. Hamilton Lee, 1949

Now that we are clear on that, follow the links below to learn more about flying your ELEV-8 Quadcopter.

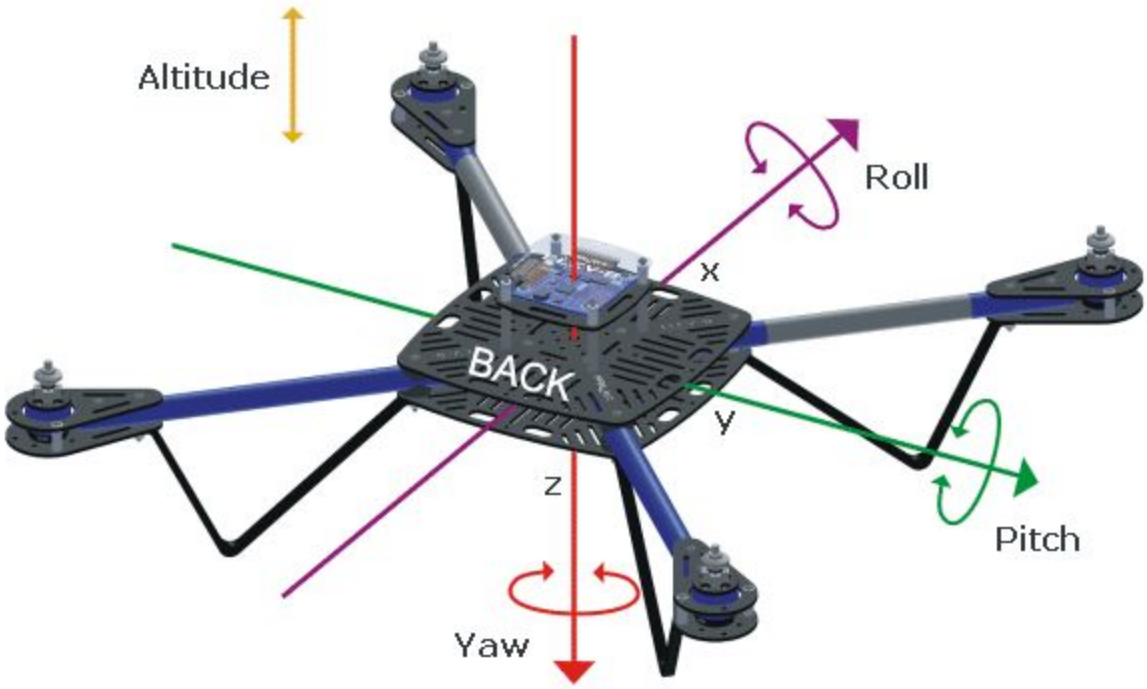
Learn Your Transmitter Controls

Understanding RC Aircraft Transmitter Controls

(Adapted with permission from the HoverflyOPEN User's Guide)
RC Aircraft Transmitters designed for aircraft feature two proportional joysticks (or sticks): one is used to control the pitch and roll of the aircraft, while the other controls throttle and yaw. Note that the yaw, pitch, and roll channels are proportional, which means the position of the stick is equal to the rotational rate (NOT the absolute position). So the farther you move the stick, the faster your multirotor will rotate, and to stop the rotation the stick must be centered. This also means that when the control stick is centered, the multirotor is not necessarily level! These three controls will also return (spring back) to center when released, whereas the throttle control will remain where it is left.



All Parallax literature assumes the use of a Mode 2 Transmitter (see above image), whereby the left stick controls throttle and yaw while the right stick controls pitch and roll. Mode 1 Transmitters (much less common) reverse the sticks, so the left stick controls pitch and roll while the right controls throttle and yaw.



- **Altitude** (throttle) of a multirotor is controlled by the vertical position of the left control stick. This stick starts in the downward or “zero throttle” position, where the motors will not spin. As the stick is moved upward, the rotational speed of the motors will increase. Every multirotor has a “neutral throttle” position where a constant altitude is maintained and the multirotor hovers.
- **Yaw** is the rotation around a vertical axis through the center of the multirotor. The yaw is controlled by the Rudder channel (horizontal movement of the left stick); to spin the (front of the) multirotor to the left, move the stick to the left; to spin to the right, move the stick to the right.
- **Pitch** is the rotation around the lateral axis (a horizontal axis through the multirotor from left to right). The pitch is controlled by the Elevator channel (vertical movement of the right stick). Increasing the pitch causes the multirotor to move forward, while a decrease causes the multirotor to move backward.
- **Roll** is the rotation around the longitudinal axis (a horizontal axis through the multirotor from back to front). The roll is controlled by the Aileron channel (horizontal movement of the right stick). Moving the stick to the right causes the multirotor to move right, while moving the stick to the left causes the multirotor to move left.

Please note that other flight modes such as Auto-Leveling (not a HoverflyOPEN capability) may significantly change the aforementioned flight characteristics.

Flight Guidelines

Universal Flight Guidelines

- Review and abide by the Academy of Model Aeronautics National Model Aircraft Safety Code.
- Inform yourself of and abide by all laws and regulations (including federal, state and local).
- The pilot must not be distracted (by people, phones, etc) or impaired (by medications, alcohol, drugs, etc).
- The pilot must always wear eye protection.
- No one (even the pilot) should ever be within 25 ft (7.6 m) of a multirotor while it's armed.

Indoor Flight Guidelines

- Flying Area should be no less than 20 ft (6 m) tall, 30 ft (9 m) wide, and 40 ft (12 m) long.
- The Flying Area must be completely free of all persons, animals, and obstructions (such as electrical lines, lights, etc.) for the duration of the flight.
- Establish a Safety Line in front of which all flying takes place.
- Only the Pilot is allowed at or in front of the Safety Line.
- Spectators must remain at least 25 ft (7.6 m) behind the Safety Line at all times.

Outdoor Flight Guidelines

- Flying Area must be completely clear of potential hazards (persons, animals, structures, tall vegetation, water bodies, electrical and gas lines, etc) for the duration of the flight.
- **Grass fields are best** for beginners; in the event of a crash they will cause significantly less damage to your quad when compared to hard surfaces. Experienced flyers may use asphalt or concrete, but all users should avoid dirt and gravel, which can turn into dangerous projectiles.
- Establish a Safety Line and Pilot Line (at least 25 ft (7.6 m) behind Safety Line). Spectators must always remain behind the pilot.
- Avoid flying in extreme temperatures (below 32°F (0°C) or above 95°F (35°C)).
- Winds should be less than 5 mph (8 kph), including gusts. Experienced pilots may be able to handle winds up to 15 mph (24 kph), but this is not recommended.
- Do not fly when precipitation, lightning, or other hazardous weather is forecasted.
- Visibility should be at least 1000 ft (400 m).
- You must follow Academy of Model Aeronautics “See and Avoid” Guidance on avoiding manned aircraft.

Before You Fly

ELEV-8 Quadcopter Pre-Flight Checklist

(Adapted with permission from the HoverflyOPEN User's Guide)
Ensure that:

- Propellers are securely attached to the correct motors. When each motor is spinning in the proper direction (CW or CCW) the pitch should direct the thrust downward
- None of the propellers are damaged (chipped, bent, cracked, etc).
- All wires are secured so that they cannot move into the spinning propellers.
- All HoverflyOPEN connections to the ESCs and Receiver have been made correctly.
- The transmitter is programmed and set to the correct model.
- All fasteners are in place and properly tightened.

Now you are ready to arm your flight controller. These next two pages in the "Before You Fly" section will walk you through both the arming and disarming processes, as well as the three common errors you may encounter.

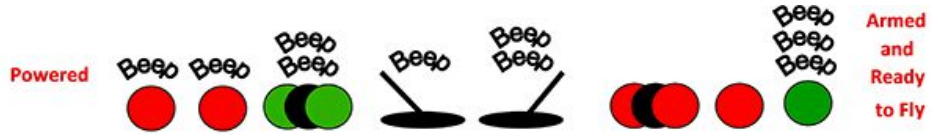
Arming and Disarming Procedures

After powering up your multirotor for flight, all Flight Controllers must be “armed” before they will respond to throttle input and supply power to the rotors, making them spin. This is a safety precaution to reduce the likelihood of unintentional rotor spin or takeoff, both of which could cause significant bodily harm and/or damage to property.

This “arming” and “disarming” information pertains **only** to the HoverflyOPEN Flight Controller.

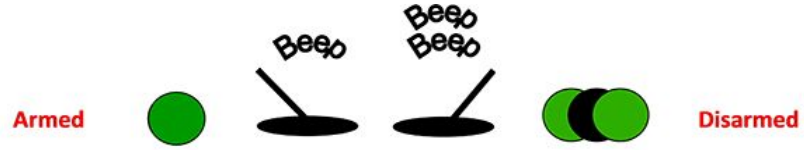
Arming Procedure

1. Move your Transmitter throttle stick to minimum.
2. Connect the battery to the multirotor to provide power.
3. The ESCs should initialize within 5-10 seconds and beep according to the ESC manual.
4. The HoverflyOPEN will twice and flash it’s LED light green when it is ready to be armed.
5. To arm, move the throttle stick to the left-bottom until you hear one beep.
6. Move the throttle stick to the right-bottom you should hear two beeps. The HoverflyOPEN’s LED will blink RED. During this period the HoverflyOPEN is calibrating its internal sensors and should remain motionless. Do not arm while holding the multirotor.
7. When arming is complete, the HoverflyOPEN will beep 3 times.
8. At this time the LED light will turn solid green. The HoverflyOPEN is now armed.
9. If the HoverflyOPEN’s LED light turns purple at any point during the arming sequence, ensure altitude hold is disabled and the multirotor remains motionless while arming. Repeat the arming sequence.



Disarming Procedure

1. Move your Transmitter throttle stick to minimum.
2. Move throttle stick to left-bottom until you hear one beep.
3. Move throttle stick to right-bottom until you hear two beeps.
4. HoverflyOPEN is disarmed.

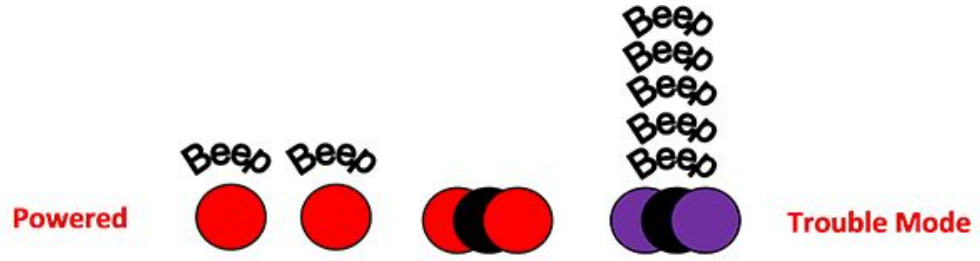


Arming Procedure Troubleshooting

Trouble Mode

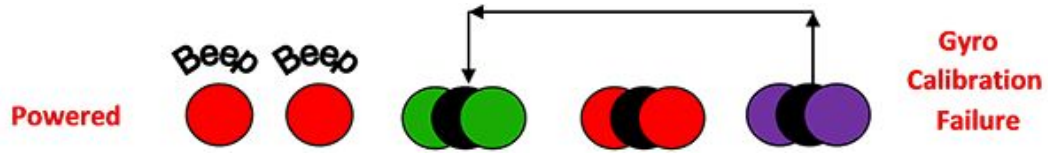
Trouble mode is activated when one of the 5 required channels is not detected (Throttle, Elevator, Aileron, Rudder, Gain).

1. Check Receiver connections and binding.
2. Disconnect and re-connect power and repeat Arming procedure.



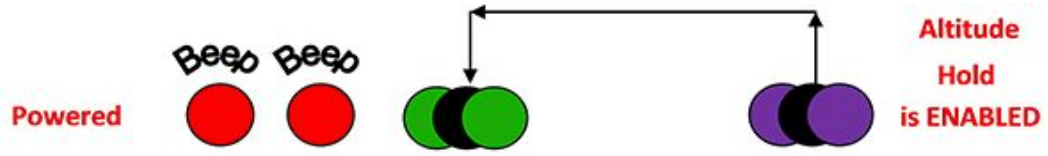
Gyro Calibration Failure

The HoverflyOPEN performs a Gyro Calibration after power-up. If this calibration fails the LED will respond with a particular blinking sequence that is shown below.



Altitude Hold Enabled When Arming

The HoveflyOPEN cannot arm when the Altitude Hold is enabled on power-up. You must disable Altitude Hold using the Gear switch in the “off” position and repeat the Arming process. The following LED sequence will be shown if Altitude Hold is enabled during the Arming process.



Flying and Optimizing Your Multirotor

General Multirotor Piloting Advice

- If possible, have a more experienced pilot take the first flight, as they will better be able to deal with any issues that arise and get it trimmed properly.
- Before every take-off, slowly throttle up about 10%, so you can be sure all props are spinning in the correct direction. Brushless motors sometimes experience a phenomenon known as “slip” whereby they spin slower and in the wrong direction. If this occurs just throttle down, wait for the propellers to stop, and then throttle back up 10% and confirm the issues has been fixed. If you skip this and quickly throttle up, you may not notice the issue until your quad just lifts off the ground and instantly flips.
- Until you have a few dozen flight hours (which will take you quite a while), don’t fly more than a few hundred feet away, or with the quadcopter facing anywhere except directly away from you. Attempting either of these will make piloting significantly more difficult.
- Note that for all rotor-based aircraft (including quadcopters), any directional movement will decrease lift, causing the quad to lose altitude, so you will want to compensate by slightly increasing the throttle.
- One of the challenges you will have is that the momentum of the multirotor requires some throttle correction as it moves up and down. In other words, after you change altitude, you will need to increase or decrease the throttle around “neutral throttle” to enter a stable hover. This is especially true when descending; once the multirotor achieves the desired altitude a swift increase in throttle will be required to offset the momentum of the falling multirotor.
- The transmitter controls are extremely sensitive, so avoid overreacting or overcompensating.
- All rotor-based aircraft (including quadcopters) are much more stable in ascent (going up), than descent (going down), so be careful to descend slowly, or you may lose control.
- **If anything goes wrong, just throttle down!** You'll be keeping it low enough that the fall shouldn’t damage it. If you don't yet have the skills or experience to fly your way out of a mistake, it's much safer for you and your equipment if you kill the throttle the instant you're not in control. (AeroQuad, 2012)
- One of the most common causes of a crash is a loss of directional resolution. This occurs when you become unable to determine the direction the multirotor is facing or moving (and thus cannot effectively control it).
- Avoid the Ground Effect (whereby the ground creates turbulence that is difficult to fly in) by hovering and flying at least 3 ft (1 m) off the ground.

The following pages offer beginning and advanced flying information, as well as lessons on proper frame balancing and adjustment of Primary Gain. It is highly recommended that you

take the time to read and follow the advice given in this section to reduce your risk of damage or injury to persons, property, or your multirotor.

Beginner Flight Practice

Low-Risk Flight Practice

Before you go out and fly your full-size multirotor, it would be prudent to spend some time practicing piloting RC multirotors in a low-risk fashion, where dozens of crashes won't stretch your wallet thin. There are two main ways to practice flying:

- We strongly recommend you purchase a BNF (bind and fly) Mini Quadcopter. BNF will allow you to use your transmitter (the same one you will use for the ELEV-8). These inexpensive and nearly indestructible models are designed for indoor flight and are a great way to learn how to fly using your particular transmitter without worrying about damage from crashing.
- Flight Simulators are another less common way to learn how to fly RC model aircraft. They are usually computer programs that come with an adapter that allow you to connect your transmitter to your computer. While there are very few flight simulators that offer multirotors, you can use RC helicopter simulators, as they fly similarly to multirotors.

First Full-Scale Flights

Once you are comfortable with your piloting abilities, you can at last begin flying your full-size multirotor! What follows is some general advice on how to successfully approach your first few flights. The first thing any new pilot must learn is throttle control. Below are some steps we recommend following to help you get a handle on the matter. (Don't forget about all of the guidelines, warnings, and precautions!). Keep in mind that learning this will take dozens of flights. It is not something you can learn in a day, or even a week, and complete mastery will take many months of dedicated practice.

1. Place the multirotor on the ground facing away from you in a wide open area. Plug in the battery. Step back at least 25 ft.
2. After arming the flight controller, slowly and carefully increase the throttle until the multirotor begins to lift off. For most multirotors, it takes just over 50% throttle to take off. As soon as your multirotor leaves the ground, gently ease off and begin to decrease the throttle and land.
3. If all systems are working correctly, the multirotor should not drift much horizontally and it should maintain fairly level flight. If this is not the case, then stop and troubleshoot; one can't fly with faulty hardware or software.

4. Repeat this process, gently lift off and then land again, until you have a good feel for how much throttle is required to keep the quad in the air. Try keeping it airborne slightly longer - but don't worry about sideways drift yet, all we care about right now is that the quad stays at a steady height. For now, keep the multirotor below head height at all times. If the quad drifts too far, ease off the throttle and land it.
5. Once you are able to hold the multirotor at a steady altitude, try to use the roll/pitch stick to counteract the multirotor's horizontal drift. If the multirotor drifts left, move the stick to the right just slightly. If it starts drifting towards you, push the stick up a fraction. You want to get a feel for how the multirotor moves and responds to control. At this point, holding your multirotor at a steady height should be mostly automatic. Remember to cut the throttle if the multirotor gets out of position, and especially if it starts moving towards you.

Continue to practice this until you can hover the multirotor in one spot for a full battery pack. At that point, you're ready to move on.

Advanced Flight Practice

Advanced Flight: Nose-In

Now that you have mastered the fundamentals discussed in the Beginner Flight Practice section (if you haven't, return to that section now), you can move on to more advanced maneuvering; specifically, flying "nose-in," whereby the multirotor is facing you (as opposed to facing away from you, as has been the case until now). Again, keep in mind that learning this will take dozens of flights and many months of practice.

1. Just as when you were first learning to fly (nose-out), place the multirotor on the ground in a wide open area and plug in the battery, only this time orient the multirotor so that it is facing *towards* you (nose-in). Step back at least 25 ft.
2. After arming the flight controller, slowly and carefully increase the throttle until the multirotor begins to lift off. Bring it to a hover about 3 ft (1 m) above the ground.
3. Very gently and slowly move the multirotor around (left, right, forwards, backwards), while you get used to the controls, which will be "backwards" since your perspective is now opposite that of the multirotor. Even if you are a pro a nose-out flying, keep it close to the ground and go slowly! If you ever become confused or disoriented, immediately cut the throttle; *do not try to "recover"*!
4. Continue to practice until you can hover nose-in for an entire battery pack. Practice even more until you can hover nose-in in light winds without significant effort; you need to be able to control without thinking, as you won't have time think through it when flying.
5. Next, practice switching between nose-in and nose-out. Start hovering nose-in, and then slowly turn to nose out using the yaw. Hover nose-out until you are comfortable and in-control, then turn back around nose-in. Repeat until you can effortlessly switch between the two positions.

6. Now, try hovering side-in. Since you should have the controls more fully mapped out in your brain, this should be fairly easy to do. Practice until you are completely confident in your ability.
7. Once you think you have mastered everything so far, it's time to put your skills to the ultimate test: practice hovering in place for an entire battery, while slowly but continuously spinning. This will require all of the skills you have learned so far; you will need to adjust the throttle to maintain a constant altitude while applying a gradual but constant yaw, all the while using pitch and roll to maintain position as the multirotor's heading constantly changes.
8. Lastly, try driving the multirotor around a bit more. Pick a spot, fly to it, and hover there for a while and spin around. Do some low passes with the multirotor in every orientation you can fathom. Bring the multirotor back to a nose-out hover, spin it to nose-in, and fly it away from you backwards. Just generally do laps and have fun.

Congratulations! You can now fly in any orientation.

Adjusting Primary Gain

Adjusting the Primary Gain of Hoverfly Flight Controllers

(Adapted with permission from the HoverflyOPEN User's Guide)

The Primary Gain value is used by the HoverCore flight stabilization algorithm to fine tune the flight performance for a particular multirotor. Some multirotors will require low values and some will fly better with high values. Neither low nor high is better nor an indication of how well a multirotor will operate, and the exact value is not important. The value is related to the length of the arms, propeller diameter and your power-to-weight ratio. In general a value that is too low would make the controls feel slow to respond and the multirotor would be difficult to fly. A value that is too high would result in quick oscillations of the multirotor and once again it would be difficult to fly. Every multirotor will have a slightly different gain and the user must adjust the Primary Gain to find the "sweet spot" where it feels best for their type of flying.

Parallax recommends an initial Primary Gain setting of 25% (see Step 22 of the ELEV-8 V2 Assembly Guide), however every multirotor is different and some will require a starting value of less than 25%. Therefore, every multirotor should be tuned to optimize the gain based on feel in flight. This is best done by pilots with at least a few hours of flying experience. Follow the steps below to optimize the Primary Gain value. NEVER ADJUST GAIN WHILE AIRBORNE

1. Power the transmitter and then the multirotor.
2. Increase the throttle and observe the multirotor.
3. If it is very unstable when it lifts off the ground (drastically tilting and rolling), you need to lower your starting Primary Gain value (probably by at least 10%).
4. If the multirotor lifts off the ground and you have control, move it left and right and observe the reaction time between your stick movement and the multirotor roll.
5. If the control feels mushy or slow to react then increase the Primary Gain by 10%.

6. Take another test flight to see how the change affects flight performance.
7. Continue to repeat steps 4-5 until you notice the multirotor begin to oscillate, indicating that the Primary Gain is too high.
8. Reduce the Primary Gain by 5%.

You will now want to fly higher and roll and tilt the multirotor quickly looking for an oscillation or overcorrection of the arms. If this occurs you will need to reduce the Primary Gain slightly. The multirotor should “feel” quick to react to your aileron and elevator commands. Beyond this, it’s up to the personal preference of the pilot; some like a bit slower response and reduce their gain even more (better for photography and videography), while others prefer the multirotor to be “on edge” with a very fast response and thus choose a high gain (better for aerobatics). You should not need to readjust your Primary Gain unless you change the multirotor significantly.

Balancing the Frame

Another way you can optimize the performance of your multirotor is to balance the frame, ensuring that the center of mass of the multirotor is in the exact geometric center. This will balance the workload of the motors, allowing you to get maximum power and performance. It is best to first balance the frame without any batteries, and then place the battery in such a position that the balance is maintained.

To Balance an ELEV-8 V2 Frame (without Battery):

1. Find two identical narrow but stable objects 4 to 10 inches (10 to 25 cm) tall that have a flat bottom and top.
2. Set the two objects on a flat surface about 14 inches (36 cm) apart, on center.
3. Flip the ELEV-8 upside-down and balance opposite booms on the objects, as shown below.

1. Shift components on the ELEV-8 around until it tips in either direction equally. You may need to remove the bottom chassis plate to have complete access to all components.
2. Rotate the ELEV-8 90 degrees to balance on the other two booms. You will need to periodically rotate it to ensure it stays balanced in the other direction.
3. Once the ELEV-8 is balanced in both directions, secure all of the components (this should include the receiver, power breakout cable, and ESCs).

Additional Resources for Multirotor Flight

Academy of Model Aeronautics National Model Aircraft Safety Code
Academy of Model Aeronautics “See and Avoid” Guidance
Academy of Model Aeronautics “Model Fliers and their Neighbors”
Academy of Model Aeronautics Flying Site Safety and Operational Rules
Academy of Model Aeronautics Indoor R/C Guidelines
DIY Drones Glossary
AeroQuad Glossary