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ASTRO-PHYSICS

State-of-the-Art Instruments for Discriminating Astronomers

MACH2GTO

GERMAN EQUATORIAL WITH GTOCP5

Keypad Optional

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ASTRO-PHYSICS
MACH2GTO GERMAN EQUATORIAL WITH
GTOCP5 Micro-Step Servo System

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ABOUT THIS MANUAL

This version of the Mach2GTO Manual was prepared for the production run of mounts (serial # M20011 and later) that began shipping in February of 2020. Most of the information in this manual is applicable to all Mach2GTOs that have been produced. We have also learned a few things through experience and the suggestions of our customers that have improved the information available in this manual.

You should note that this manual is actually one component of a three-document system.

- Mach2GTO German Equatorial Mount manual
- GTO Micro-step Servo System manual
- Keypad manual (only shipped with optional Keypad order)

This Mach2GTO Manual will cover the Mach2GTO's mechanical features and physical operations.

We highly recommend the Support section of our website for the latest information and for future updated versions of this manual. There are also valuable information and help guides.

A final note and an apology to our friends in the southern hemisphere. Many of the instructions in this manual are written entirely from the point of view of those of us in the northern hemisphere. Since descriptive terms like left and right are meaningless without a defined point of reference, we tend to use east and west to avoid ambiguity. The east and west sides of a German equatorial mount are, of course, reversed in the southern hemisphere. At one point, our thought was to always use phrases like the following: "...on the east side (west side in the southern hemisphere)..." This quickly became cumbersome and made the text more difficult to read. For simplicity, we decided to leave many of the explanations in their northern hemisphere framework. Thank you for your understanding.

Note: Some photos may differ slightly from the current mounts that are shipping.

Please Record the Following Information for Future Reference

Mount Serial Number: ____________________

GTOCP5 Serial Number: ____________________

Keypad Serial Number: ____________________

Purchase Date: ____________________

User Name and Password: ____________________

MACH2GTO PARTS LIST

1 Mach2GTO German Equatorial Head with Micro-step Servo System
1 GTO Control Box (model GTOCP5) with control box-to-pier adapter (CBAPT)
1 13.7” x 1.875” Stainless Counterweight Shaft (M2043) with Delrin Washer and Machined Safety Stop (M12676)
1 24 volt power supply (PS24V10AP)
1 D.C. power cord set - 6’ cable with Powerpole connectors (CABPP6) and clip (FPCLIP)
1 1/4-20 Machined Knob Kit (M1485KBKIT)
1 15’ serial cable (CABSER15)
1 USB Flash Drive containing PDF of Instruction Manuals
1 Hex key set
Instruction Manuals and Registration Card
All required fasteners

In order to fully use your mount, you will need some of the following items sold separately. Many of these items will be discussed throughout these instructions.

- **Dovetail saddle plate:** There are several choices to fit your telescope and observing needs. See detailed information in “APPENDIX F: MOUNTING Plate Options” on page 48
  - 10” Dual-style Dovetail Saddle (DOVEDV10) – recommended for most scopes used with this mount.
  - 16” D-style Dovetail Saddle (DOVELM162) – recommended for large scopes

- **Pier or Tripod:**
  - 6” Eagle Folding Pier (EAGLE6-EZ)
  - Berlebach Wood Tripod (AWTBER2) – requires Extension for Control Box Adapter (Q6280KIT)
  - Losmandy Light-weight Tripod for AP (LMLWT-AP) – ideal for portability when travelling
  - Adapt to your own custom pier or tripod with our Tripod Adapter (ADATRI)

- **Counterweights:** 5 lb. (5SCWT), 10 lb. (10SCWT) and 18 lb. (18SCWT) counterweights are available for the standard 1.875” diameter counterweight shaft. Generally, 85-125% of the weight of the scope, mounting plates and accessories is required in counterweights (more weight is required with larger diameter SCT scopes).

Several additional options are available. Many of these items will be discussed throughout these instructions:

- **Optional Keypad Controller with 15’ Coiled Cable:** Hand-held computer to operate the mount without a PC and additional software.

- **Right-Angle Polar Alignment Scope with LED Illuminator (RAPAS) and Adapter (RAPM2):** for quick and easy polar alignment. Adapter and polar scope attach externally to the Mach2GTO.

- **Pier Accessory Trays:** A flat accessory tray with raised sides (TRAY06), a tray with eyepiece holes (TRAY06H), and two support bar options (TRAYSB or TRAYSB1) are now available to fit the 6” Eagle Adjustable Folding Pier and both tripods. They are handy places to keep your eyepieces and astro-gadgets close at hand! They can also be used with the 8” Eagle Extension (EAGLE6E8) on other tripods. An extension is required for attaching trays to a Berlebach or Losmandy tripod

- **Autoguiding Accessories:** Our 10 x 60 Vario-Finder with Guider Bracket Kit (1060VGKIT) is a highly recommended accessory for imagers. The GTOCP5 Control Box takes advantage of timed pulse guiding commands offered by most software guiding programs for best precision. See the GTOCP5 Micro-Step Servo System manual for more information.

  Additionally, various imaging and CCD-based guiding configurations can take advantage of the Mach2GTO’s autoguider port (RJ-11-6) which uses the industry standard SBIG ST-4 wiring setup.

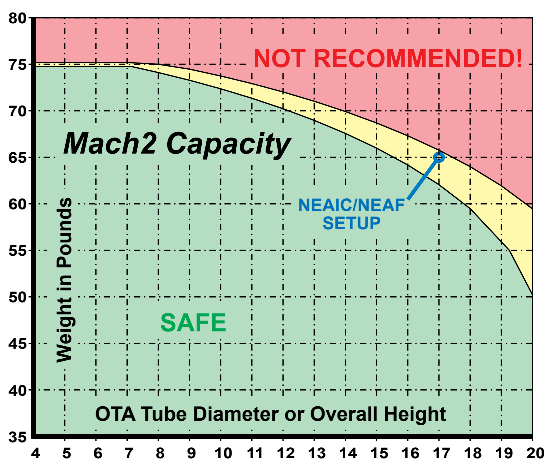
- **Alligator Clips with APC Fuse to Powerpole Connector (CABPPAL):** This adapter is used when powering the mount from a battery (deep-cycle or Lithium Ion recommended) in the field. The alligator clips attach directly to the battery terminals.

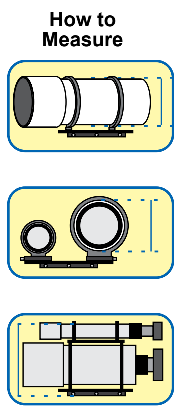
- **USB Cables and Hubs**: Refer to our recommendations beginning on page 22.

- **Pelican iM2875 Storm Travel case:** Case can utilize the shipping foam with slight modification.

MECHANICAL FEATURES AND SPECIFICATIONS

Construction	All parts CNC machined aluminum, stainless steel & brass bar stock; stain-less steel fasteners
Worm wheels - RA/Dec	5.9” (150 mm), 225 tooth aluminum
Worm gears - RA/Dec	0.71” (17.9 mm) diameter, brass
Axis shafts - RA/Dec	1.77” (45 mm) diameter
Periodic error	0.25 arcseconds peak-to-peak, 0.05 RMS
Motors	Brushless micro-step servo system
AC-DC Power supply	24-volt, 10 amps continuous, universal 85-240V
Power requirements	Nominal 12 to 24-volt DC supply, minimum 5 amps continuous 12 Volts: Tracking - 1.5 amps DC, Max slewing rate @ 1200x (both axes) - 4.2 amps DC (50 watts) 24 Volts: Tracking - 0.8 amps DC, Max slewing rate @ 1800x (both axes) - 3.6 amps DC (86 watts)
Slew speed (maximum)	1200x with 12 volts (5 degrees/second) 1800x with 24 volts (7.5 degrees/second)
Latitude range	0-68 degrees, engraved scale
Azimuth adjustment	Approximately 13 degrees (+/- 6.5 degrees from center)
Counterweight shaft	Dimension: 1.875” (47.6 mm) diameter x 13.625” (346 mm) usable length Weight: 10.9 lb (4.9 kg) Light-weight scopes might not need counterweights
Weight of mount	Total: 42 lb (19.8 kg)
Imaging capacity of mount	75 lb (34 kg), scope & accessories only, (maximum capacity depends on scope diameter & length) See chart below.
Instrument mounting interface	Refer to “Attach Mounting Plate” on page 19.
Diameter of base	5.80” (147.3 mm) (portion that is inserted into pier top or ADATRI adapter)

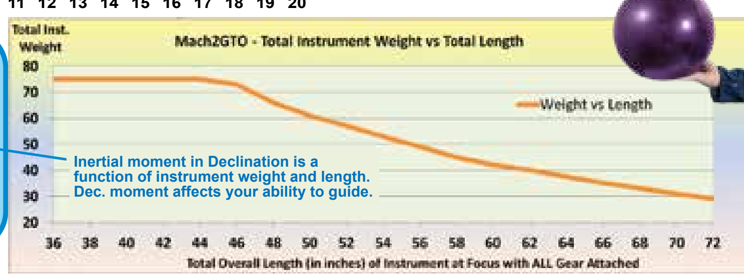




WHY WEIGHT CAPACITY ALONE IS AN INADEQUATE SPECIFICATION

Go ahead! Try this at home!

The capacity graph above deals primarily with effects on the RA axis. RA must hold both the instrument and the counterweights. Declination has its own considerations



Don’t mess with Karen!

INTRODUCTION

The Astro-Physics Mach2GTO – **Observatory Performance in a Small Package!** This is a highly-advanced, compact and lightweight mount that was designed for utmost portability while maintaining extreme rigidity and superb tracking accuracy. No shortcuts were taken to achieve these goals. The integrated absolute encoders, the use of precision machine tool bearings and the innovative worm wheel / clutch design represent a new approach to the overall performance of this mount.

The advent of modern CCD cameras and telescopes with high-resolution optics has placed greater demands on the ability of mounts to do their part to achieve precision tracking and guiding. At the same time, the mount should be easy to use with adjustments and setups that are straightforward and accurate. We have done everything possible to eliminate the frustrations and limitations inherent in a lesser mount and to put the fun back into the hobby of amateur astronomy.

The Mach2GTO employs the reliable and sophisticated Astro-Physics GTOCP5 Micro-Step Servo System. The system uses precise micro-step motors that are controlled with absolute encoders by the remarkable GTOCP5 control box. The GTOCP5 is truly the brains of the system taking your wishes as expressed through a command input device like the Astro-Physics Keypad or a computer, and translating them into actions taken by the mount.

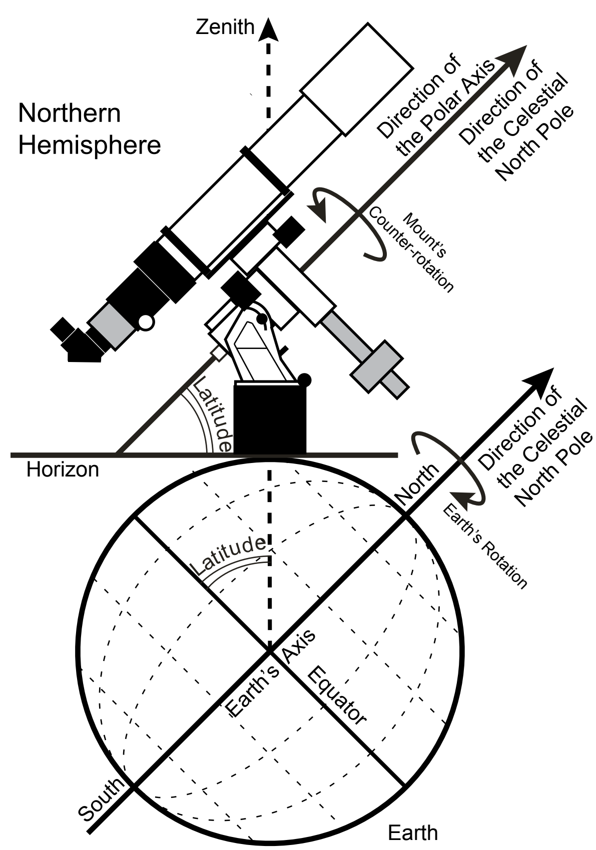
The advanced features of the optional keypad allow you to slew automatically to objects in a wide range of databases, as well as any RA / Dec coordinates. A large selection of common star names and non-stellar objects makes your selection a snap. Version 5.x also includes an orthogonality routine and pointing model. Keypad operation is simple and intuitive.

Various computer software and our fully supported V2 ASCOM driver are available to make the connection between you, the astronomer, and the servo system versatile and straightforward. Details on the servo system and the various options for control software can be found in the separate Astro-Physics GTOCP5 manual.

The Mach2GTO has the strength, rigidity and sophistication to tempt you to permanently place it in a state-of-the-art observatory. However, its portability and ease of setup make it the finest mount of its size for remote use in your favorite dark sky site and even for travel to exotic observing locations around the world. This is the perfect mount for a small to mid-size refractor, Newtonian, Cassegrain or astrograph. Whether you enjoy visual astronomy exclusively or plan an aggressive astro-imaging program, this mount will allow you to maximize your night out under the stars.

In order to fully enjoy your first night out, we recommend that you familiarize yourself with the assembly and basic operation of the mount indoors. The temperature will be comfortable, the mosquitoes at bay, and you'll have enough light to see the illustrations and read the manuals. Please take particular note of balancing, use of the clutches and operation of the keypad controller.

We offer Quick Start Summaries in this manual and more information in the GTOCP5 manual to assist you with keypad and computer operation.



Why Polar Alignment is Important

Polar alignment is required in order to compensate for the Earth's rotation. If you were to take a long exposure photograph while aimed at the celestial pole, you would discover that all stars seem to revolve around it. This effect is due to the rotation of the earth on its axis. Motor driven equatorial mounts were designed to compensate for the earth's rotation by moving the telescope at the same rate, though opposite to the earth's rotation. When the polar axis of the telescope is pointed at the celestial pole (polar aligned) as shown in the diagram, the mount will follow (track) the motions of the stars, planets and deep sky objects. As a result, the object that you are observing will appear motionless as you observe through the eyepiece or take astrophotos.

Key Points Unique to the Mach2GTO

- **The GTOCP5 Control Box is individually paired to the mount.** It cannot be swapped to any other mount; not even another Mach2GTO. Note that the serial number of the GTOCP5 is the same as the serial number of the mount. That is because the GTOCP5 contains the information necessary for the perfect pairing of the worm and worm wheel with the absolute encoders.
- **The Mach2GTO has integrated absolute encoders as mentioned above.** These encoders eliminate all RA periodic error and Dec backlash, in addition to providing absolute positioning. PEMPro is not needed with the Mach2GTO, nor do you want to attempt to run periodic error curves.
- **There is no need to resume from reference park positions with the Mach2GTO.** It always knows where it is! Just power up the mount and go to your first object. Though not necessary, it is often convenient to park at Park 2, Park 3 or Park 5 positions for reasons discussed later in this manual.
- **You can trick the Mach2GTO, but a trip to Home will fix it.** Telling the mount to recalibrate on Deneb when it is really Vega will cause incorrect orientation. However, just send it to Home and all will be perfect again...ready for the next object. It is always best to know your objects before doing a ReCal.

NOTE: The compass shown below has been replaced by a lanyard post to hang the strap of your optional Keypad.

UNDERSTANDING YOUR MACH2GTO

Your new Mach2GTO Universal Robotic mount sets a new standard for portable telescope mounts. It is so easy to use that you will be up and running in no time at all and the mount will simply disappear into the background. No fuss, no bother. This section will introduce you to some features and fundamentals that will enable you to set up and use your mount quickly.

Universal Robotic means that Mach2 fulfills all of the requirements of a robotic mount for automated operation for imaging, satellite tracking, comet tracking, star survey work and others. In addition, the clutches allow it to be used manually for star sweeping. It is so easy to use that it can be set up quickly in the field with minimal effort and no complicated startup routines. The encoders keep track of the axis positions at all times whether parked, unparked, power on or power off.

RA and Dec Clutch Knobs

WARNINGS!

- Be careful when moving the mount with the clutches. A severely out-of-balance scope may make an unexpected and perilous swing.
- Before carrying or transporting your mount, be sure all clutch knobs are locked to prevent an axis rotation and weight shift in your hands.

You can balance the Mach2 nicely with the clutches. The motion is smooth and accurate and quite sensitive. Simply loosen the clutches, swing the scope around to any part of the sky, tighten the clutches and the mount has kept track of where you went, down to the arcsecond. No need to sync or recalibrate (ReCal) on a star when you have finished moving the scope manually.

What do they do?

The four RA and four Dec clutch knobs have the function of connecting the RA and Dec axes to their respective drive worm wheel gears. Their function is progressive, from light tension (axes free to move – as required during correct balancing of the telescope) to a completely locked state. Please note that the clutches have no bearing whatsoever on the worm drive itself. They are simply the mechanism that marries the worm wheel to the axis. The worm gears are never taken out of mesh when the clutches are loosened.

As shipped, all Mach2GTO mounts have all four RA and Dec clutch knobs firmly hand tightened. This will give you a good idea of the maximum tightness (clutch action) that can be achieved by hand effort alone. Normally all four clutch knobs on each axis (RA or Dec) should be tightened evenly with the same tension. The clutches can be set by hand for light telescope loads, or the can be fully tightened with an Allen key for heavier loads. You can temporarily tighten just one knob during balancing; it is not necessary to always have equal tension during such operations.

When properly balanced, you can move the scope around the sky manually with clutches loose, or slightly tensioned, for sweeping the Milky Way or looking for deep sky objects with your telescope. The mount will keep track of where you are pointed and will resume tracking when you stop moving the scope. The mount will always know where you are pointing, even with fully loosened clutches.

How tight can the clutch be and can you do any damage by over-tightening them?

These clutches can be tightened as much as needed. There is no danger of over-tightening. You will see that each clutch knob has a 3/16” hex socket for tightening with an Allen key. Using the provided hex key, you can lock up the clutches so that only the worm drives are able to move each axis. Fully locking the clutches only requires snugging the knobs with the hex key...remember, the knobs are not the lug nuts of your car tire!

You should **NOT** attempt to push your scope by hand against a fully locked clutch, or undue stress will be placed on the worm wheel, worm gear, and bearings. Also note that locked clutches provide no safety factor for your equipment should it hit the pier!

Most users will never need to use a hex key on their Mach2GTO’s clutches. However, if you are heavily loaded, if your system is out of balance, or if you are doing critical long exposure astrophotography, you may wish to have the extra clutch tightness. As a general rule, if you have a big scope (6” refractor or 10” SCT) with all the accessories, you will need more clutch tension than a 4” or 5” scope.

Hard Stops and Clutches in the Mach2GTO

The Mach2GTO has internal wiring that cannot be allowed to go more than 1 rotation of the axes. The hard stops prevent cord wrap and possible damage to the internal cables. The axis shafts have two pins that stop rotation beyond 360 degrees.

The stops allow the RA axis to start up to 6 hours before the normal counterweight-up position in the east and up to 5 hours past the normal meridian flip point in the west. Under normal operation with the telescope up and the counterweights down, you will never encounter the hard stops. If you wish to image past the meridian, the stops will engage after 5 hours of tracking and stop the motion of the axes. The motors will turn off automatically when the mount is either slewed or tracked into the hard stops. You can also prevent slewing or tracking to these extremes by setting the mount limits in the Keypad setup routine or in the APCC-Pro software. Refer to the appropriate manuals for guidance on these features.

WARNING: The stops can be damaged if you allow a very heavy and severely unbalanced telescope load to swing into the stop with the clutches loosened. The best way to avoid this is to never load a telescope onto the mount without first attaching all the counterweights to the counterweight shaft. Removing counterweights before removing a telescope load can result in the RA axis and scope load swinging wild with possible damage to the scope, yourself, and possibly the hard stop pin. Even without a telescope load the RA axis can swing wildly if you have all 4 clutch knobs completely loose. It can then swing clockwise into the RA stop due to the unbalanced weight of the Dec axis. Therefore, it is advisable to keep some tension on the clutch knobs during setup. There is no harm to turn the axes with some clutch friction applied. Fully locked clutches cannot be turned and should never be forced to turn manually.

Gear Mesh

The Mach2GTO has an advanced gearbox that maintains full contact of the gear teeth between the worm gear and worm wheel. The teeth are always in contact, even when the clutches are fully loosened. They cannot slip or be damaged because they are never separated.

The gearbox contains the motor, belt and pulley gear reduction system, all of which is fully protected from damage by a set of aluminum covers. The covers can be removed to inspect the belts and wire harness. The belts are high strength premium timing belts made for long life under extreme conditions. There are no adjustments needed to any of these components under normal use.

It is not necessary to remove the gearbox in order to re-grease the worm teeth. This can be done by removing a small cover on the side of the gear enclosure which exposes a small section of the worm teeth for cleaning and regreasing. Refer to “Greasing Mount” on page 38 for more information.

GTOCP5 Control System

We have developed a new control system which combines the precision performance of the Renishaw Resolute Absolute Encoder with the whisper-quiet motion of brushless micro-step servo motors to produce a very accurate observatory-grade mount that can also be set up in just a few minutes in the field. The mount can be operated manually via the clutches or electronically with the encoder loop providing the pointing and tracking functions.

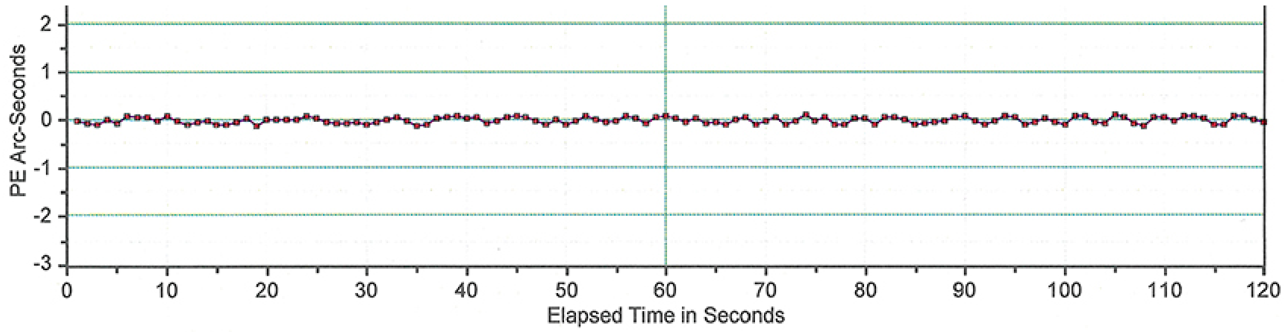
- Each GTOCP5 control box is matched to its Mach2GTO and has been programmed specifically for that mount. It cannot be interchanged with another mount. Note that the serial numbers match so that you can ensure they remain paired.
- The Mach2GTO uses a simple belt-drive micro-stepper motor in a closed servo-loop configuration.
- A rapid feed-forward servo loop stiffens the axes against outside disturbances such as cable drag and wind loading.
- Both axes can be run at custom tracking rates from sub-arcsecond motions per hour to 1000x sidereal.
- The GTOCP5 brushless servo system can be run from 12 volts with max slewing of 1200X (5 deg/sec) to 24 volts with max slewing of 1800X (7.5 deg/sec).
- The power to the motors is self-limiting and cannot cause any kind of damage to the windings or the electronics, even when in a stalled state.
- Integration of dual-axis absolute encoders ensure optimum performance.
- Multiple input options including: Ethernet, USB, RS-232 serial ports, and Keypad.

For detailed information regarding the function and operation of the GTOCP5, refer to the GTOCP5 manual that was included with your mount and can be found on the Support web page.

Periodic Error Memory (PEM) Correction

The periodic error (PE) will be fully corrected when your mount is programmed by using input from the absolute encoders. DO NOT attempt to use programs like PEMPro thinking that you need to correct periodic error. The next section will discuss the role of the absolute encoders to provide near perfect PE.

About Absolute Encoders on the Mach2GTO



Mach2 Tracking Performance with Absolute Encoders - PE = 0.21 arcseconds

Never Needs Homing. Simply Polar Align; Power Up; and GO!!

An absolute encoder never needs to be homed to start your session. It is always home the minute power is applied. It always knows where it is and transmits the exact shaft position to the control box at all times.

The encoders on the Mach2 are mounted on the axis shafts which move when the clutches are loose, and therefore the encoders will read the position of the scope whether the clutch is loose or fully tightened. This is in contrast with our 1100GTO and 1600GTO mounts where the optional absolute encoders are part of the worm wheel. Since that wheel never moves manually when the clutches are released, those mounts will not keep track of manual movements with clutches loose.

Absolute encoders are always engaged when you power your mount to provide the highest performance . There is no reason to turn them off.

How to Recover from a Recalibration Error

Your Mach2GTO always knows its position and can easily recover if you make a mistake by recalibrating on an incorrect object. Although your mount may not point correctly to the RA or Dec coordinate that you specified, it is not lost. The absolute encoders know exactly where they are. You can quickly recover by using the Home function in the Keypad or Find Home in APCC. Follow the instructions provided in the appropriate manual.

Mach2GTO Encoders Compared with Other Mounts

Mach2GTO Encoders Compared with Other AP Mounts

All of our 1100GTO and 1600GTO mounts with Absolute Encoders have always used the Renishaw Resolute Absolute Encoders for precise positioning and tracking. Now our newest mounts, the Mach2GTO, also have Renishaw Resolute Encoders. What are the main differences between the Renishaw and other less expensive relative encoders?

Renishaw Gold Standard Accuracy!

Renishaw encoder accuracy is tested and verified against a laboratory standard. Each ring comes certified with its own calibration measurement. The guaranteed maximum error on these rings translates to less than 1/2 arcsecond per hour tracking error.

The Renishaw Resolute read-head interpolates a special barcode that is engraved on the matching stainless steel ring into 67 million individual addresses. Every address is unique and fully reproducible down to sub-arcsecond levels. This is not possible with any relative encoder system.

Dependability to Astro-Physics Standards!

We have used Renishaw encoders for many years on our larger mounts, both in portable setups and in observatory remote installations and have found them to be totally reliable. Renishaw encoders are also considered to be the gold standard in the machine tool and robotics industries where precision is required. Yes, they are much more expensive than a simple relative encoder, but for the type of accuracy required in a telescope mount, there is nothing out there that comes close. We know, we have been evaluating options for years.

Absolute vs. Relative Encoders

Relative encoders use a simple ring that has engraved marks with separations on the order of 60 to 100 arcseconds between ticks. In order to achieve sub-arcsecond resolution, the gaps between these marks are filled in electronically by a method known as interpolation. Even the best interpolation methods have errors on the order of 5% (3 to 5 arcseconds). When used in a telescope drive system these relative encoders introduce a fast-moving ripple in the RA tracking rate of 3 to 5 arcseconds, although the average or RMS value of this error can be quite low.

These peak excursions cause stars to move slightly back-and-forth in the RA direction during sidereal tracking. This tracking ripple can remain hidden when imaging with short wide-field scopes, but will manifest itself when using long-focus instruments for high-resolution work. It is generally a fast-moving error, so it cannot be guided out.

Because of the ever present interpolation error (Sub-divisional Error, a.k.a. SDE) characteristic of lower cost relative encoders, we decided long ago that we would not use them for tracking. Renishaw absolute encoders use a different type of interpolation system that smooths out the SDE to a level that is not detectable. There is no mechanism for a relative encoder to remove the SDE.

Benefits of Absolute Encoders Summary

The utility of absolute encoders varies from brand to brand. Some manufacturers make very limited use of encoders and use relative (not absolute) encoders to provide a potential benefit to tracking and nothing else. The benefits inherent to the Mach2GTO with its premium dual on-axis absolute encoders include:

- The mount always knows where it is pointed regardless of power loss, movement of the axes when the power is off, bumping the mount or wind movement.
- Homing positions can be set to whatever orientation a user wants, without limitation.
- No re-homing is required for remote locations should there be a power loss.
- Periodic error is fully corrected. No need for occasional PE measurement curves.
- Zero backlash in both axes for precision guiding.
- Dual-axis absolute encoders allow for variable tracking that automatically adjusts for refraction parameters.
- Very accurate pointing makes it easy to find very faint objects.
- Very precise tracking such that unguided imaging may be accomplished with an appropriate optical/imaging setup.
- Very precise guiding, if needed, with instant response in both axes. Guiding is only needed to correct for optical/imaging train issues, not mount issues.
- The dual-axis encoders enable the mount axes to accurately respond to your guider software commands down to the 1/10 arc sec level. There is no periodic error to fight; there is no Dec backlash delay to overcome.
- Corrects for polar misalignment and repeatable mechanical flexure.
- Very precise dual-axis tracking is very important for high-precision tracking on objects like comets, asteroids, and artificial satellites, where the mount uses a “self-guiding” function based on orbital elements.
- Although absolute encoders cannot anticipate wind, they can react to it after the fact. So, you will have excursions but the axis being affected will recover much faster when the encoders are on. The best strategy is to set your mount low to the ground without extending the tripod legs. Large telescope tubes catch more wind then skinny ones. Same with short scopes versus long ones.

Separate Your Mount for Travel, Reduced Weight or Semi-Permanent Setups

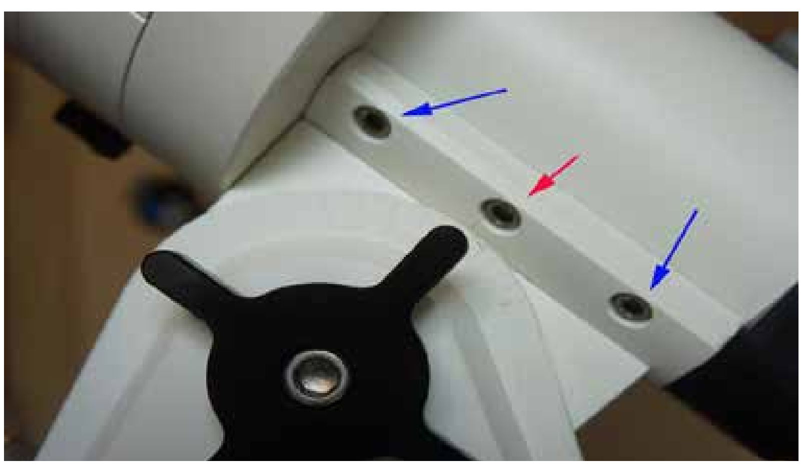
Due to design restrictions related to the integrated, permanent internal cabling, it was necessary to create the Mach2GTO mount without our usual RA and Dec separation. We have provided “Caution: Do Not Separate Axes” labels on the mount to remind you so that you don’t inadvertently damage the cables if you forget. Please do not remove the warning labels provided.

Although the Mach2GTO is a small mount and should not be a problem to setup by most users, there may be occasions or circumstances where you want to separate your mount into smaller, lighter components. These may include airline travel, permanent backyard piers, or just the desire to carry less weight. In these situations, the base can be easily separated from the rest of the mount.

- This reduces the weight that you have to lift by 11 lbs, so your heaviest component is only 31 lbs.
- You can leave the base on your tripod when you move it indoors so you are ready for action the next time you go out.
- You can leave your pier with the base outside, polar-aligned and covered in a tarp; ready to go for your next observing session.
- You may fit the two pieces into your luggage for transport.

The procedure is simple. Use sensible caution.

1. If you have been using your mount, remove all instruments, counterweights, mounting plates and counterweight shaft.
2. Tighten all clutch knobs so that the RA and Dec axes do not move suddenly and freely.
3. If not attached to a pier, lay the mount on a thick bath towel or other soft padding so that the mount is not scratched. You do not want the RA and Dec axes to tumble from the base when the screws are removed.
4. Three socket head screws on each side of the base secure the RA axis to the polar forks. Remove these screws. Be sure to support both the RA and Dec axes that are still assembled together.
5. When you re-assemble, you can leave out the two middle screws since they are not necessary. Simply place the mount back onto the base, attach the 4 outer screws and tighten them.



NOW IT'S TIME TO SET UP!

Since most of us must set up our instruments in the dark, in the cold, or while battling mosquitoes, a bit of pre-planning and organization is important. There are a few simple tasks that can be accomplished in the comfort of your home before heading outside. We advise everyone to do a complete practice run from start to finish before venturing out into the field. This is especially important if you are new to German Equatorial Mounts.

Additional Handy Tools

In Your Accessory / Tool Box:

- Small torpedo level to level your pier or scope when using the handy reference park positions, particularly during the daytime polar alignment routine.
- Compass – Don't forget to know your magnetic offset when using a compass (there can be a large difference depending upon your location).
- Documentation – Physical copies of your mount, control box and keypad (if you have one) manuals as well as any other documentation that you received with your mount (or control box) or that you find in the Support section of our website that may be useful.
- Hardware and Tools – The prepared astronomer always carries extra screws and fasteners when traveling away from home. A set of tools (screwdrivers, hex keys, pliers, strap wrench, etc.) and cables (power and communication) may also save a dark-sky trip if a problem occurs!

On Your Smart Phone / Computer:

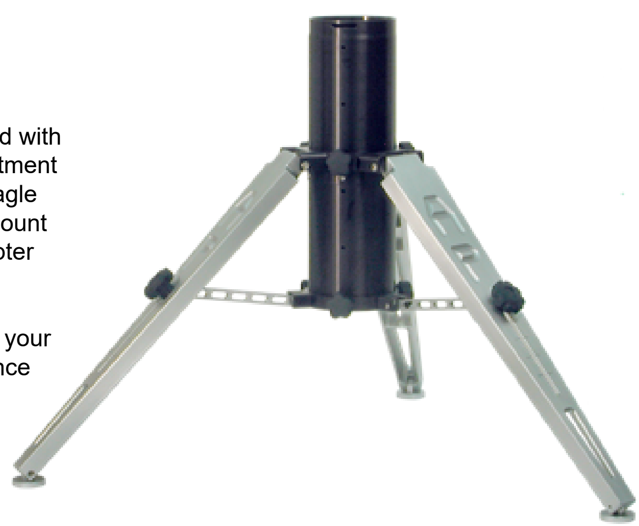
For the utmost of convenience, the following items can be downloaded to your smart phone, which you are likely to carry with you everywhere.

- Apps that allow your phone to be used as a level, inclinometer and compass. Don't forget to know your magnetic offset when using a compass since there can be a large difference (smart phone Apps generally offer the option of magnetic offset).
- Astro-Physics Polar Alignment App – The latitude and longitude of your current site will display. Apps are available for iOS, Android and Windows and is also included as part of the AP V2 ASCOM driver.
- Download PDFs of all relevant and recent documents from the Support section of our website or you can link to our website if you have service at your observing site.

Assemble Pier, Tripod or Flat Surface Adapter

(purchased separately)

6" Eagle Folding Pier (EAGLE6-EZ)



Assembly instructions for the 6" Eagle Folding Pier are included with the pier. Please refer to those instructions for assembly, adjustment and leveling procedures. Your Mach2GTO will fit into the 6" Eagle Folding Pier without any additional adapters. Simply set the mount into the open top of the pier and attach with the three pier adapter knobs included with the mount.

Position the tripod with one of the legs pointing roughly toward your pole. The counterweight shaft should be over this leg for balance safety.

You may wish to consider adding the 4" or 8" Extension for the Eagle Pier (EAGLE6E4 or EAGLE6E8) to improve your viewing height comfort when using longer refracting telescopes.

Berlebach Wood Tripod (AWTBER2)

Open the legs of the tripod at the desired observing location. Note which direction is north (south if you are below the equator).

1. Position the tripod with one of the legs pointing roughly toward your Pole (North or South). The counterweight shaft should be over this leg for balance safety.

2. Adjust legs to the desired height and spread them fully.

3. Lock in position with the hand knobs and make sure that leg clamps are tight. NOTE: Your tripod must be equipped with the Tripod Adapter (ADATRI) to mount the Mach2GTO. If you purchased your tripod from Astro-Physics, it came with this adapter already installed.

4. Attach the shelf to the central leg brace with the knob provided.

5. Attach the optional 4” or 8” Extension (EAGLE6E4 or EAGLE6E8), if used.

Losmandy Light-Weight Tripod (LMLWT-AP)

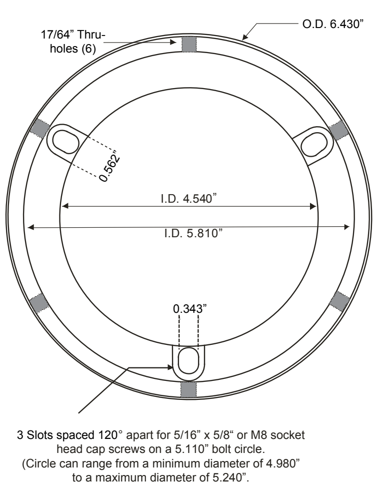
This tripod is the perfect choice when traveling light with your Mach2GTO.

The adjustable legs give the tripod a height range from 26” to 44” (low for imaging and tall enough for a refractor). You can use our Eagle Extensions if you need more height. When folded completely down with the legs retracted, it makes a compact 9” x 9” x 28”.

As with all tripods, position the tripod with one of the legs pointing roughly toward your Pole (North or South). The counterweight shaft should be over this leg for balance safety.

This tripod is not intended for heavy loads, nor with long refractors. This is an eclipse chaser or vacation tripod. *Bag shown is optional (C0041).*

ADATRI Tripod Adapter for 400, 600, Mach1 & Mach2



Tripod Adapter (ADATRI)

If you have your own custom pier or tripod with a flat surface on top, you can use our Tripod Adapter (ADATRI) for mounting the Mach2GTO. Current versions of the 900 Standard Pier Adapter (900SPA) and the Flat Pier Plate for ATS piers (119FP) will also accept this adapter to use the Mach2GTO with 8” Astro-Physics and 8” ATS piers.

We also offer a separate adapter that can be used in conjunction with this Tripod Adapter in order to attach the Mach2GTO to a Losmandy Heavy Duty Tripod or a Losmandy Meade Tripod Adapter (LT2APM).

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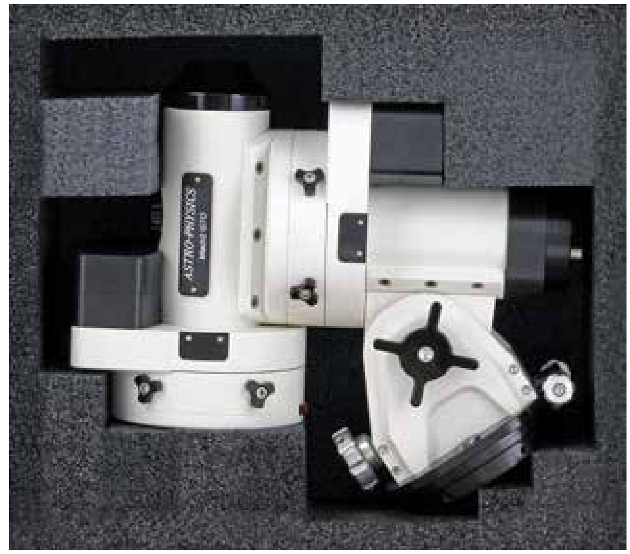
Attach the Mount to the Pier or Tripod



The pier adapter is integral to the base of your Mach2GTO. There are six 1/4”-20 threaded holes in the pier adapter base for positioning flexibility. You will use three of them (one every 120°) with the provided machined locking knobs. Have these knobs close at hand.

When you first receive your mount, you will notice that the Dec axis is tucked under the RA axis as shown in the photo to the right. Be sure that the clutch knobs are tight so that the axes do not shift suddenly when you lift the mount out of the box. Support with both hands. While still in this position, insert the mount onto your pier or tripod.

Line up the through-slots on the pier or tripod with the threaded holes in the mount’s pier base. Hand fasten with the three locking knobs. Imagers should further tighten with a hex key to ensure rigidity. The slots provide 30 degrees of adjustability.

Next, loosen the four (4) RA clutch knobs to swing the axis clockwise into the upright position as shown. Once in that position, tighten the four (4) clutch knobs to prevent the unbalanced axis from swinging further clockwise and hitting the hard stop. The mount will be stable and cannot run away and swing wildly even when no telescope is attached.

The mount should be oriented on the tripod so that the counterweight shaft is lined up with one of the legs, and not between the legs. This insures maximum system stability and rigidity.

NOTE: The compass shown in these photos has been replaced by a stainless lanyard post.

Attach GTOCP5 Control Box

In order to mount the GTOCP5 control box to the Mach2GTO, it is necessary to use the Control Box Adapter (CBAPT), which was included with your mount. This adapter is designed to attach in two different ways to our Eagle pier. It can be angled outward from the mount / pier when securing the mount or it can be attached flat to the pier's column.

- **Attaching to pier or Eagle Extension with the machined knobs.** When securing the mount to a pier, use the south facing machined knob to attach the control box adapter to the pier. This will have it angling out at about a 30 degree angle.

- **Attaching to Berlebach tripod or other tripod with leg interference.** It will be necessary to also use the Control Box Adapter Extension (Q6280KIT) with the control box adapter in order for the CBAPT to clear the tripod legs and locking levers. *It is shown in the central photo below as non-anodized for visibility.*

- **Attaching flat to the pier.** Alternatively, the Control Box Adapter (CBAPT) can be mounted to the south side of the mount's Eagle pier. In this position the CBAPT adapter can be left permanently affixed to the pier for convenience. It may also help to minimize excessive dew issues in wet environments.

Attach Pier Trays, if Any

If you have Tray Support Bar(s) (TRAYSB or TRAYSB1), attach them now to the top of your pier or tripod. Note that a tray is best put on the south side of the pier so that you do not interfere with the scope when slewing.

Pier trays slide easily into the slot(s) of the support bars without tools.

Attach Counterweight Shaft

Thread the counterweight shaft onto the Dec axis. The shaft's lead-in will help to align the threads. **Be careful to not cross-thread the shaft in the adapter!** We provide a Delrin washer to use at the base of the shaft's threads to help prevent the shaft from getting stuck to the mount's counterweight shaft adapter.

Consider Rough Polar Alignment at this Point

Since it is easier to make gross polar alignment adjustments at this stage before you put weight on the mount, you may wish to do it now. Refer to "Polar Alignment - the Fundamentals" on page 18

Attach Counterweights

IMPORTANT: Always attach the counterweights before mounting the telescope to the saddle plate to prevent sudden movement of an unbalanced tube assembly, which may cause damage or injury. And don't forget the Safety Stop. Counterweights are heavy and will hurt if they fall on your foot.

1. Remove the safety stop from the base of the counterweight shaft, if it is installed.

2. Add sufficient counterweights (purchased separately) to the counterweight shaft to balance the telescope you intend to use. Our newer counterweights contain a spring that will retract the locking pin when the counterweight knob is loosened. If using an older style counterweight without the spring, loosen the counterweight knob and hold the counterweight with the knob pointing downward so that gravity slides the pin out of the way. A firm tightening of the counterweight knob will not damage the surface of the counterweight shaft. The pin that tightens against the stainless counterweight shaft is brass.

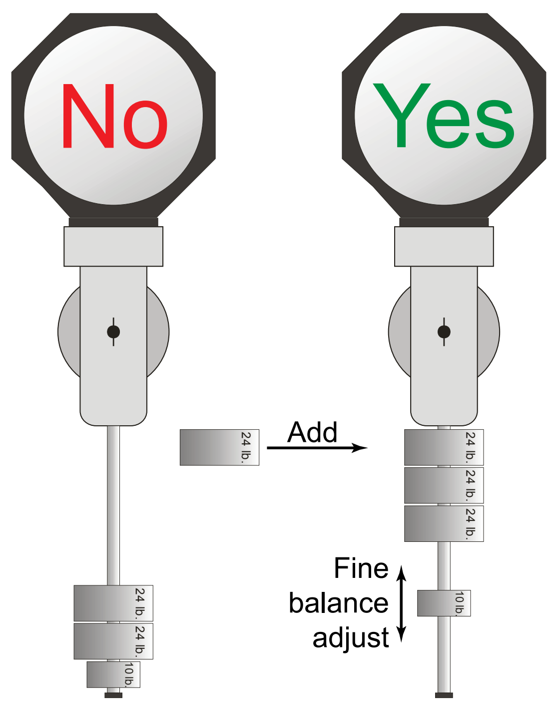
   Always use two hands to attach or move the counterweights on the shaft. It is advisable to have the counterweight knob pointing down toward the pier. This will minimize the chance of accidentally loosening the counterweight during the observing session.

3. **FOR YOUR SAFETY: Attach the Safety Stop to the end of the Counterweight Shaft**. This will help to prevent injury if someone accidentally loosens the counterweight knob.

Counterweight and Inertial Moment Arm Considerations

The counterweights should ride high on the counterweight shaft. It is best to add counterweights and slide them to the top of the shaft with the heaviest at the top and then use the smallest weight to perform the precision balancing.

The reason for this is called **Inertial Moment Arm**. Less weight near the bottom of the shaft will balance the scope, but will greatly increase the moment arm force; that is to say, it will require a much greater torque to start the axis rotating. This is a very important consideration when you are trying to do precise guiding.



Attach Mounting Plate

(Purchased separately, refer to “Appendix E: Mounting Plate Fastener Chart” on page 47)

Several mounting plates (also called saddle plates) are available for the Mach2GTO mount. If you own more than one instrument, you may need more than one plate, or you may wish to use one of the dovetail saddle plate options with more than one male dovetail sliding bar. Attach your mounting plate with the screws provided with the plate.

Be sure to orient your mounting plate and scope in accordance with the Dec cap arrow!

Saddle Plates: Attach our 10” DOVEDV10 or 16” DOVELM162 to the Dec cap paying attention to the engraved arrow which points in the direction of the scope front. The saddle’s locking knobs can be to the right or the left side based upon your preference. The dovetail plate (sliding bar) of your choice with attached scope rings can now be tilted into the saddle and locked. Balance can be done by sliding the dovetail plate once the scope and accessories have been added.

15” Flat Plate (FP1500): This plate is constructed with keyhole slots at the location where your mounting rings attach. This feature enables you to partially loosen the screws on your rings just enough to insert them into the larger part of the keyhole, then slide the rings to the narrow part and tighten them with a hex key. You can even accomplish this with the rings on the scope, although this maneuver may be difficult to accomplish with a large, heavy instrument. We prefer this keyhole method to the standard way of completely removing the screws and possibly dropping them in the grass.

Side-by-side: Users may wish to mount dual scopes for viewing or imaging reasons. The Mach2GTO design requires that the orientation of the Dec. cap plate be done with the arrow always pointing north when setting up. This being the case, for a side-by-side setup, it will be necessary to attach the dovetail saddle (DOVEDV10 or DOVELM162) aligned east-west rather than in line with the arrow as with a single scope.

Once this is done the side-by-side dovetail plate (SBD13SS or SBD18SS) can be inserted and an additional dovetail saddle attached to each end of the plate. These end saddles will be parallel with the Dec. cap arrow pointing to the north celestial pole. Note that a total of three saddles will be used. See section on balancing a side-by-side system (pages 25-26).

It is important to use the proper screws; please refer to “Appendix E: Mounting Plate Fastener Chart” on page 47)

The tapped mounting holes in Dec top plate are 1/4”-20 with 2.362” side-to-side and front-to-back spacing.

Attach Telescope

We recommend Park 2 as a convenient position for safely loading and unloading your scope. Here are two common approaches:

- Dovetail plate, option 1: Attach your mounting rings to the dovetail plate, place it into the dovetail saddle plate and secure the saddle plate locking knobs. Then open the rings and lift your scope into place. With a little practice, you will figure out the most convenient arrangement of the knobs for the rings and the saddle plate (i.e. either facing you or on the other side).

- Dovetail plate option 2, best for light-weight instruments: Attach the rings and telescope to the dovetail plate. Lift the entire assembly into the saddle plate and securely fasten the locking knobs of the plate.

- Fixed saddle plate: Attach the saddle plate to your mount and attach the rings to the plate. Open the rings and lift your scope into place. With a little practice, you will figure out the most convenient arrangement knobs for the rings.

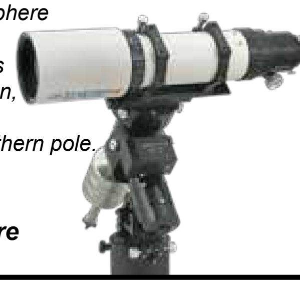
PARK 2

Northern Hemisphere

The scope is level on top of the mount facing the eastern horizon. The counterweight shaft is pointing down.

Both Hemispheres: RA axis is vertical, Dec = 0

The southern hemisphere is mirror reversed. The scope still points to the eastern horizon, but east is to the left when facing the southern pole.



Southern Hemisphere

CABLE CONNECTION

Connecting RA and Dec Cables to the Mount

Connecting the mount to the GTOCP5 control box is very straightforward. There are two identical 16" cables to connect the control box to the mount. One connects the RA motor / encoder and the other connects the Dec motor / encoder. Be sure to connect RA to RA and Dec to Dec

Note the genders of the cable connectors and connect appropriately. The male connectors attach to the control box and the female to the mount. Be sure to screw on the knurled ring to lock the cable in place.

Once the above cables have been secured, connect the power cable to the GTOCP5 control box and twist the ring to lock it in place. The power cable can only be attached in one direction chosen by the small tab in the connector.

Connecting Accessories to Internal Cabling

Input to Mount

The Mach2GTO offers pre-installed internal cabling for communication and power to your scope-mounted devices. This is a major step forward in cable management. It eliminates the problem of dangling cables that cause guiding jumps while imaging and solves the problem of how to add an internal cable once you're fully set up with heavy scopes and camera gear. It also prevents stuffing the mount with too many cables that tug and twist and will often cause the mount to experience less-than- smooth tracking.

For accessories, there is a 12-volt Anderson Powerpole connector and a USB 3.0 type A female connector located at the back of the mount on the RA axis. Run a recommended 14 gauge cable (equipped with Anderson Powerpoles) from a 12-volt power supply or a 12-volt battery to the 12-volt connector at the rear of the mount. This will provide power to the Powerpole connector located at the rear of the Dec top plate.

Likewise, connect a USB 3.0 type A male-to-type A male cable from your computer to the USB 3.0 connector on the mount. A USB 2.0 cable can also be used, but it will limit your communications to USB 2.0 speeds. Pay attention to the length limits of USB cables (3m for USB 3.0 and 5m for USB 2.0). Alternatively, you can use a quality USB 3.0 powered hub at the mount and then a short USB cable from it to the mount's connector. *Gearmo's* USB 3.0 4-Port Industrial Metal Hub w/15KV ESD Protection is an example of an industrialized hub that will operate in sub-zero temperatures. **Note: A USB 3.0 or USB 2.0 type A male-to-type A male cable is required from computer to mount.**

Output from Mount

There is a 12-volt Anderson Powerpole connector and a USB 3.0 type A female connector located at the back of the Dec top plate. These will provide you with power and communication. However, your imaging setup will likely require you to add a USB hub and power distribution to the top of your scope.

There are several products in the marketplace that combine these functions. *Pegasus Astro's* Ultimate Powerbox v2 provides all the functions without an incorporated computer. *Primaluce Lab's* Eagle3 is also full-function and incorporates a computer. Other products are becoming available.

LET'S TALK CABLES

Computer to GTOCP5

Connecting your computer to the GTOCP5 control box can be done using a variety of options. These options are discussed in the GTOCP5 manual. The option that you choose should be based upon your needs and whether it is for quick convenience, distance to mount or a robust permanent setup.

Wi-Fi: A one-night star party or a night of public outreach is often done more conveniently via Wi-Fi. There are no cables that the public can trip over and it offers a "cool" factor for kids. However, it is the least robust of the connectivity options.

USB: USB is a very convenient method, as we all generally have USB cables sitting around the house that we use with our other peripheries, such as printers. If we do not have them handy, they can easily be found in local stores. However, USB 2.0 is limited to a maximum of 15 feet (5 meters).

Serial RS-232: Serial connectivity is very robust, but modern lap tops do not have serial connectors. It is necessary to use a USB to serial adapter (recommended to use adapters with FTDI chips only, not prolific chips). This method will allow a slightly longer distance to be used between the computer and the mount. If you are using a desktop computer that has built-in serial connectors, then this is an extremely robust method for controlling your mount. Direct serial cables can be up to 100 feet in length without issues.

Ethernet: Ethernet connection is the most robust method for mount connection and we strongly advise connecting to a network; particularly for remote observatories and permanent installations when doing advanced imaging. When purchasing Ethernet cables, look for Cat6 cables when possible instead of the flimsier Cat5e cables. Ethernet cables can be up to 100 feet or more in length. On a setup like this, consider using serial cable for a backup for added stability.

Computer to Internal Cable Link

We supply the Mach2GTO mount with pre-installed power and USB 3.0 cables. All one needs to do is to connect your power and communication sources to the auxiliary connector inputs at the rear of the RA axis. Your telescope equipment can then draw power and communications from the auxiliary output connectors at the Dec top plate.

Power Cables (12 volt): Power cables are very basic and with a little learned skill you can make all the required custom cables using Anderson Powerpoles. All the supplies (Anderson Powerpoles, red-black cable in various gauges and the all-important crimper) can be obtained online from Powerwerx, a very reliable source of quality products. They also have many ready-made cable accessories. Fellow imagers in the astronomy community can also help with cable making.

USB 3.0 Cables: The limited operating length of USB 3.0 cables (**3 meters**) makes selecting these cables more complicated. This is important because the internal USB 3.0 cable is not a hub nor is it a repeater; it does not boost signal strength. It is likely that you'll have to go online to find the needed cables.

We have found that it is necessary to use an active USB 3.0 cable (male type A to female type A) along with a short USB 3.0 male type A to male type A cable to connect a computer to the back of the mount without losing signal strength. Alternatively, where less distance is needed and more USB connections are needed, a powered USB 3.0 hub at the base of the mount can supply signal strength needed in through mount cabling. Remember that you must use a USB 3.0 port on your computer to take advantage of the advanced speed. These ports are identifiable by the color of the plastic tounge in the computer port being bright blue, or by the USB SuperSpeed logo on or near the port.

Note that if you are not using USB 3.0 equipment, the through mount cable is backwards compatible with USB 2.0 equipment and will accept the compatible cables with no issue. ***Passive USB 3.0 cables (including the 2 foot internal cable) can be no more than 9 feet (3 meters) in length from a powered port, and passive USB 2.0 cables can be no more than 15 feet (5 meters) in length from a powered port .***

The following page provides some examples which are intended to guide your thinking process without limiting your creative process. There are many ways to set up your system as we all have different requirements.

Connecting Computer to Mount Internal Input

These connections are made to the Mach2GTO Back Plate on the RA axis.

Using USB 3.0 Active Cable and Short USB Cable

- USB 3.0 Active Cable (male A-to-female A)
  Example: Tripp Lite USB 3.0 Active Extension Repeater Cable (USB-A M/F)

- USB 3.0 male A-to-male A Cable for Data Transfer (short cable)
  Example: UGREEN USB 3.0 Type A Male-to-Type A Male Cable for Data Transfer, 1.5-ft

Connecting Mount Internal Output to Communication/Power Hubs

These connections are made to the Dec axis Top Plate just under your mounting plate.

Using Pegasus Astro "Ultimate Powerbox V2" and "Pocket Powerbox Advance"

- USB 3.0 male A-to-male B Cable (standard)

- Custom 12 volt Cables with Anderson Powerpole Connector to XT-60 Female Connector (Ultimate Powerbox) or RCA Male Connector (Powerbox Advance)

  It is recommended to use a 16 to 18 AWG cable.

Using USB 3.0 Communication Hub and RIGRunner Power Distribution

- USB 3.0 male A-to-male B Cable (standard)

- USB 3.0 Powered Hub
  Example: Gearmo USB 3.0 4-Port Industrial Metal Hub w/15KV ESD Protection

- Powerwerx Power Distribution

  - Custom 12 volt Cables with Anderson Powerpole Connectors

  - 4 Position Power Distribution Block for 15/30/45A Powerpole Connectors

  - West Mountain Radio RIGrunner 4005

Using Primaluce Lab Eagle3 Communication Hub and Power Distribution

- USB 3.0 male A-to-male B Cable (standard)

- Primaluce 12 volt Power Cable to Anderson Powerpole Connector

BALANCING THE TELESCOPE

To achieve the best performance from your mount, your telescope should be well-balanced. This is more important for imaging setups than for visual setups since greater precision is required for guiding.

Common sense dictates that you want to begin the balancing procedure with your setup counterweight heavy so that the scope does not suddenly leap from your hands and spin around into the pier. As long as the counterweight is down, sudden movements of the Dec axis cannot cause a damaging mishap. You will want to perform the balancing with the scope set up exactly as it will be used. Eyepieces, diagonals, finder scopes, cameras, guiders, etc. should all be in place before you begin. Ensure that your focuser is in its focused position, the dew shield extended and the dust cap removed.

Be sure to read these sections before you balance:

- “Attach Counterweight Shaft” on page 18
- “Hard Stops and Clutches in the Mach2GTO” on page 9
- “Counterweight and Inertial Moment Arm Considerations” on page 18

Cable Considerations

Remember that dangling cables will dramatically change balance and create guiding problems, so you’ll want to be sure that all cables are carefully secured and not dragging before balancing.

<u>VERY IMPORTANT</u>: Begin the balance process in Park 3 position so that an extremely out-of-balance load does not cause an abrupt swing which can damage the scope and user!!!

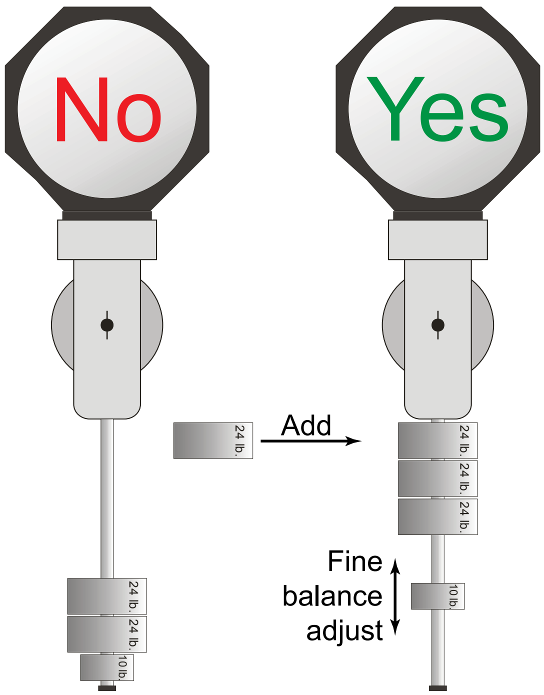
1. With the counterweight shaft down and the scope pointing toward the Pole (Park 3), loosen the Dec clutch knobs a few turns and feel which way the scope’s weight is offset. Placing a hand on each end of the scope and lifting back and forth will give you a good feel for balance. Slide the scope (in its rings or via the dovetail) until it feels balanced, then point the scope to the north again and tighten the clutches.

2. Next, loosen the RA clutch knobs a few turns and, while holding the counterweight shaft, move the axis into a horizontal orientation. You will probably need to rotate the Dec axis a bit so that it also assumes a horizontal orientation. Place a hand at the end of the shaft and on the scope and, lifting back and forth, make counterweight adjustments to equalize the balance as best possible.

   Remember to consider <u>Inertial Moment Arm</u> and place most of your weights near the top of the shaft and use the smallest weight to do your fine balance adjustment. This degree of balancing will be sufficient for those who wish to have some fun doing visual observing with family and friends.

3. If you are planning to do long-exposure, deep-sky imaging, then you’ll want to refine the balance more precisely. After the RA axis is properly balanced with counterweight shaft horizontal, tighten the RA clutch knobs and loosen the Dec clutches. This will allow you to get fine-balance adjustment of the Dec axis. If any unbalance is present, it should be slightly biased toward the camera end.

Once the telescope is attached and balanced in both axes, the clutches can be alternately loosened and tightened to allow manual movement in RA and Dec for manual sweeping of the sky. The motors will still track if the RA clutches are set for a slight amount of friction. The mount will continue to keep track of sky positions whether you are moving the scope manually or with the motors. When you are finished sweeping the sky manually, simply tighten the clutches and enter an object into the keypad or other program and slew to it using GoTo. This assumes that the mount has been properly polar aligned.



BALANCING SIDE-BY-SIDE

In a nutshell, this is what you should do. If you are careful about following this procedure without shortcuts or "guesstimates", you will save a lot of time and effort in the long run. People look at the procedure and say, "Heck with it, I'll just wing it." They usually end up sorry!

The key is preparation! You are balancing 3 systems. Do ALL of this on a worktable, preferably with a helper.

1. Balance the first system.

   a) Fully assemble one of the telescope systems you will be using. This includes, but is not limited to:

      i) The dovetail for that scope

      ii) The rings or other attachment medium

      iii) The complete imaging train including all adapters, correctors, telecompressors OAGs etc.

      iv) All guiding hardware, if it will be on this system

      v) Any finders or other devices

      vi) Any special wiring harnesses or electronic devices

      vii) Dew Heaters and controllers.

      viii) ANYTHING that will be attached to this system!!

   b) Adjust focus as close as possible to where it will be for imaging.

   c) Place a dowel rod under the mounting plate to create a seesaw. BE CAREFUL!!

   d) Using the dowel rod as a fulcrum, find the exact balance point of the system.

   e) Mark the exact balance point with a piece of blue painter's tape.

2. Balance the second system.

   a) Basically, repeat the above steps.

3. Since the two parallel dovetail saddle plates are probably somewhat offset, we need to next balance the side-by-side plate trio FRONT TO BACK first.

   a) This should just be the bottom transverse dovetail plate and the two parallel saddle plates that are bolted on top. Nothing else.

   b) Run the dowel rod lengthwise under the bottom dovetail plate. Try to keep it parallel with the transverse plate.

   c) Balance the trio of plates front to back on the dowel rod.

   d) Mark each saddle plate at the point where it balances over the dowel.

   e) Remove the dowel rod.

4. Attach each scope system. Simply line up the tape balance points on each saddle with the tape balance points on each of the parallel saddles.

5. Now place the dowel rod back under the bottom dovetail plate, but this time it is perpendicular to the dovetail (parallel to the OTAs).

   a) Rock the system back and forth until you find its balance point.

   b) Mark the bottom dovetail with tape at the exact balance point.

6. Put the entire system into the primary saddle plate. This plate will have limited adjustment because it is fixed by its mounting holes. The final part of this is the trickiest.

   a) Our saddle plates offer several mounting options. Look at the setup in front of you and decide which set of mounting holes will best serve your needs.

   b) Mark the center of the mounting hole pattern that you will be using with tape.   This may not necessarily be the perfect balance point.

7. Place the dowel rod under the center of the mounting hole pattern.

8. Now, adjust the bottom dovetail in the saddle until the system is balanced above the dowel that is in the center of the Dec mounting hole pattern.

9. Mark the saddle and bottom dovetail so you know exactly where the dovetail needs to be positioned.

10. Take everything apart, but DON'T LOSE THOSE TAPE PIECES!!

11. When you reassemble, simply line up your tape pieces and 95% or more of your Declination side-by-side balancing will be done.

12. Final note: When balancing RA, more weight higher up on the shaft is better than less weight further down the shaft.

If the preliminary work is done carefully, you will blow anyone away who might be watching you. Most experienced observers shake their heads when they see someone trying to set up a side-by-side system because they know how hard it can be to get the thing properly balanced. It is very satisfying to put the pieces together and have near perfection right from the get-go!

POLAR ALIGNMENT – THE FUNDAMENTALS

For rough polar alignment, your goal is to aim the RA axis (not the scope) toward the celestial pole. You will need to make altitude (up / down) and azimuth (side-to-side) adjustments to the position of the mount.

Before beginning, make sure that the mount is pointing roughly north using a compass set with magnetic offset or a phone app and that your pier or tripod is level using the mount's built-in bubble level. Remember that the counterweight shaft should be over the north leg of the tripod / pier for stability.

Know that magnetic north is not the same as true north and varies both with time and with your location. In 2020, magnetic north in Caribou, Maine was west of true north by a whopping 17 degrees! On Mauna Kea in Hawaii, by contrast, magnetic north was about 9 1/2 degrees east of true north. Observers in Little Rock, Arkansas are lucky and are nearly dead on.

These values change by several arcminutes every year. With experience at a particular site, however, you will soon learn to use a compass to find true north. You will know just how far off magnetic north is for your location. In addition, there is an excellent website funded by our U.S. tax dollars that will compute the declination of magnetic north relative to true north for any location that you input. The link is as follows: http://www.ngdc.noaa.gov/geomag-web/#declination

Note on Bubble Levels: It is possible to achieve perfect polar alignment without having the pier level, but it is slightly more difficult. With a pier that is not level, each adjustment in azimuth also causes a minor shift in altitude and vice versa. This is why we have included the bubble level on the Mach2GTO. However, don't waste time obsessing about having the pier perfectly level. This is, after all, NOT an Alt / Az mount! Devote the time to the actual polar alignment instead. If you are reasonably close to level, you will not be able to notice a difference. Keep in mind that unless you are a serious astrophotographer or imager, "perfect" polar alignment is not critical.

Leveling your tripod is also important to enable the mount to return to an accurate Home position if the mount is "lost." Refer to the Home and Limits section of the GTOCP5 manual for more information.

We recommend that you do your rough polar alignment using just the mount at this time (no scope or counterweights), since you will be making major adjustments to the position. The remainder of the equipment: telescope, finder, camera or eyepiece and counterweights will add considerable weight and require more hand effort to make the adjustments. Later, you will do your final polar alignment with the telescope and counterweights attached, but the adjustments will be small.

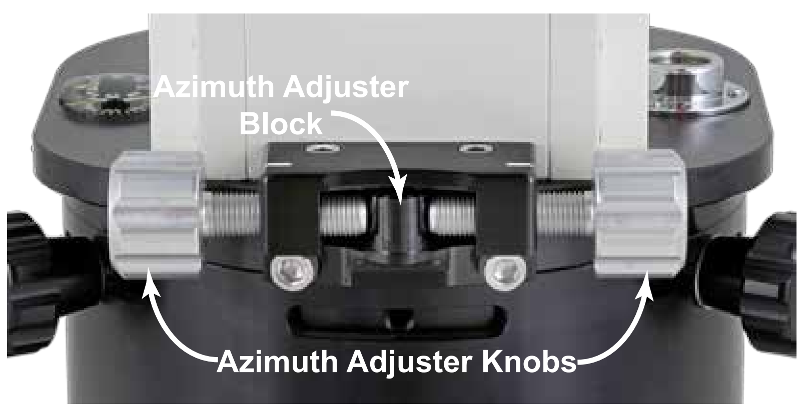
Azimuth Adjustments

Caution: The azimuth adjuster knobs have socket cap screws in each end. *Never tighten the knobs beyond hand tight or you may damage the components.* Their purpose is to provide even finer resolution for your final small azimuth micro-adjustments. By using hex keys, you can make much smaller incremental moves than is possible with just fingers on the knobs.

1. Start with the Azimuth Adjuster Block centered between the threaded knobs so that you will have adjustability to the east or west.

2. Move or turn the entire pier or tripod east or west until the mount is oriented approximately toward the pole (an imaginary line drawn through the RA shaft). You can take advantage of the azimuth adjustment slots of your pier or pier adapter for your rough polar alignment. Also, if you want the mount to be level, check the bubble level again after moving everything. Remember, mount levelling is not critical for most observers, but it helps speed the alignment process.

   The Precision-Adjust Rotating Pier Base does not use lock knobs for the azimuth, so there is no resulting shift. It consists of two plates that are precisely machined to a perfect fit with no tilt or shift. Adjustment is precise and absolute. The Azimuth Adjuster Knobs effectively become the



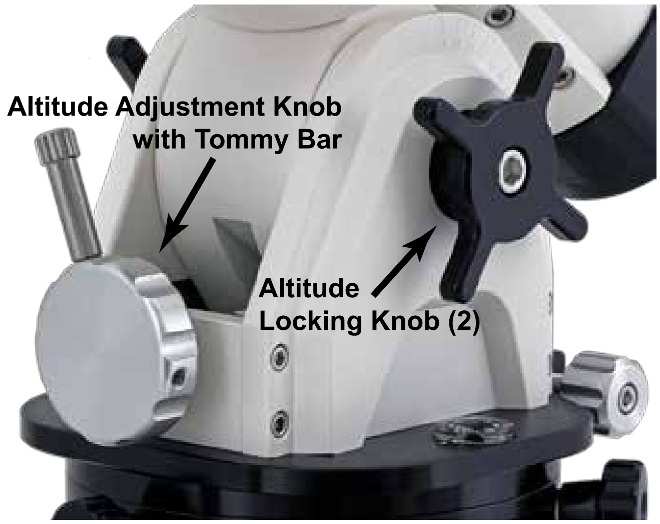
azimuth locking devices.

To make azimuth adjustments, use the two azimuth adjuster knobs, one on each side of the mount, to make adjustments. You must back off the opposing Azimuth Knob in order to move the other knob in that direction.

Turn the adjuster knob until it tightens against the azimuth adjuster block. Note that the azimuth adjuster block remains fixed. In the northern hemisphere, the right knob rotates the mount to the west, and the left to the east.

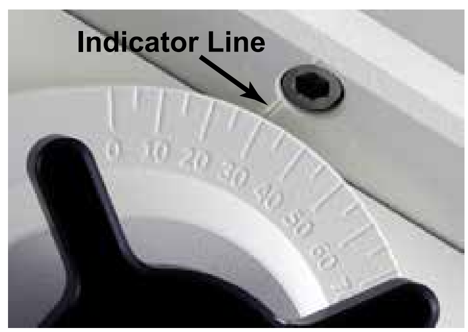
Altitude Adjustments

1. The altitude adjustment mechanism on the Mach2GTO has two components. There is a large Altitude Adjustment Knob on the front (north) side of the mount for making the adjustments. This knob has a removable Tommy Bar that can be shifted to several different positions as needed. The Altitude Locking Knobs on the sides of the polar forks have a captain's wheel design to assist when tightening the knobs.



   The shaft between the altitude locking knobs is the pivot axis for the altitude adjustments. Turning the altitude adjuster rotates or pivots the mount, up or down, around this axis. Latitudes below about 55 degrees will always have the total system weight in front of this pivot axis, and will therefore have gravity pulling everything down toward the front. At these latitudes, make your approach to the pole from below so that you are pushing up against gravity. This will keep the adjustment system fully engaged.

   At latitudes above about 65 degrees, the system weight is behind the altitude pivot axis, so you will want to approach the pole from above. At these higher latitudes, gravity will assist in keeping the adjuster fully engaged from above and you will want to approach the pole by pulling down while adjusting. At latitudes between about 55 and 65, the mount is pretty well balanced over the altitude pivot.



2. To start your altitude adjustment, loosen the altitude locking knobs. You can speed up the altitude adjustment by presetting your latitude using the scale on the polar forks. Simply turn the altitude adjustment knob until the indicator line above the latitude scale on the polar forks points to your latitude.

   Please understand that this will be an approximation and not a precision adjustment.

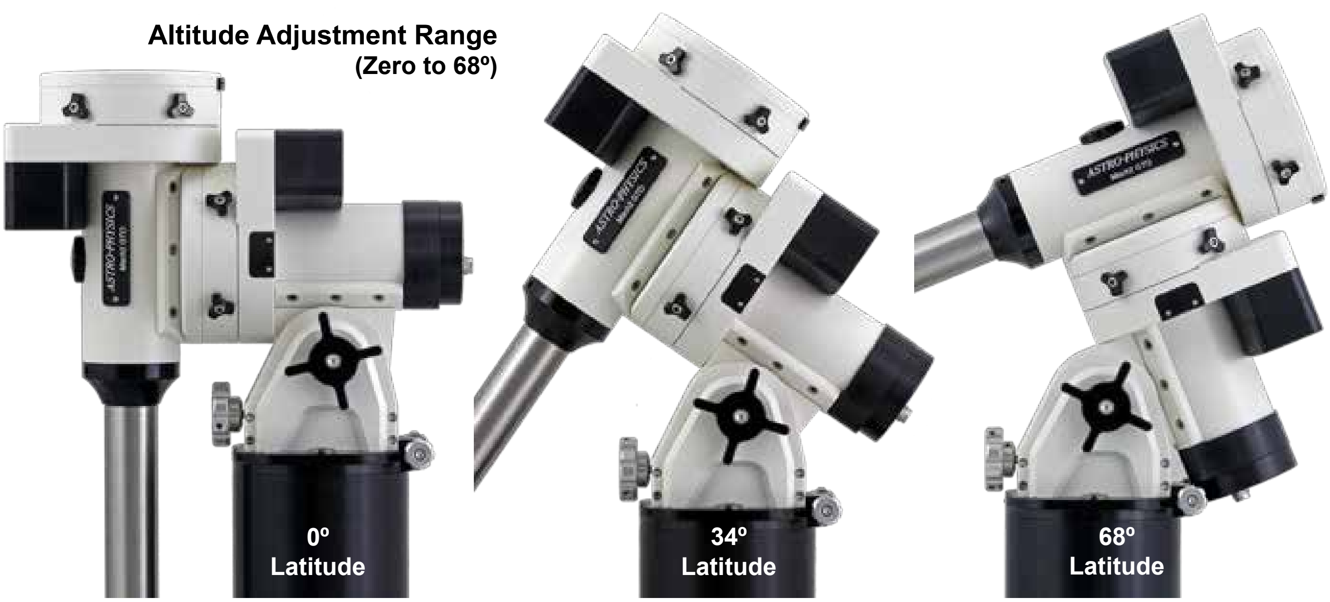
NOTE: The compass shown above has been replaced by a lanyard post.

Azimuth Adjustment Range

The illustration below shows the azimuth adjuster's 13-degree range. If you need more adjustability, you can loosen the three machined locking knobs that secure the mount to the pier. This will allow you an additional 30 degrees (+/- 15 degrees).

Altitude Adjustment Range

The illustration below shows the altitude adjuster's 68-degree range. This range will cover all locations from the equator to the arctic circle. However, please note that if you live within a few degrees of the equator, you may not be able to slide the counterweights all the way to the top of the counterweight shaft as they may bump into the altitude adjustment knob. This will not affect performance or functionality.



POLAR ALIGNMENT – THE REFINEMENT

There are numerous methods for polar alignment. Some options utilize additional accessories and/or software. Others just use simple tools or techniques. You may wish to try several before deciding on your favorite.

Methods for Fine Polar Alignment

Use It & Remove It

- **Right-Angle Polar Alignment Scope (RAPAS)** – Using our highly accurate, neck-friendly Right-Angle Polar Alignment Scope will provide all the polar aligning accuracy needed for visual observing. If you make the one-time RA "push-pull" plate adjustment as described in the RAPAS instructions, then you will be able to start imaging immediately after aligning with the RAPAS. Long focal length scopes may benefit from further refinement of polar alignment.
  This scope is designed for both Northern and Southern Hemispheres.
    - Slide the RAPAS into its dovetail that was attached to the mount.
    - Position Polaris on the reticle via the mount's alt-az adjusters.
    - Tighten the alt-az adjusters.
    - Loosen the thumbscrew indicated by the arrow. Remove the RAPAS with its dovetail by sliding it back out. Removal will prevent collisions as the mount moves.
- **QHY PoleMaster Polar Alignment Camera** – The Mach2GTO is designed to attach a PoleMaster camera to the front of the Dec axis using a QHY-supplied adapter. The camera images a sweep of the polar region and calculates the location of the celestial pole.
- **Keypad or Computer**
    - The Daytime Routine as outlined in "Mach2GTO Daytime Polar Alignment Method" on page 33, is a great trick for daytime setup. It will allow you to "wow" your friends by setting up and finding planets and bright stars in the daytime and give you a big head start for nighttime viewing. In addition, it is the recommended first step in alignment for anyone in the southern hemisphere. Even those in the south who own our polar scope will find it helpful, since it will generally put the rather difficult-to-spot southern stars into the polar scope's field of view.
    - Roland's "Appendix C: Roland's GTO Quick Star Drift Method - 2020 Version" on page 45 utilizes a finder scope or imaging camera which enables you to make precise polar alignment via a couple of meridian flips.

      Using the Daytime Routine, followed by the GTO Quick Star Drift Method, will provide accurate enough polar alignment for extensive imaging. This combination is our recommended procedure for anyone in the southern hemisphere, or anyone who finds their view of the pole obstructed.
- **Computer Software Solutions**
    - Polar Align via *PEMPro's* "Pole Align Wizard". PEMPro™ is a software by Ray Gralak and distributed by *CCDware*™. This powerful application was developed to analyze and improve the periodic error performance of mounts that are not equipped with the Mach2GTO's absolute encoders; however, it also includes the highly precise "Pole Align Wizard".

      "Pole Align Wizard" is one of the best methods of accurately polar aligning! It is like traditional drift aligning, but on steroids! It has the advantage of automatically choosing the optimized stars for drift aligning and does not have to worry about star magnitude since the CCD can see dimmer than an eye. Also, it compensates for air refraction and other variables that manual drift aligning cannot. It does require the use of a CCD camera and corresponding camera control software. The Wizard walks you through the alignment process with easy step-by-step instructions.

- Other Software – There are many software packages that include aids to polar alignment that can be found through discussion on the ap-gto user group. Some will work better than others. Apart from "Pole Align Wizard", we do not have experience with these other software programs and cannot vouch for them or provide support.

- **GTO Quick Star Drift Method** – Traditionally, this very time-consuming procedure has been regarded as the most accurate method of polar alignment. However, if you are using the old method of drift alignment that employs stars near the eastern or western horizon, you may encounter problems from atmospheric refraction, which will skew your alignment. To obtain more accurate results, choose stars somewhere near the celestial equator due south or slightly east and west, but not below 45 degrees elevation.

  For portable setups, we believe that our GTO Quick Star Drift Method using the Meridian Delay Feature and a finderscope, as found in the keypad documentation and as noted above, is a much more practical approach in terms of providing highly accurate alignment and still leaving enough time to actually get some imaging done. A permanent observatory setup where long unguided exposures are taken may still benefit from a final tweaking using the traditional star drift method (as modified by the 45 degree elevation recommendation above) or from a software enhanced variant like the *PEMPro*™ "Pole Align Wizard" that allows a CCD to measure and calculate the drift much faster than can be done at the eyepiece.

- **Drift Alignment – RA Correction Method** – This will provide the highest precision of polar alignment with the least amount of drift within 45 degrees of the zenith (where most imaging is done). Please see this method described in "Appendix B: Drift Alignment – RA Correction Method" on page 44 of this manual or on the Support page of our website. *Note: The RA Correction Method is the preferred alignment method when tweaking the RAPAS orthogonality.*

Altitude and Azimuth Adjustments

The mechanics of altitude and azimuth adjustment are relatively straightforward. In the discussion below, we will provide some information and tips that will give you the greatest success with your Mach2GTO regardless of the method you choose for determining the amount and direction of each adjustment. We'll leave the choice of method up to you. We list the fine altitude adjustment first because our GTO Quick Star Drift Method and RA Corrective Method begin with altitude. Many texts for the classic star drift method begin with the azimuth adjustments.

When you made your rough alignment earlier, you loosened up the altitude locking knobs, got the mount close, and then tightened them back down. Any minor shifting that might have occurred from locking things down tight was of no consequence since it was a rough procedure. Shifting from the azimuth adjustment system has been eliminated by the Precision Adjust Rotating Base and Hi-Res Azimuth Adjuster. Now you are fine-tuning the alignment, so we want to use small steps and keep things tight.

Fine Altitude Adjustment

It is important that you have the altitude locking knobs at the proper tension for your final altitude adjustments. This is basically just tight enough that any up-down or side-to-side play is removed as described here.

a) Loosen the altitude locking knobs a small amount. You should NOT need to loosen the knobs by more than one-half turn.

b) Grab the end of the counterweight shaft with your left hand and wiggle it up and down to feel the small amount of play or backlash in the system. This is normal with the knobs loosened, and is inevitable in an adjustment system that must cover a range of 68 degrees.

c) Gradually tighten the altitude locking knobs up to the point where you no longer feel the play. Do not tighten the knobs any more than is necessary to hold the mount firmly in position. The goal is to reach the point where the mount is secure and solid, yet the final, small adjustments are still possible.

Even with the knobs thus tightened, you will be able to make the necessary minor adjustments in altitude to precisely align the mount. You should feel considerable resistance when making these final altitude adjustments, but they are small adjustments, and should not be too difficult. Making these small adjustments with the lever tightened will not hurt the mount.

1. Be sure that your azimuth is securely locked in place with both adjuster knobs tight against the adjuster block before making fine altitude adjustments.

2. We want to use gravity to our benefit. In the earlier section on rough polar alignment, we mentioned differing approach-

es depending on your latitude. These approaches will be refreshed here.

a) If you are below about 55 degrees in latitude, always make your final approach to the Pole from below. If you find yourself pointed above the Pole, slightly overshoot your downward adjustment so that you can then make a final tweak upward. If you do need to adjust downward, it helps to push down on the end of the counterweight shaft while making the downward adjustment. Then, finish with the upward adjustment.

b) If you are above about 65 degrees in latitude, make your approach to the Pole from above. Your final adjustment should be downward. If you find yourself pointed below the Pole, slightly overshoot your upward adjustment so that you can then make a final tweak downward. If you do need to adjust upward, it helps to lift up on the end of the counterweight shaft while making the upward adjustment. Then, finish with the downward adjustment.

c) If you are in the “balanced range” of latitudes - from about 55-65 degrees - start by making sure your counterweight shaft is pointing down and northward. Then, move a counterweight down the shaft to bring the system slightly out-of-balance with the counterweight side being heavier. Now adjust as if you were below 46 degrees and when finished, remember to rebalance the system.

d) Why the difference in how you approach the pole from higher latitudes? The reason has to do with the concept of gravitational rest position. When you make your final adjustment, you want to leave the mount in its rest position with regard to the altitude adjuster and gravity. This means that if the lock lever were loosened, the mount would not settle into a lower position because of gravity.

Fine Azimuth Adjustment

The Mach2GTO’s Precision-Adjust Rotating Base and Hi-Res Azimuth Adjuster assembly makes for easy and accurate polar alignment in your observatory or in the field; and they combine to eliminate issues of adjustment backlash and lock-down shifting. The Precision Adjust Rotating Base adopts the design used for the 1100GTO and 1600GTO mounts, as well as the 900 and 1200 Precision Adjust Rotating Pier Adapters. The Hi-Res Azimuth Adjuster located to the back of the mount is extremely convenient to users of the polar scope. The distance from the center of azimuth rotation to the adjuster increases the resolution of the adjuster knobs.

With the Precision-Adjust Rotating Base and Hi-Res Azimuth Adjuster, it is the azimuth adjuster knobs that actually lock the azimuth in place. (This is the same as for the larger mounts with the precision-adjust rotating feature.) Your adjustment technique must not leave the knob you have backed off loose. When finished, both knobs must be tight against the azimuth adjuster block to hold the azimuth angle you have set. If you follow our method below, the act of adjustment will leave both adjusters tight against the azimuth adjuster pin.

> **Caution:** As mentioned during the discussion of rough polar alignment, the azimuth adjuster knobs have socket cap screws in each end. *Never tighten the knobs beyond hand tight or you may damage the components.* Their purpose is to provide even finer resolution for your final small azimuth micro-adjustments. By using hex keys, you can make much smaller incremental moves than is possible with just fingers on the knobs.

Adjustment Method: The natural tendency when making azimuth adjustments is to first back one adjuster knob off a significant amount, then make the required azimuth adjustments with the other knob, and then when finished, to tighten the first knob back up against the azimuth block. This can result in a slight shift as the first knob is tightened against the block.

We recommend that you completely abandon this approach for all of your azimuth adjustment. Instead, start with both knobs tightened against the azimuth adjuster block. Then, back off the first knob ***only by the small amount of the adjustment you plan to make.*** Use the scallops on the knob and the indicator marks on the azimuth adjuster body as reference points to mark your starting and ending points.

One full turn of either Azimuth Adjuster Knob is roughly 0.7 degrees or 42 arcminutes. Each knob has seven scallops and seven raised parts on the gripping surface. This divides the knob into fourteen equal segments corresponding to about 0.05 degrees or 3 arc-minutes each.

Make the actual adjustment by tightening the other knob against the slightly loosened knob thereby making the tiny adjustment you required and eliminating any lock-down shift because everything is already tight when you are finished. By using the markings on the knobs, you can easily undo any errors or estimate the magnitude of your next adjustment.

Tweaking Your Alignment

As a final thought on altitude and azimuth adjustments, some people love to tweak their alignment. Tweaking the azimuth should no longer pose any issues since the Precision Adjust Rotating Base and Hi-Res Azimuth Adjuster do NOT introduce any shifting into the process. If you do make a final altitude tweak, however, DO NOT loosen or further tighten the altitude locking knobs lever. Resist the temptation and leave the altitude locking knobs alone!

Mach2GTO Daytime Polar Alignment Method

1. Roughly aim the mount using a compass (or phone app) toward the pole in azimuth.
2. Approximately level the mount with the bubble level (or phone app).
3. Set up your scope and equipment on the mount, balance, and tighten clutches.
4. Power up the mount and unpark. This will initialize the Mach2GTO.
5. Command the mount to go to Park 5 (see Park position at right).
6. Use a carpenter's level and turn the altitude knob until the scope is level.
7. Tell the mount to GoTo a visible object: the sun (with solar filter protection), the moon, bright planets or stars.
8. Use the azimuth adjuster until the object is centered in the field.
9. You are polar aligned and ready to start observing!

You can repeat this process (#5 to #8) to gain accuracy. This will provide accuracy for visual observing.

PARK 5

Northern Hemisphere

The scope is level on the east side of the mount, facing the northern horizon. The counterweight shaft is also level and pointing due west.

Both Hemispheres: RA is horizontal,
North: Dec = (90-Latitude) South: Dec = (-90-Latitude)

The southern hemisphere is mirror reversed. The scope is still level on the east side of the mount, but is facing the southern horizon. The counterweight shaft is also level and pointing due west.

Southern Hemisphere

Using Software to Improve Pointing Accuracy

Software solutions are available today that will help to compensate for orthogonal problems as well as other idiosyncrasies of your telescope, mount and optics. These programs analyze and compensate for these problems, resulting in improved telescope pointing performance. Note: Only APCC Pro will also provide high-precision, dual-axis tracking compensation.

- *Astro-Physics Command Center (APCC PRO)*, Pro version with pointing and dual-axis tracking model. This software was provided with your Mach2GTO, www.astro-physics.com/apcc-pro
- Astro-Physics Keypad, version 5.xx firmware allows the creation of an orthogonality routine as well as pointing model and tracking models. www.astro-physics.com/keyvfk2
- *MaxPoint*™ Modeling Software from Diffraction Limited, www.cyanogen.com
- *TPoint*™ Modeling Software from Software Bisque, www.bisque.com

QUICK START SUMMARY – FIRST SESSION WITH YOUR KEYPAD

This summary gives an outline of the workflow to have a successful first observing session. Enjoy!

***IMPORTANT*: Your Keypad must be using v5.xx firmware with Mach2GTO.**

1. Set up your Keypad settings. This can be done in the convenience of your home before going into the field for observing. You do not need to assemble your scope and accessories.
    a) Connect all your mount's cables. Be sure that the RA and Dec cables, the Keypad cable and the power cable are all connected properly.
    b) Power up the mount.
    c) Set location information per the instructions in the Keypad manual. Set latitude and longitude in degrees:minutes:seconds format.
    d) Set date and time information. Set date and time and specify daylight savings or standard. Time must be set in 24 hour time format.
    e) Enter your location in the Keypad. Location 1 is usually set as a home location.
    f) Power off the mount.
2. At your observing site, assemble the mount with scope and all equipment that will be used for your session.
3. Balance the system.
4. Polar align the mount – at least roughly.
5. Power up the mount and follow the instructions in the Keypad manual.
6. After finishing your night's observing (or day's solar observing), you may wish to park the mount into your chosen Park position. Refer to "At the End of Your Session" on page 36
7. Power off the mount.

QUICK START SUMMARY – FIRST SESSION WITH YOUR COMPUTER

This summary gives a brief outline of the workflow to have a successful first observing session. Please consult the GTOCP5 manual for more extensive information.

Enjoy!

1. Install and set up your control software and drivers. This can be done before you even take delivery of your mount. *As a note, your software programs should not be set to "run as administrator".*

   a) Set up ASCOM and the drivers first.

      i) ASCOM Platform 6.4SP1 (as of June 2020, check website for current requirement) - https://ascom-standards.org/index.htm

      ii) AP V2 ASCOM driver - https://www.gralak.com/apdriver/

      iii) FTDI driver - http://www.ftdichip.com/Drivers/VCP.htm
      Refer to the PDF indicated on that page in order to locate the driver, see example in the PDF referenced below:
      https://www.astro-physics.info/tech_support/accessories/serial_usb/ftdi-driver-find4.pdf

   b) Install third party software (*Starry Night*™, *TheSkyX*™, *MaxImDL*™, *Sequence Generator Pro*™, etc.).

   c) Adjust software settings - follow the appropriate workflow documentation that is found in the GTOCP5 manual.

   d) If using the Keypad along with a computer, set the Keypad to AutoConnect=EXT and power cycle the mount in order to lock in the change. ***IMPORTANT*: Your Keypad must be using v5.xx firmware with Mach2GTO.**

2. Assemble the mount with scope and all equipment that will be used for the evening.

3. Balance the system.

4. Polar align the mount – at least roughly. If using the daytime routine, wait until after the mount is initialized. If using the RAPAS, do it before initializing.

5. Power up the mount and connect with your primary control software. This will start the AP V2 ASCOM driver and initialize the mount. Your initialization settings will have been set already in step #1.

   a) If using APCC, always start it and connect with it first.

   b) If the AP V2 driver is your primary control software, it must be started with a client program.

6. Connect other software that you will use with the mount.

7. After finishing your night's observing (or day's solar observing), it is best to park the mount into your chosen Park position. This can be done using APCC or the AP V2 driver. It can also be done via ASCOM-compliant software. Refer to "At the End of Your Session" on page 36

8. Disconnect and then close your third-party software. Close APCC if it is being used.

9. Power off the mount.

AT THE END OF YOUR SESSION

During shutdown, the mount can be parked in one of 5 preset positions or simply left wherever it is pointed and the power can be shut off. Tighten all of the clutches so that you can safely remove the equipment. Telescope load must always be removed first, followed by the counterweights and finally the counterweight shaft. During all this time it is important to keep the clutches tight to prevent accidental, wild, unbalanced movement of the axes.

If you choose to leave counterweights on your mount without your telescope, only use Park 2 or Park 3. In these positions the weights should not put any turning force on the RA gear. Refer to “Appendix A” on page 22 for illustrations and discussion of the various park positions.

There is no need for any routine for shutting the mount off. No matter how it is done, the mount will retain its orientation, even if the scope is moved to a new position after power off. For field setups it is not necessary to re-create the exact orientation of the scope from a previous session. For instance, you can send the scope to point to the pole (Park 3), turn off power, remove the scope and tear down the setup. The next time you set up, you can turn on power with the scope pointing in any direction (due south or into the ground, if you wish). If the mount is reasonably polar aligned you can do a GoTo and the scope will point to the object that you chose.

REMEMBER THESE TIPS

- **Begin your balance procedure in Park 3 position (pointing to the celestial pole).** This will ensure that an out of balance scope does not have a sudden, wild swing that could damage the scope, the mount or you!

- **GTOCP5 Control Box will auto-park mount when powered off.** The GTOCP5 control box will auto-park the mount in place when the power is turned off or is interrupted. Nevertheless, we do recommend parking the mount to a convenient park position when finishing the evening's viewing if leaving the mount set up for another night.

  Recommended: **Park 3** is a safe and balanced position. **Park 2** is a convenient position for loading and unloading your scope. **Park 5** is a safe, low profile position with minimum cable twisting. See Park positions in "Appendix A".

- **Never perform a Plate Solve at Park 3.** The RA at Park 3 is undefined. This can cause the plate solve to be off by 180 degrees, resulting in the next slew going counterweight up.

- **Be sure that all clutches on the mount are tight.** Firmly hand-tighten all clutches on both axes of the mount. With heavy loads, you may consider adding a bit more tightness using an Allen wrench. Forgetting to tighten the clutches may degrade guiding performance.

- **Be sure to remove the RAPAS after polar aligning.** The Right-Angle Polar Alignment Scope MUST be removed after polar alignment is complete. Not doing so can risk damage from counterweight or scope collision!
  Use It and Remove It.

- **Computer and Keypad use together.** If you are using a computer for primary mount control, but wish to have the Keypad connected for convenience while at an eyepiece, then set the Keypad to AutoConnect: EXT so that the computer will initialize the mount, not the Keypad. Refer to the Keypad manual for guidance.

- **Use the mount with its own power supply.** For best performance the mount should have its own power supply. This is especially true when imaging. Normally, the mount will be using a 24-volt power supply, but it can also run with 12 volts; however, the maximum slew rate will be reduced from 1800x to 1200x.

- **Always tie off cables for CCD cameras.** Tying cables to the focuser body ensures that the weight of the cables don't cause movement (flexure) in the imaging system during a long exposure.

- **Reference the Astro-Physics Support page of the website.** There is a wealth of information on the Support webpage that can often answer the questions you have, as well as provide in-depth understanding and fixes. All the latest versions of the manuals can be found there.

Please take special notice:

- **Outdoor Storage** – If you have a mount that is left outside for extended periods covered by a tarp or scope cover, then it is highly recommended to remove the GTOCP5 and Keypad and take them inside to a safer environment. Tarps and covers cause significant condensation build up unless steps are taken to mediate the problem. Often low-wattage light bulbs or fans are used to reduce condensation for short term storage, but this is no guaranty.

- **VERY IMPORTANT**: We take every precaution to make our control boxes moisture and dew resistant; however, they are not waterproof! We cannot be responsible for water damage when reasonable care has not been taken to shield them from excessive dew or when storing them outside under tarps for extended periods.

Please feel free to contribute hints and tricks of your own for future editions of this manual. At Astro-Physics, we know that our customers come up with some clever solutions! E-mail your suggestions to support@astro-physics.com. We also encourage you to participate in our user group: ap-gto.groups.io/g/mail

MOUNT CARE, CLEANING AND MAINTENANCE

Like any fine piece of equipment, your mount's longevity and performance are directly correlated with the quality of the care that you give it. Handle it with respect, keep it as clean and dry as is practical, and perform a few minor maintenance tasks, and your Mach2GTO will give you many years of trouble-free service.

Care

Although we build it to be rugged enough for field use, your Mach2GTO is a precision instrument with very accurate worm and wheel adjustments. Please be careful if you place the mount on a flat surface, i.e. the ground or trunk of your car. This is a consideration for any fine instrument.

When carrying or transporting your mount, be sure all axis knobs are locked to prevent an axis rotation and weight shift in your hands. We suggest that you transport and store the mount in a case or in a well-padded box, such as the one in which it shipped. More damage can be done in a few careless seconds in transit than in many hours of normal operation.

Try to keep your mount protected from dust and moisture when not in use. In warm, humid weather, be aware of the dew that may have formed on the mount while in the field and allow the mount to dry out before packing it away for storage.

Cleaning and Touch-up

Wipe your mount clean with a soft, dry cloth. If needed, you can use a damp cloth or a cloth that has been sprayed with a mild, non-abrasive cleaner (window or all purpose cleaner – no bleach). Do not spray cleaners directly onto your mount. If you use a cleaning product, follow with a damp cloth to remove the chemicals from the mount.

The painted surfaces of your mount may end up with scuff marks from repeated transport and assembly / disassembly. Most of the time, these marks can be removed with a product like *Color Back*™ by *Turtlewax*™ (automotive product). Simply apply with a paper towel and buff out the mark. If your paint becomes chipped, touch-up kits are available for purchase – please call us. *NOTE: Paint touch-up kits can only be sold to U.S. customers due to regulations governing shipment of hazardous materials.*

Counterweight Appearance

Stainless steel is resistant to oxidation, but over time its appearance can degrade, especially if you live near salt water. Applying a good car wax coating will help to maintain the pristine stainless steel finish of your counterweights. Should cleaning need to be done, it is recommended to use an SOS detergent pad to clean the weights. Be sure to dry them thoroughly, and then follow up with the car wax.

Worm Wheel Maintenance

Using the entire worm wheel ensures even wear and extended life. Under normal use the mount moves back and forth using only one half of the worm wheel...the other half is not used. Here's what to do: Send the mount to Park 1, unlock the clutches and push the mount to Park 4. Lock the clutches and you're done. Do it twice a year…that should be enough.

Greasing Mount

We have designed access ports for periodic greasing into the Mach2GTO. One is located on each axis. By opening the port, you'll be able remove the old grease using a toothbrush and soft cloth to brush and wipe away the grease while turning the axis to fully reach the entire gear. The gear wheel can be advanced to another section by simply moving the mount east or west at slew speeds via the directional buttons. Similarly, the new grease can be applied by brushing it into the gear while turning the axis.

All 360 degrees of the worm can be accessed that way, even with the mount fully loaded with counterweights and telescopes. No need to tear down a permanent setup to do this maintenance.

Contact our office for a Grease Kit (GREASEM) of custom mixed greases. Frequency for greasing will depend on mount use and environment. Greasing every year or two will maintain your mount for life.

TROUBLESHOOTING AND SUPPORT

Troubleshooting and Tips

Additional troubleshooting questions are in the "Keypad" or "GTO Micro-Step Servo System" manuals. The issues discussed in those manuals relate to mount communication issues. Please refer to them. We will add to this section as we become aware of user concerns.

Note: We recommend ASCOM-compliant software.

For polar alignment, I am using declination drift technique with stars on east & south. Now, I do not see any drifts in declination on both sides (E & S), so the mount "should be" properly aligned. However, I still have small drift in RA which looks like the RA motor is a bit faster than earth rotation. This drift is something like 1.5 arcseconds during 1 minute or so.

The sidereal tracking rate is exact in the mount (it is crystal controlled and checked here for accuracy). However, the stars do not move at exactly the sidereal rate everywhere in the sky. The only place they move at that rate is straight overhead. As soon as you depart from that point in the sky, the stars will be moving more slowly, especially as you approach the horizons. Thus, it looks like the mount is moving slightly faster than the sidereal rate.

The stars will also be moving slightly in the Dec axis as well. This is due to air refraction and scope flexure. The lower into the air mass, the greater the apparent motion.

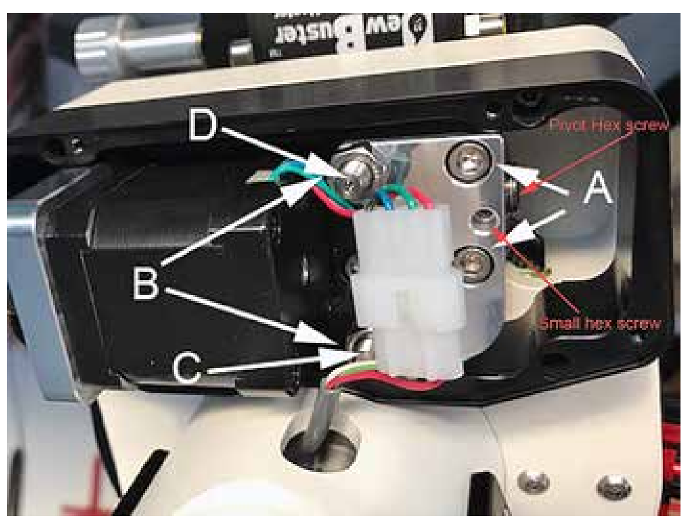
In order to increase the area of sky from the zenith that will give you fairly good tracking, you will need to offset the polar axis by a small amount. See our RA Corrective Method for tweaking polar alignment that is found in "Appendix B" The amount will depend on what your latitude is. The best approach is to use our APCC Pro software when imaging. It will vary the tracking rate and provide dual-axis tracking for different parts of the sky.

My GTOCP5 Control Box does not appear to be working properly. Can I use the control box from my other Astro-Physics mount with my Mach2GTO?

No. Your mount's GTOCP5 control box has been programed for your specific mount and no other. It cannot be switched to other mounts, not even to other Mach2GTO mounts. Doing so will require that you send your mount back to us for re-programming.

Mach2 Backstop Adjustment Instructions

In the attached image the backstop adjustment is done with the spring plunger labeled C. before trying to turn this, loosen the corresponding locking nut (B). Then using a 5/64 Allen key turn the spring plunger clockwise gently until it bottoms out. Do not force it tight. Once bottomed out, back it away slightly (1/8 turn or slightly less) so that the worm can still move a small amount up and down when you push on the back of the motor. When you let go of the motor, the spring pressure will push the worm into full mesh automatically. While you still have the Allen key in the spring plunger, tighten the lock nut, and make sure that you don't let the spring plunger tighten further. The upper spring plunger (D) should not be adjusted ever.



If it appears that you still can feel a rocking motion when you push on the counterweight shaft with a small amount of pressure from your fingers, then you can try one other adjustment. In the picture you will see two red arrows showing the pivot Hex screw and the small hex screw. The small one locks the large Hex screw and keeps it from rotating. Loosen the small locking screw and then with a 1/4 inch Allen key turn the Pivot screw counterclockwise to loosen it, and then turn it clockwise until it feels snug but not tight. Now try moving the counterweight shaft again. In order to do this adjustment you will have to back off the second anodized motor cover. Do not remove it from the mount, simply back it away enough to get access to this screw.

Mach2 Pivot Bolt Adjustment

Your pivot bolt might be too tight which is preventing the worm from pivoting fully into mesh. It's an easy adjustment.

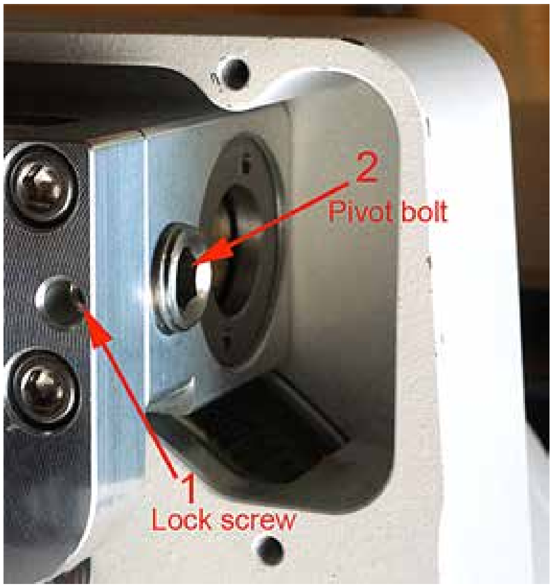
Remove the outer motor box cover and set it aside with its 4 screws.

Remove the 4 screws that hold the inner cover and put those screws aside in another place, but do not mix them with the outer screws!

Now slide the inner cover back and out of the way to expose the worm assembly. You don't need to remove it entirely.

First make sure that the 3 Allen screws that hold the motor assembly to the RA axis are fully tight. If they are, then proceed with the next step:

Referring to the image, loosen the locking screw #1 (5/64 Allen Key). Then with a 1/4" Allen key loosen the pivot bolt #2 about 1/2 turn ccw while gently pushing on the counterweight shaft in the RA direction. Gently! not with guerilla force please. It should stiffen up as the worm mates with the worm wheel teeth. Once it is in full mesh, tighten the pivot bolt a small amount and again feel the RA axis to make sure that it is meshed. You can then push down on the top back of the motor to bring the worm slightly out of mesh, then let go to allow the springs to pop the worm teeth back into mesh. The motor assembly should be able to rotate slightly in and out of mesh when you apply force to the back of the motor.



If everything feels right, re-tighten the locking screw. Then replace the inner motor cover with the shorter 4 screws (very important that you do not use the outer cover screws!!) Finish by replacing the outer cover.

Additional Support

Remember that additional information on the micro-step servo system is found in the separate "Astro-Physics GTO Micro-Step Servo System" manual.

For additional information regarding the Mach2GTO, refer to the Support section of our website. We also encourage you to participate in the ap-gto.groups.io/g/mail user group. The members of this group are very knowledgeable about the operation of their mounts, CCD/CMOS imaging and other related issues. The staff of Astro-Physics also participates and you will find a wealth of information in the archives. To find the group, link from the forum page on our website.

If any problems occur, please don't hesitate to contact Astro-Physics for assistance.

We encourage you to submit your technical support questions directly to Astro-Physics by phone or e-mail: support@astro-physics.com.

We may add additional troubleshooting tips to future versions of this manual or in a separate technical document. In such an instance, we would add this information to the support section of our website as well.

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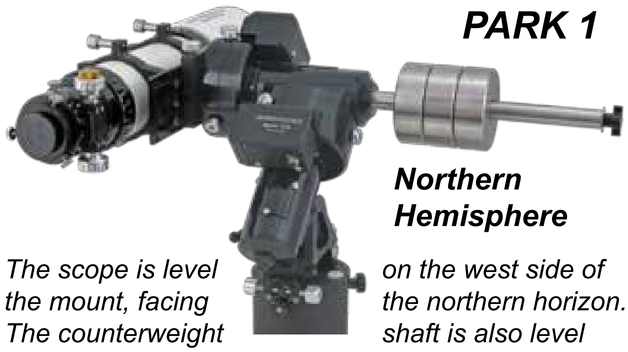
www.astro-physics.com

APPENDIX A: PRE-DEFINED PARK POSITIONS

The Mach2GTO does not require starting from pre-defined park positions, but it is often helpful to finish the evening in one.

Recommended: **Park 3** is a safe and balanced position. **Park 2** is a convenient position for loading and unloading your scope. **Park 5** is a safe, low profile position with minimum cable twisting.

PARK 1



Northern Hemisphere

The scope is level on the west side of the mount, facing the northern horizon. The counterweight shaft is also level and pointing due east.

Both Hemispheres: RA is horizontal,
North: Dec = (90-Latitude) South: Dec = (-90-Latitude)

The southern hemisphere is mirror reversed. The scope is still level on the west side of the mount, but is facing the southern horizon. The counterweight shaft is also still level and pointing due east.

Southern Hemisphere

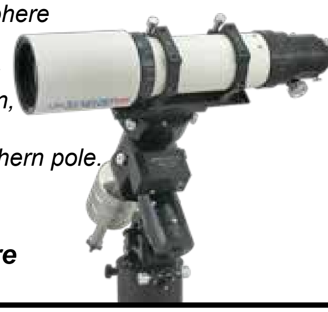
PARK 2

Northern Hemisphere

The scope is level on top of the mount facing the eastern horizon. The counterweight shaft is pointing down.

Both Hemispheres: RA axis is vertical, Dec = 0

The southern hemisphere is mirror reversed. The scope still points to the eastern horizon, but east is to the left when facing the southern pole.



Southern Hemisphere

PARK 3

Northern Hemisphere & Southern Hemisphere

The scope is pointing to the pole. The counterweight shaft is pointing down.

RA axis is vertical, Dec = 90

PARK 4

Northern Hemisphere

The scope is level on the east side of the mount, facing the southern horizon. The counterweight shaft is also level and pointing due west.

Both Hemispheres: RA is horizontal,
North: Dec = (-90+Latitude) South: Dec = (90+Latitude)

The southern hemisphere is mirror reversed. The scope is still level on the east side of the mount, but is facing the northern horizon. The counter-weight shaft is also still level and pointing due west.

Southern Hemisphere

PARK 5

Northern Hemisphere

The scope is level on the east side of the mount, facing the northern horizon. The counterweight shaft is also level and pointing due west.

Both Hemispheres: RA is horizontal,
North: Dec = (90-Latitude) South: Dec = (-90-Latitude)

The southern hemisphere is mirror reversed. The scope is still level on the east side of the mount, but is facing the southern horizon. The counterweight shaft is also level and pointing due west.

Southern Hemisphere

HOME POSITION

(Mach2GTO / GTOCP5)

Northern Hemisphere & Southern Hemisphere

This is a very special position that is established by Astro-Physics when programming the Absolute Encoders. It is highly precise.

APPENDIX B: DRIFT ALIGNMENT – RA CORRECTION METHOD

What you need: CCD guide camera, computer with program that will give you a guiding graph.

Classic Drift Align minimizes only Dec drift over most of the sky. However, that results in significant RA drift at the zenith. Drift in RA increases the closer you are to the Earth's equator. Why was this classic method of drift alignment developed? It was developed this way because in times past, most equatorial mounts had only right ascension drives and no way to adjust declination drift. If you could eliminate Dec drifting, all you needed was a drive corrector for the RA motor that would allow you to adjust the RA drive rate to compensate for the RA drift; you had a fairly nice unguided system and could take images. However, since most of our imaging is done from 45 degrees to the zenith, we will benefit more from this RA Correction Method.

Several Things to Keep in Mind

- Before you begin you will want to level the mount so that as you make adjustments in either azimuth or altitude; adjusting one will not affect the other.
- Make sure that all aspects of your mount and scope are tight (rings, scope and mount fasteners, focuser and camera, etc.). If you are using a mirrored scope, be sure that the mirror is locked (if available) to minimize flex and flop.
- You must make the azimuth adjustment first so that you can then make the altitude adjustment accurately; otherwise, the azimuth adjustment will change your altitude setting and it will have to be re-done.
- The altitude adjustment must always be finalized by pushing upwards against gravity with the locking knobs quite snug (not to be further tightened). If you overshoot, then you should loosen the knobs and lower the altitude and repeat the upward adjustment.

Procedure

1. Begin by having your mount polar aligned by a polar scope or other method.
2. Align your CCD guide camera to be square with the R.A and Dec axes of your mount. Know which axis is RA and which is Dec. Assume nothing…test it. Unless your mount has absolute encoders, make sure that PEM is turned on with a good PE curve. PE correction is not needed when using absolute encoders.
3. Go to a star near the celestial equator / meridian and start guiding.
4. Set your guiding aggressiveness to 0%.
5. Open your guiding graph and watch only the drift on the Dec line. Using the azimuth knobs, adjust the mount's azimuth until the star stays on the line and does not drift up or down. Don't worry about what is happening on the RA line, just zero out drift on the Dec line.
6. Once that is done, go to a star near the zenith (usually on the East side within 1/2 hour of the meridian).
7. This time you will watch only the RA line on the guiding graph. Adjust the mount's altitude knob (only pushing upward) until the star stays on the line and does not drift. If you overshoot, loosen the altitude locking knobs; lower the altitude; re-tighten the knobs and start again. Remember, your guiding aggressiveness is set to 0%.
8. Done this way, the two adjustments are independent and don't interfere with each other. The adjustment can be done in about 20-30 minutes. Repeating steps 1-6 will allow refinement and confirmation.

What you will end up with is no RA and no Dec drifting at the zenith. This near zero drift zone will extend approximately 35 to 40 degrees in either direction, giving you a 4 hour drift-free window for imaging. Depending on focal length and pixel scale, you might get round stars in a typical 10 - 20 minute exposure as much as 45 degrees from the zenith.

So, you can do drift alignment either way: align on the pole with classic drift alignment or align on the refracted pole with the RA method. The former will minimize Dec drift over a large area of the sky; the latter will minimize RA and Dec drift at the higher parts of the sky where most imaging takes place. Everywhere else you will need to guide.

Note: Making and using a Pointing/Tracking model in APCC Pro will improve results even further.

APPENDIX C: ROLAND'S GTO QUICK STAR DRIFT METHOD - 2020 VERSION

What you need: Keypad or APCC to provide Meridian Delay function and a cross hair from either a finder or computer program (like Maxim DL).

Azimuth Alignment

This first section will describe a precise way to polar align the mount's azimuth. Once that is done, it will not require any further adjustment. The idea is to use the natural geometry of the sky with respect to an earth-bound mount to produce a perfectly aligned azimuth. That's the axis that rotates the bottom of the RA axis east and west.

Concept: If the scope is pointed straight at the zenith on either the west or east side of the mount, that point will remain stationary as you rotate the azimuth axis. So, if a star is in the eyepiece at that point and you bring it to the center of a cross hair, you can rotate the azimuth axis and the star will stay on the cross hair - at least for some minutes if you are tracking it. However, if you then slew to a star down south along the meridian line, it will deviate either east or west depending if the azimuth axis is too far west or east. The star at the zenith is then a pivot point, and the star down toward the south is your calibration star (or azimuth adjustment star). Bring that one to the cross hair by turning the azimuth adjusters and you are theoretically perfectly polar aligned.

So, the simple routine goes something like this:

1. Roughly polar align using any method that gets you close.

2. Using your planetarium program, pick a star near the zenith on one side of the meridian. Roland likes to use a star in the west with scope on the east side. That way it won't migrate across the meridian while doing this alignment step.

3. Bring the star to the center of a crosshair and do a ReCal. MaximDL has a nice crosshair if you want to use an imaging camera for this alignment.

4. Now pick a star down toward the south near the meridian line and on the SAME SIDE of the meridian (or north if you are in an upside down hemisphere), and slew to it. The star will appear either east or west of the crosshair, so now just turn the azimuth adjuster until the star is on the center-line of your crosshair. It may or may not be aligned N-S (in Dec) but that is of no consequence. No ReCal is necessary because you did not move to it via the motors.

Basically you are done with azimuth, but you can re-check by slewing back to the first star and do these 3 steps again for more precise alignment.

Altitude Adjustment

1. Slew to a star near the meridian (within an hour), center the star N-S on a cross-hair and ReCal. Ignore E-W offset.

2. Using Meridian Delay (using a Keypad or APCC), enter the same star and enter GoTo which will flip the scope to the other side.

3. Now simply bring the star 1/2 way to the cross-hair via the altitude adjuster and the rest of the way via the N-S buttons (again ignore E-W offset).

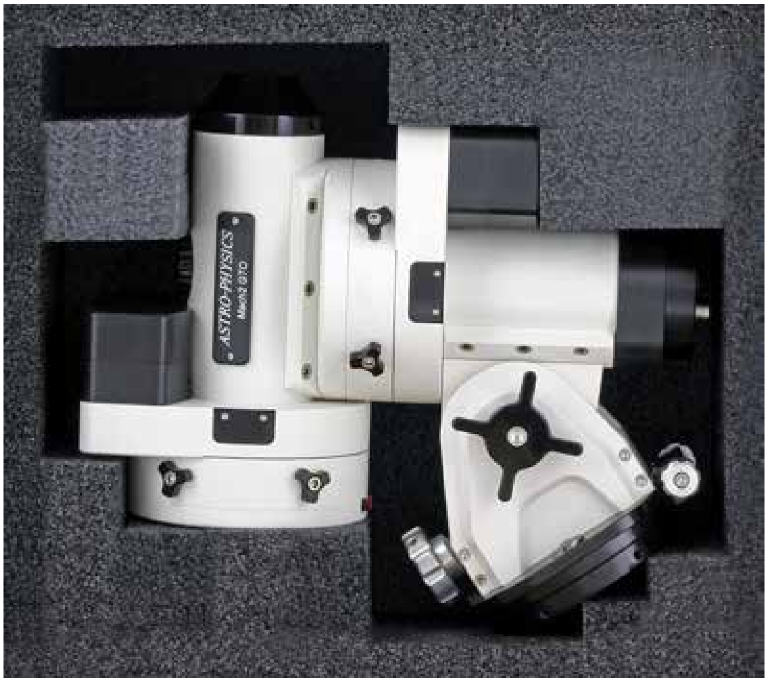
4. Press ReCal and you are basically done.

5. You might watch the overhead star drift and maybe tweak the alignment a tiny amount, if at all.

6. This method is usually good enough for 5-minute exposures with an 800mm focal length scope.

7. You can repeat this by going back-and-forth a few times repeating this process, but it should be quite accurate the first time. If you have floppy optics, it may not converge.

APPENDIX D: POSITION FOR SHIPPING AND COMPACT STORAGE
(RA axis turned fully counterweight up)

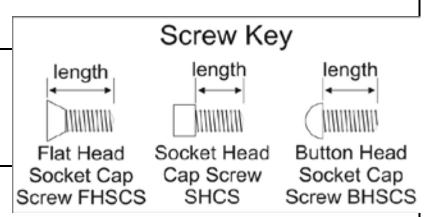


Note: You may wish to save this shipping box for use when transporting the mount or in the unlikely event that the mount would need repair. The foam can also be used in commercial cases.

The **Pelican iM2875 Storm Travel** case is one such case.

APPENDIX E: MOUNTING PLATE FASTENER CHART

A-P Part #	Description	Ships with:
FP1500	15" Flat Plate	(4) 1/4-20 x 5/8" SHCS [for mounting to 400, 900 or Mach1] (4) M6-1.0 x 20mm SHCS [for mounting to 600E] (4) 1/4-20 x 3/4" SHCS [for mounting to 1100, 1200, & 1600]
FP1800	18" Flat Plate	(6) 1/4-20 x 1" FHSCS [for mounting to 900, 1100, 1200 or 1600] (4) 1/4-20 x 1-1/4" FHSCS [Mach1]
DOVELM2	8.5" D-style Dovetail Saddle for Losmandy D-style Plates for 400, 600E, Mach1, 900 and 1100 Mounts	(4) 1/4-20 x 5/8" SHCS [for mounting 400 or Mach1] (4) M6-1.0 x 20mm SHCS [for mounting 600E] (2) 1/4-20 x 5/8" FHSCS [for mounting to 1200] (4) 1/4-20 x 3/4" SHCS [for mounting to 900, 1100, 1200 or 1600] [or to attach to SBD13SS or SBD16SS]
DOVEDV10	10" Dual-style Dovetail Saddle for Losmandy D-Style and Vixen V-Style Plates for 400, 600E, Mach1, 900 and 1100 Mounts	(4) 1/4-20 x 5/8" SHCS [for mounting 400, Mach1, 900 or 1100] (4) M6-1.0 x 20mm SHCS [for mounting 600E] (2) 1/4-20 x 5/8" SHCS [for special safety stop] (2) 1/4-20 Nut [for special safety stop]
DOVELM162	16" D-style Dovetail Saddle for Losmandy D-style Plates for 900, 1200, Mach1GTO. Also for 3600GTO w/ SB3622 or SB3627 Can also be mounted on AP ring tops with blocks	(6) 1/4-20 x 1" SHCS [for mounting to 900, 1100, 1200, 1600 or Mach1 (M1 uses 4), or to attach to SBD13SS or SBD16SS] (1) 1/4-20 x 3/4" FHSCS [opt. 900, 1100, 1200 or 1600 for end positions] (4) 1/4-20 x 3/4" SHCS [for SB3622 in side-by-side configuration and for attachment to blocks for ring-top mounting]
900RP	15" Ribbed Plate for 900 or Mach1	(6) 1/4-20 x 1" FHSCS [for mounting to 900 or 1100] (4) 1/4-20 x 1-1/4" FHSCS [for mounting Mach1]
1200RP15	15" Ribbed Plate for 1200 and 1600	(6) 1/4-20 x 3/4" SHCS [for mouting to 1200 or 1600]
1200RP	24" Ribbed Plate for 1200 and 1600	(6) 1/4-20 x 1" SHCS [for mounting to 1200 or 1600]
Q4047	900/Mach1 Adapter for use with DOVE08	(6) 1/4-20 x 5/8" FHSCS [for mounting to 900 or 1100] (4) 1/4-20 x 1" FHSCS [for mounting to Mach1]
SB0800	7" AP-style Sliding Bar	(2) 1/4"-20 x 5/8" SHCS [for center hole in rings]
SBV08	8" V-Style Dovetail Plate	(2) 1/4-20 x 5/8" SHCS [for center hole in rings] (1) 1/4-20 x 3/8" SHCS [for safety stop]
SBV15	15" Wide-Profile V-Style Dovetail Plate	(2) 1/4-20 x 1/2" SHCS [for center hole in rings] (4) 1/4-20 x 3/4" FHSCS [for attaching directly to AP rings] (1) 1/4-20 x 3/8" SHCS [for safety stop]
SBD12	12" D-Style Dovetail Plate	(4) 1/4-20 x 1" low profile SHCS [for attaching the SBDAPB or LMAPBLOCKS] (4) 1/4-20 x 1-1/4" FHSCS [for attaching directly to AP Rings] (2) 1/4-20 x 1/2" SHCS [for center hole in rings] (4) 1/4-20 x 1/2" low profile SHCS (1) 1/4-20 x 3/8" SHCS [for Safety Stop]
SBD16	16" x 5" Wide D-style Dovetail Plate for Losmandy D-Style Dovetail Saddles	(4) 1/4-20 x 3/4" SHCS [for attaching the SBDAPB Riser Blocks] (4) 1/4-20 x 1-1/4" FHSCS [for attaching directly to AP Rings] (1) 1/4-20 x 3/8" SHCS [for Safety Stop]
SBDAPB	AP Riser Blocks for AP D-style Plates	(4) #10-32 x 1/2" SHCS [for attaching to mounting ring tops] (2) 1/4-20 x 1/2" SHCS
SBDTB	Adapter Blocks for Takahashi	(4) M10 x 20 mm SHCS [for attaching to SBD16]
SBD13SS **SBD18SS**	13" or 18" Side-by-Side Dovetail Plate for Losmandy D-style Dovetail Saddles	(2) 1/4-20 x 3/8" SHCS [for Safety Stops -required at both ends] (1) 1/4-20 x 5/8" SHCS [for special safety stop] (1) 1/4-20 Nut [for special safety stop]
SBD2V	12" Losmandy D-Style Male to Vixen V-Style Female Adapter / Sliding Bar	(1) 1/4-20 x 1/4" low profile SHCS [to replace Safety Stop on V plate] (1) 1/4-20 x 1/4" SHCS [Safety Stop for SBD2V]
LT2APM	Losmandy Tripod to Astro-Physics Mount Adapter Plate	(3) 5/16-18 x 5/8" SHCS (4) 1/4-20 x 5/8" SHCS (4) 1/4-20 x 1" SHCS (3) 3/8-16 x 3/4 SHCS
CBAPT	Control Box Adapter	(1) 1/4-20 x 3/4" BHSCS (1) 1/4-20 x 1" BHSCS (1) 5/16-18 x 1" BHSCS (2) 5/16-18 x 3/4" BHSCS (1) Washer 1/4"
TRAYSB **TRAYSB1**	Bi-Level Support Bar & Single Level Support Bar	(1) 1/4-20 x 1" BHSCS (1) 5/16-18 x 1" BHSCS (1) Washer 1/4"
DOVEPW	16.5" Dovetail Saddle for Planewave 7.652" dovetail on AP 1200, 1600 and 3600	(6) 3/8-16 x 1" SHCS (6) 1/4-20 x 1" SHCS
SBPW23	23" P-Style Dovetail Plate for DOVEPW	(2) 3/8-16 x 1/2" low profile SHCS (4) 1/4-20 x 5/8" SHCS
DOVE3622	22" Dovetail Saddle for 3600	(6) 3/8-16 x 1" SHCS (4) 3/8-16 x 1-1/2" SHCS
SB3622 **SB3627**	Dovetail Plate for DOVE3622 Saddle	(2) 3/8-16 x 1/2" low profile SHCS (4) 1/4-20 x 7/8" SHCS for lock-down



1/6/2020

APPENDIX F: MOUNTING PLATE OPTIONS

15" Flat Mounting Plate (FP1500) (Discontinued)

This plate is 15" long by 4.6" wide by 0.5" thick. Two pairs of keyhole slots that measure 3.2" between centers are provided for the instrument mounting rings. The pairs are 13.75" apart. You can drill additional holes to suit your needs. This plate also fits the 400, 600E, Mach1, 900 and 1100 German Equatorial mounts.

Losmandy D-Style and Vixen V-Style Compatible Saddle Plates

The following dovetail saddles offer alternatives for the Losmandy D-style and Vixen V-style dovetail plates. These include two sliding bars made by Astro-Physics: (SBD12 and SBD16), and two Astro-Physics side-by-side bars: (SBD13SS and SBD18SS). For those of you who have scopes with the Vixen V-style sliding bars, we produce the 10" Dual-style dovetail saddle (DOVEDV10). We also offer a wide V-style dovertail plate (SBV15).

10" Dovetail Saddle Plate for both D-style and V-style Plates (DOVEDV10) (replacing DOVELM2)

This 10" Dual-style Saddle Plate fills the need of customers who have multiple scopes. Often times the smaller scopes are outfitted with Vixen V-style dovetail plates; whereas, the larger scopes have the more stable Losmandy D-style plates. The DOVEDV10 is the perfect solution as the best of both worlds.

It is a very robust dovetail saddle that will securely attach all your scopes to the mount. The clamp design provides the strongest possible lock for both style plates. The saddle has three locking clamps. Using all three will provide extra security, while using one of the end clamps along with the center clamp will allow shorter dovetail plates to be secured.

The clamping blocks grip your dovetail plate firmly. Springs keep the blocks in an open position until you tighten the knobs. The unique design of the clamping blocks ensures that they remain properly aligned with no need for additional guide pins and the brass washers on the knobs allow firm tightening without binding.

The saddle has the convenience of the Astro-Physics tilt-in feature applicable to both style plates. It has additional attachment holes so that the saddle can be shifted forward or backward, depending on whether you are balancing a front-heavy or back-heavy scope. In addition to D-style plates, it matches well with the Astro-Physics 15" V-style Plate (SBV15).

16" Easy-Balance Dovetail Saddle Plate for Losmandy D-style Plates (DOVELM162)

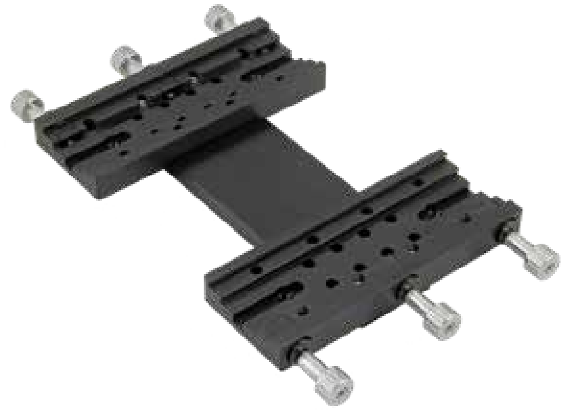
The DOVELM162 provides a multitude of mount attachment options, and was specifically designed to meet the balancing demands of "back-end-heavy" instruments like SCTs and Ritchey-Chrétiens, especially those with heavy imaging gear hanging off the back!

This plate has small knobs to avoid interference with the declination hub and the knobs have cap screws in the ends that accept a 3/16" hex wrench for extremely secure clamping of your instrument. Additional features include ribbed structure underneath to reduce weight and tapped 10-32 holes in the side for cable attachment.

Note that the bolt-hole patterns are marked with scribe cuts. Attach this plate with four 1/4-20 x 1" socket head cap screws. Holes along the center-line of the saddle plate are for use with the larger 900, 1100, 1200 and 1600 series of mounts and are not used with the Mach2GTO.

Side-by-Side, Vixen Style and Other Plate Options

In general, we recommend side-by-side configurations more often for our larger mounts. However, the Mach2GTO can handle a pair of smaller instruments in a side-by-side configuration. A nice pairing for a versatile visual setup might be a small wide field refractor along with a smaller-sized Maksutov Cassegrain for high-power viewing. We never recommend using a side-by-side mounting as a guidescope / imaging scope setup due to the possibility of differential flexure.



13" and 18" Side-by-Side D-style Plates (SBD13SS & SBD18SS)

These plates will fit into any D-style compatible plates and will accept the DOVELM2 (discontinued), the DOVEDV10 or the DOVELM162 as the instrument saddle plates for each scope. The 13" plate allows optical axes to be placed on 9.5" (250 mm) centers, and the 18" plate allows instruments on 14.5" (368 mm) optical centers.

15" V-style Dovetail Plate (SBV15)

This 15" long Vixen V-style dovetail plate is designed to add maximum strength and rigidity to your scope setup. It uses a wide attachment surface with the 2.362" (60 mm) side-to-side hole pattern of Astro-Physics and many other scope rings, along with the universality of center slots.

Though it was designed to be used with the 10" Dual-style Saddle Plate (DOVEDV10), the SBV15 can be used with all Vixen V-style OEM systems.

The plate can also be used as an accessory plate by attaching it to the top of rings. This will allow affixing a variety of accessories using V-style adapters.

Other Mounting Plate Options

Additional mounting plate options including custom plates may be available from other sources.