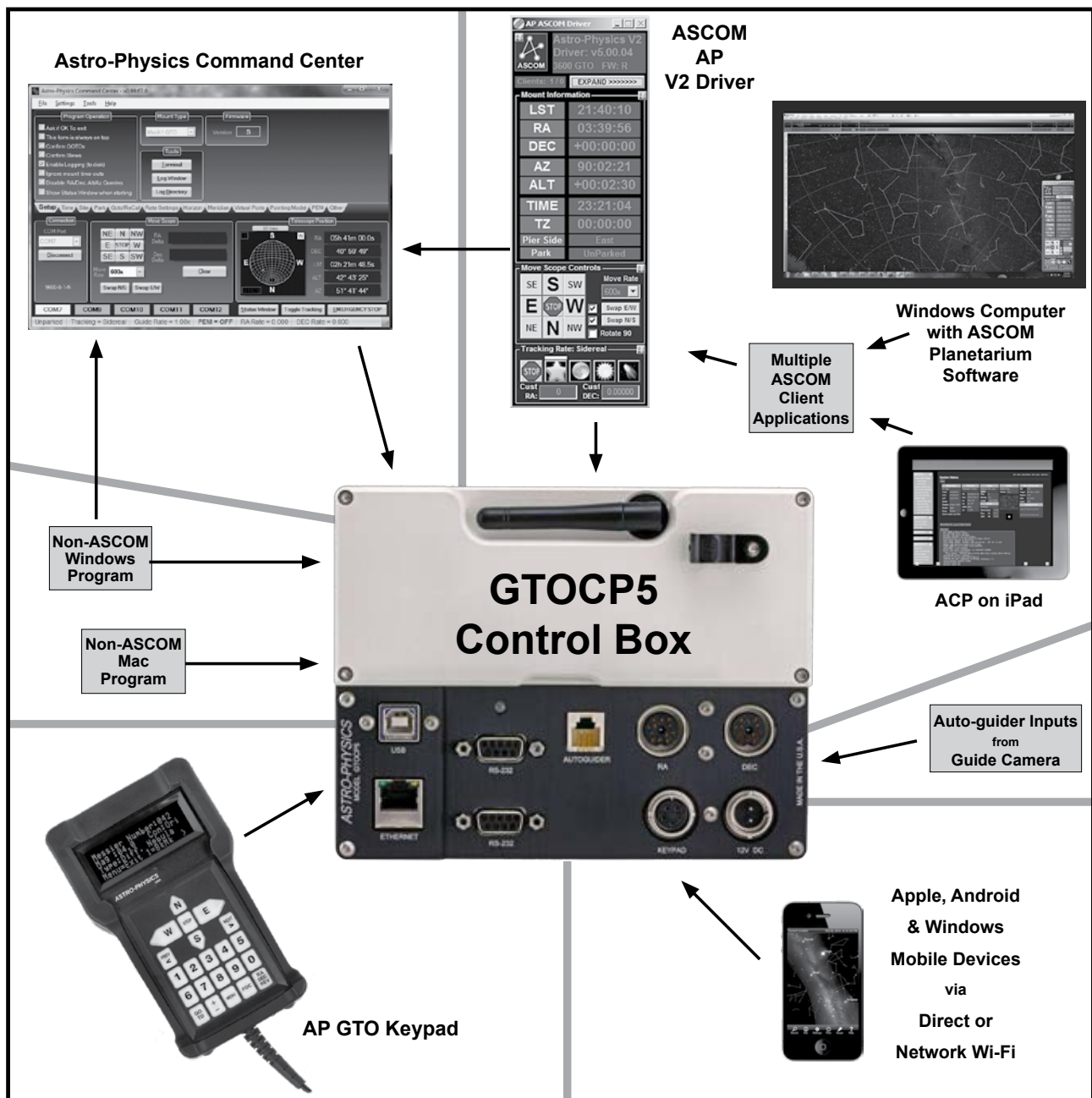


Astro-Physics

GTOCP5 Micro-step Servo System

Mach2GTO only

Operating Instructions



August 2020

Astro-Physics

GTOCP5 Micro-step Servo System

Mach2GTO Only

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PLEASE RECORD THE FOLLOWING INFORMATION FOR FUTURE REFERENCE

GTOCP5 Serial Number: _____

Purchase Date: _____

User Name _____ Password _____

Ethernet IP Address _____

Access Point Wi-Fi Network Name _____

Access Point IP Address _____

GTOCP5 CONTROL BOX – YOUR MOUNT’S BRAIN

Your mount is a unique combination of precision, intelligence and strength. The heavy-duty, CNC machined parts give the mount the strength and rigidity to hold a load in a rock-steady fashion while exposed to the elements and while that entire load is in motion. The precision of every component allows accuracies that are measured in fractional arc seconds. The intelligence to control all of this is in the GTO Micro-step Servo System.

There are three major sub-systems to the GTOCP5 Micro-step Servo System:

1. **The GTOCP5 Control Box** This is the real “brain” of your mount. Please try to understand this from the outset. Your mount is **NOT** controlled by the Keypad or by your computer. They merely serve as input devices and convenient interfaces for you, the user. The GTOCP5 serves the following functions among others:
 - It provides the voltage to drive the motors.
 - It determines the motors’ rotational direction, rotational speed and the total number of rotations required to arrive at the destination coordinates that are commanded.
 - It maintains the accurate tracking speed that is chosen and applies any needed corrections from the absolute encoder feedback.
 - It takes the provided input and translates it into the correct actions that fulfill our wishes.
 - It seamlessly integrates the encoder and limit functions with the regular servo control functions for an unprecedented level of control.
 - It bears repeating: It is the GTOCP5 control box that controls the mount!
2. **The Micro-step Motors and Absolute Encoders of the Mach2GTO.** These DC micro-step motors are the work horses that actually move the mount. Their integration with the absolute encoders provide the necessary feedback information for the GTOCP5 to perform its varied operations. The encoders working with the microprocessor in the GTOCP5 operate to an accuracy of 0.05 arc seconds per step. These motors can be accurately controlled over a speed range of 4800:1, which allows 1.0x sidereal for guiding to 1800x sidereal for 7.5 degree per second slewing.
3. **An External Input Device to Interface with the User.** In order to control the movement of the mount, you will need to connect at least one of the devices below. For more information, refer to "Controlling Your GTOCP5 Mount" on page 20.
 - Computer with a planetarium program or observatory control software. The AP V2 ASCOM Driver and the "The Astro-Physics Command Center - Standard & Pro Versions" on page 27 are both included with your mount. APCC provides advanced functionality and safety features in addition to the ability to create tracking and pointing models.
 - Mobile smart device with mount command functions that employ the Astro-Physics Command Protocol. For more information, see "Workflow When Using Mobile Smart Devices" on page 34.
 - Keypad (optional)



To ensure the reliability of this control equipment, the Astro-Physics Micro-step Servo System uses industrial components. We chose a sturdy industrial handheld computer as our keypad. These components are far more rugged than conventional consumer electronics, and they will continue to function properly well below zero degrees F (-18 C). The optional Keypad uses a vacuum fluorescent display that does not lose its speed or readability in the coldest winter conditions...all the way down to -40 degrees F (-40 C). However, if you plan to use your mount in extreme temperatures and conditions, please contact Astro-Physics first.

All of this control and sophistication is accomplished in an incredibly efficient manner. The Micro-step Servo System can be operated from 12-24 volt DC power source. Using 24 volts provides the added advantage of higher slew speeds.

ENVIRONMENTAL CONSIDERATIONS

Astro-Physics mounts are used in a variety of climates and conditions. Some people live in areas with high humidity and others use their mounts in dry, dusty environments. Insects can be problematic no matter where you are located. Each of these environments present challenges for all of your electronic equipment, including your mount.

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.

Wet and Humid Climates

The GTOCP5 control box and optional Keypad are not waterproof. They should be protected from rain and excessive condensation.

- Your control box has drain holes on the backside of the two lower corners. You may wish to leave these drain holes open.
- If your mount is left outdoors under a tarp for extended periods of time, we recommend that you remove the control box and keypad and bring them indoors. Tarps and covers can cause significant moisture build up from condensation even when you use low wattage light bulbs or other means to reduce condensation.
- If your mount is caught in the rain or you forget to turn off the automatic sprinkler during your observing session, remove the control box, open the cover and pour out any water that may have accumulated. Leave it open until the components dry out and DO NOT POWER UP UNIT until fully dry.

Dry and Dusty Climates

- Your control box has drain holes on the backside of the two lower corners. You may wish to cover these holes if your concerns are insects and dust. We provide small plugs that insert into the holes. If these are misplaced, a small piece of tape will do the trick and will not be visible.

Covers for Connectors

We provide a set of covers for all of the connectors on your control box. Although these covers will help to reduce the moisture, dust, or insects that can enter your control box, they do not provide 100% protection. If they are misplaced, you may order another set (part # CONCOVS).

GTO MICRO-STEP SERVO SYSTEM SPECIFICATIONS

Electronic Components	Rated for industrial and rugged automotive applications
Motors	Brushless micro-step servo system
Power Requirements	Nominal 12 to 24 VDC 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)
Hand-held Computer	Optional Keypad to control all mount functions. Includes extensive databases and tour features in a simple, intuitive interface. Software updates via internet.
GTOCP5 Servo Control Box	GTOCP5 Control Box, removable
GTOCP5 Dimensions	6.375" x 4.9" x 1.8" (16.1 x 12.5 x 4.6 cm)
GTOCP5 Weight	1.8 lb. (0.8 kg)
Standards	Meets FCC and CE standards. Lead-free RoHS compliance
Slew Speed (Maximum)	1800x with 24V; 1200x with 12V

Power Consumption

The mount powers both micro-steppers with full current at all times. The Dec motor must be powered even when it is not turning in order to maintain an exact micro-step position. This is fundamental to micro-step motors. Slewing both motors at 1800x draws the most power. The motors are beefy and rated at 2.7 amps each.

The motors can be powered at a lower level, but then you may run into stalls and/or resonance situations. Care must be taken to carefully balance the load so that the motors will work within their lowered load capability at the lower current levels. We can never achieve the low current consumption of our earlier DC servo motors because they have very much higher efficiency than a stepper motor. Also the Dec motor on a DC servo doesn't draw any current when it is sitting still, whereas a micro-stepper must draw full current whether it is moving or not in order to maintain sub-arcsecond positions.

GTOCP5 CONTROL BOX - LAYOUT AND FEATURES

The GTOCP5 (also referred to as CP5 throughout these instructions) control box contains all of the circuitry to drive the two micro-step motors and the logic required to navigate the sky. It will be operational and track at the sidereal rate when connected to both motor/gearboxes of the mount and a power source.

Please remember that this box contains advanced electronics and must be treated with the same care given to other fine equipment. You can see that the unit is machined of aluminum and is built to be rugged; however, it is not indestructible.



12-pin Receptacle for RA Motor and Encoder

A 16" servo cable with a 12-pin male connector plugs into this receptacle. The other end of the cable attaches to the RA receptacle on the rear of the RA axis. Be sure to connect RA to RA and screw on the knurled ring to lock it in place. The two 16" cables that are provided are interchangeable between RA and Dec.

12-pin Receptacle for Dec Motor and Encoder

A 16" servo cable with a 12-pin male connector plugs into this receptacle. The other end of the cable attaches to the Dec receptacle on the rear of the RA axis. Be sure to connect Dec to Dec and screw on the knurled ring to lock it in place. The two 16" cables that are provided are interchangeable.

12-24 Volt Locking Receptacle

Place the DC power cable's 2-pin locking plug into the 2-pin receptacle marked 12V on the GTO Control Panel and lock in place by a twist of the plug's locking collar onto the receptacle. The other end of the power cable terminates with Anderson Power Pole connectors which provide convenience when connecting to a number of different power connectors. Although a 24 volt power supply is provided with the mount, we also offer optional ring terminal and alligator clip extensions for versatility and when going into the field with batteries. **The GTOCP5 receptacle is top pin (pin #1) positive (the orientation notch is to the right).**

There is no on-off switch on the GTOCP5. We recommend that you connect all of your cables to the GTOCP5 Servo Control Box before applying power, whether from a power supply or from a battery. To turn the unit off, simply disconnect the power cable.

Power Indicator Light

This LED will remain illuminated when your system is powered up and operating properly. The red-colored LED indicates proper functioning of the servo system. If the servo detects a problem, the LED will turn from red to amber. An amber LED indicates that the servo has gone into Safe mode or Motor Stall mode and is no longer trying to drive the motors. The motors will be stopped and de-energized for safety. Position data is not lost during this condition. If the voltage falls below about 10.5 volts, the power LED will go out completely. The Keypad will also not function properly below about 11 volts.

If you experience an amber LED, first check your power source to be sure it is delivering adequate voltage and current to drive the system. Look for loose or corroded power connections. If your power supply is good, the amber LED means that

your motors are overloaded, probably due to an unbalanced load on your mount. It could also mean that your scope or counterweights have hit an obstruction and stopped the motion of the axis. Refer to the Troubleshooting section on page 45 for further discussion.

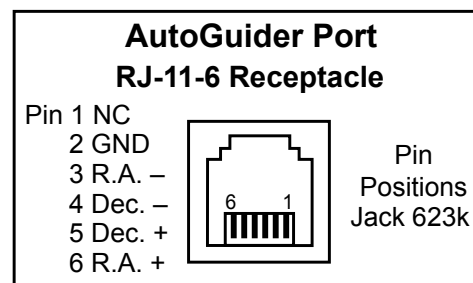
Keypad Receptacle

Attach the 5-pin male connector plug on the end of the Keypad's coiled cable to this receptacle and lock it in place (push in the knurled ring then turn). The Keypad receptacle is actually a serial port with an added 12-volt power source.

Autoguider Port Receptacle

This receptacle interfaces with the RJ-11-6 modular plug of an autoguider cable, purchased separately or as part of a CCD imaging camera or autoguider. The port uses the industry standard ST-4 pinout as shown at right.

The autoguider will be functional and ready to go as soon as you plug it in. Please refer to the appropriate manual from the manufacturer for operation of the autoguider. As we explain more fully in "Tracking Past the Meridian" on page 39, you mustn't confuse your guiding software's X and Y axes with RA and Dec. They are NOT necessarily the same.



USB Port

We have added a ruggedized USB 2.0 port to the GTOCP5. The USB port uses an on-board FTDI RS-232 serial UART to seamlessly connect as if it were a true serial port. This device is powered both from the USB itself and also from the power of the GTOCP5. Additional information is provided on "USB Port" on page 10.

RS-232 Ports (2)

These are the traditional serial ports that have been used to connect our mounts to an external computer for years. They are still highly recommended for their ruggedness and reliability. When considering your options for communicating with your mount, refer to "Communicating with Your Mount" on page 10.

Ethernet Port

The GTOCP5 offers Ethernet connectivity to the Astro-Physics GTO Servo System. Extensive information is provided in "Communicating with Your Mount" on page 10 .

Wi-Fi Module and Antenna

The Wi-Fi module is part of the circuit board within the GTOCP5 and the antenna is recessed into the top of the box on the exterior. The position of the articulating arm of the antenna can be adjusted. When communicating via Wi-Fi, move the antenna as needed to provide the optimum signal to your control box. Be aware that the position of the control box in relation to your modem may reduce your signal. A clear line of sight is ideal. Also, be sure that the antenna is free of dangling cables that could cause interference. Refer to the Troubleshooting section on page 45 for further discussion

Removing and Installing the GTOCP5 Control Box

An important part of the design philosophy at Astro-Physics is to use a modular approach to the system components. Where possible, in the rare event of a failure, components may be removed for repair or replacement. This modular philosophy is exemplified by the GTOCP5 control box and its predecessors.

The GTOCP5 may be held in a dovetail bracket angled from the top of the Eagle EZ pier, or alternatively, with the bracket attached to the side of the pier. When using one of the available tripods, it may be necessary to attach the control box adapter by using an extension to offset the adapter for clearance. Refer to the Mach2GTO manual for more information.

The GTOCP5 is secured into the dovetail bracket by two #8-32 thumbscrews. To remove the GTOCP5 simply loosen these thumbscrews and then tilt and lift the box free from the dovetail connection. Reverse the procedure to install.

Easy removal – can be especially handy for mounts that are subject to extra environmental stresses. The GTOCP5 can be removed and taken inside to a safer environment when not in use.



COMMUNICATING WITH YOUR MOUNT

The GTOCP4 and GTOCP5 (abbreviated CP4/5) introduce communication alternatives in addition to the venerable RS-232 serial ports (both serial ports have full functionality for keypad downloads beginning with version VCP4-P01-14)). These are USB, Ethernet and Wi-Fi. Each will be discussed individually below, but a bit of introductory text is in order. First off, you must understand that ALL control, information and operational data passing to and from the mount is in the form of simple ASCII characters in text commands and responses. Whether you are controlling the mount from the keypad, from a computer, or from a smart phone or tablet, an order to slew the mount will consist of the exact same commands, made up of these same ASCII characters, sent in the exact same order, and basically at the same speed.

Do not be duped into thinking that traditional serial communication is somehow inferior to USB, Ethernet or Wi-Fi. Your goal is to select the alternative(s) that best meet your needs with respect to your control device, and the distance between the control device and the mount. Crash-proof dependability of the communication medium is FAR MORE IMPORTANT than high speed!

Regardless of the communication method, when you are controlling the position of the mount with a computer program such as the Astro-Physics Command Center (APCC), DC3 Dreams' *ACP™*, or Simulation Curriculum Corp.'s *Starry Night™*, there is constant communication between the computer and the microprocessor in the CP4/5. The computer software requests constant updates to the position and status of the mount, and the CP5's microprocessor chip responds with continual RA and Dec coordinate data via the cable or wireless connections to your computer. When you use the software to give instructions to slew to a new object, the commands (RA and Dec coordinates) are sent to the mount. Please read the sections that follow entitled "Controlling Your GTO Mount" on page 20 and "Understanding the German Equatorial Servo Logic" on page 36 for additional information.

As a final introductory note, remember that the CP4/5 is the "brains" of the system. The mount won't quit if your control device is disconnected for a while, or if you change connections mid-session. For example, at a large star party, there may be a ton of competing WiFi networks flooding the air waves. If 10 minutes into a 20 minute exposure, you realize that the WiFi is flakey, you can disconnect and then reconnect with USB, serial or an Ethernet cable. You can plug in and then unplug the GTO Keypad at will without issue. The CP4/5 will simply continue on regardless

Choosing Your Communication Interfaces

Distance of Mount from Control Device

One of the primary factors in choosing your connection method(s) will be the distance separating the control device from the mount.

- Computer closer to mount: People who have their mounts close to the controlling computer, and do not have network capabilities at hand, may find direct USB connection to be their most convenient choice. For mobile setups like observing in your backyard or going to star parties, Wi-Fi is a flexible solution.
- Computer further from mount. Somewhat longer distances may be better served with peer-to-peer Ethernet, a cabled network connection to a router, an installed serial card or a USB-to-serial adapter and a longer serial cable. For control of a mount that is within 100 yards or so of the controlling computer, we have found the Icron Technologies Ranger 2304 USB extender to be an excellent solution.

Remote Observatories

Remote observatories will generally require a computer or an IP addressable server in the remote observatory itself, along with a high-speed internet connection for communication with your home computer. The Ethernet and Wi-Fi discussed below will prove helpful. However, such complete long-range solutions are beyond the scope of Astro-Physics to supply or support.

If you are outfitting your observatory with a new computer, you might want to consider a small industrial computer or media-player computer like the Global Shuttle DS series (i.e. the DS57U or newer), the Cincoze line, or the Moxa V series among others. These computers are used to run the huge video billboards that are now everywhere, and they are environmentally robust, even at low temperatures. They also come with multiple true serial ports, and many operate on 12 volts - perfect for the solar-powered observatory! As with any computer electronics, change is the only real constant.

USB Port 2.0



The USB port uses an on-board FTDI RS-232 serial UART to seamlessly connect as if it were a true serial port. This device is powered both from the USB itself and also from the power of the CP4/5, providing an extra layer of redundancy over external USB-Serial devices. Because the internal FTDI

chipset in the CP4/5 remains powered, it will almost never crash. In addition, the chip is uniquely serialized, so that every time you connect to the CP4/5 it will be found on the same COM port, preventing COM port hunts. The port itself is sturdy and will provide excellent connector retention after many, many connections.

To use the USB connection, make sure you install the FTDI driver on your computer FIRST. The driver can be found at <http://www.ftdichip.com/Drivers/VCP.htm>. Once the driver is installed, simply plug your computer into the CP4/5 using a USB cable. The computer will take a moment to make sure it has the proper driver and designate a COM port. When this is done, all that is left is connecting software.

If you need to determine which COM port is being used, open the Windows Device Manager and look for the COM ports. The device manager will display the COM ports by number alongside the device name, "USB Serial Port". The port number shown will be the port number used in the AP V2 Driver, APCC, or any other telescope control software. Note that you may need to restart any external programs (like APCC) that are running for them to find the new COM port.

As with all USB devices, this one works best when common sense is applied.

- Use a high quality USB cable and use the shortest cable that will work for your system. Remember, USB 2.0 is limited to about 15-16 ft. (5 meters). Do not try to use a USB 3.0 cable, because the 3.0 Type B connector is sized to only fit 3.0 Type B ports.
- Connect directly to a primary USB port on your computer if possible (generally these are located on the rear of a desktop computer).
- Avoid using hubs or extenders, if possible. If you must use a hub, use a high-quality hub that is powered. If you must extend your USB range we highly recommend the [Icron Ranger 2304 USB Extender \(USBEXT4P-2304\)](#) which you can purchase from our website. The Icron Ranger 2304 provides four USB ports, one of which can be used for the mount, leaving 3 available USB 2.0 ports. The Icron Ranger 2304 supports isochronous data transfer and will therefore work with most USB 2.0 CCD cameras.

VERY IMPORTANT!! You MUST install the FTDI Driver onto your computer BEFORE you connect the CP4/5's USB port to your computer for the first time! The latest driver can be found at: <http://www.ftdichip.com/Drivers/VCP.htm>. Note also that the FTDI USB-to-serial devices are all uniquely serialized. Each one will be assigned its own COM port that will be remembered through power-cycles.

Operating System	Release Date	x86 (32-bit)	x64 (64-bit)	ARM	ARM64	PowerPC	SPARC	Other	Comments
Windows	2015-04-15	2.10.10	2.10.10	-	-	-	-	-	WHQL Certified. Includes VCP and D2XX. Available as a setup executable. Please read the Release Notes and Installation Guides.
Linux	2008-08-14	1.1.0	1.1.0	-	-	-	-	-	485 FTDI devices were supported in Ubuntu 11.10. Serial 1.0.0-10. Please see the Release Notes and Installation Guides.
Mac OS X 10.5.8 and above	2015-04-15	2.10.10	2.10.10	-	-	-	-	-	485 FTDI devices were supported in Ubuntu 11.10. Serial 1.0.0-10. Please see the Release Notes and Installation Guides.
Mac OS X 10.9 and above	2015-04-15	2.10.10	2.10.10	-	-	-	-	-	485 FTDI devices were supported in Ubuntu 11.10. Serial 1.0.0-10. Please see the Release Notes and Installation Guides.

RS-232 Ports (2)

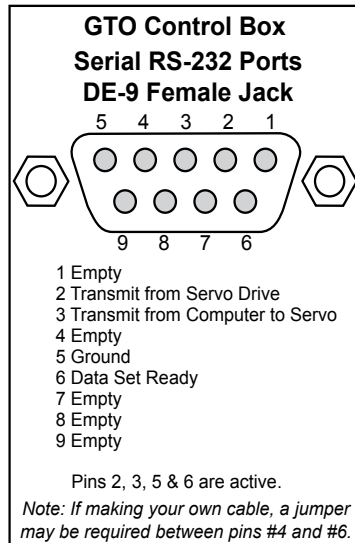
These are the traditional serial ports that have been used to connect our mounts to an external computer for years. Serial ports have many advantages and they are highly recommended for their ruggedness and reliability. The CP4/5 command language is based on the principle of serial communication, a tradition dating back to the earliest mount control systems. One of the huge advantages of serial is that serial cables can be very long; 100 ft. serial cables are generally not a problem. Industrial and commercial equipment control is still totally dominated by serial for its robust dependability and simple operation.

We provide a 15 foot straight-through (non-crossing) cable with a 9-pin (DE-9) male connector to interface with the CP4/5 panel, or you can purchase a longer cable (from 1' to 100' length). Be sure that it is a straight-through type. Our DE-9

receptacles provide locking posts to secure the cable firmly onto the control box. If your serial cable does not have a 9-pin connector, you can use a gender changer or adapter to convert it.

Please note: Make sure your serial cable is wired straight-through! The use of “crossing”, “reversing”, “null”, or “null modem” cables is a frequent source of communications failure and frustration.

FYI – The DE-9 plug and receptacle are often mistakenly referred to as DB-9s. The E or B represents the shell size of the plug or receptacle. The B shell is the larger size used for the 25-pin DB-25 plug and receptacle, but the smaller 9-pin version uses the E size shell and is therefore correctly called a DE-9.



We provide two RS-232 serial-port connections on the CP4/5 to give you additional flexibility. The availability of a second port also facilitates the backup COM port feature in the Astro-Physics Command Center (APCC). If you use APCC, you also gain the benefit of its additional virtual serial ports.

Serial ports, by their nature cannot be Y-connected or split with hubs. Each physical serial connection that you use on the mount must have a corresponding unique COM port available on your computer. If you use a laptop, you will probably need to purchase a USB-to-serial adapter to use one of the serial ports.

In the past, we recommended and sold adapters from Keyspan. These are still fine adapters, but we are now recommending and selling adapters from FTDI. A primary reason for this change is that the CP4/5's on-board USB serial UART is also by FTDI. This way, you need only a single driver to work with all of your USB to serial applications. Another reason for the switch is that the FTDI units have a wider operating temperature range, especially important on cold nights under the stars. Unlike many lower quality devices, both the FTDI and Keyspan adapters also maintain their COM assignments when plugged into different USB receptacles on any given computer.

For desktop computers, we strongly recommend installing a multi-port PCI serial card directly onto your computer's motherboard. This is basically the same as the native serial ports that were standard on all computers back in the "old days."

Ethernet Port



The CP4/5 introduces Ethernet connectivity to the Astro-Physics GTO Servo System. Ethernet is the fastest communication method between the mount and the computer, operating magnitudes faster than serial and USB, and even slightly outpacing the Wi-Fi. It is suitable for long-distance communication out to 100 m (386 feet) and can be easily customized in length with an inexpensive crimping tool. The port allows the plug to lock in place, preventing accidental pullout. The interface is the standard RJ45-8 receptacle for Cat 5e and higher cables, and is equipped with crossover detection so that you do not have to concern yourself with the exact wiring of the cable.

Ethernet connection interfaces are available in software like the Astro-Physics Command Center Standard and Pro versions (APCC-ST and APCC-Pro) and the Astro-Physics V2 ASCOM Driver. These programs allow you to connect other programs through virtual ports.

This discussion includes a number of terms that may not be familiar to you. We have provided a glossary and further explanation in "Technical Information and Terminology Regarding Ethernet" on page 15 for your reference.

Ethernet (LAN) can be point-to-point (*aka* peer-to-peer) with a computer, or networked without user configuration. Devices connected via Ethernet or Wi-Fi are identified by their IP address. The CP4/5's internal default IP address is in the form of 169.254.x.y. The values for X and Y will depend on your CP4/5's serial number. This will be the IP address used for point-to-point connections. Most home networks will assign an IP address of the form 192.168.x.y or 10.0.x.y. There are several methods to determine the IP address, please refer to "Determine Your IP Address" on page 13

In the sections below, we will provide additional information regarding the IP address and how to find it, how to connect to APCC and the ASCOM AP V2 Driver, how to configure your CP4/5 home page on your browser and load new software.

Connect Your GTOCP4 or GTOCP5 via Ethernet

If you are simply connecting point-to-point with your computer, it is not necessary to change any settings since this is the default setting. You are ready to connect to your CP4/5.

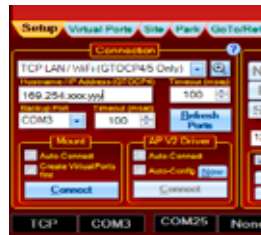
Using software with the Ethernet connection is super easy. Here is the procedure with APCC and the V2 driver. If there

are multiple IP addresses available from which to choose, refer to "Determine Your IP Address" on page 13. Other applications and programs will behave similarly.

APCC-ST and APCC-PRO COM Setting

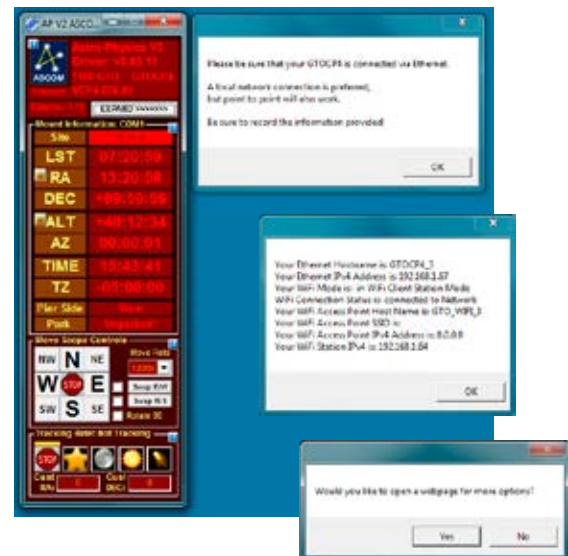
Versions 1.8.2.0 and 1.8.2.1 respectively or later recommended for the GTOCP5; GTOCP4 can be v. 1.8.0.5

- In the Connection group box, select from the top drop down list:
TCP LAN/Wi-Fi (GTOCP4/5 Only) or
UDP LAN/Wi-Fi (GTOCP4/5 Only)
- Click the small button to the right of your selection. This will open a list of available mount connections. Get the IP address from this list. Be sure to select the LAN IP address – not the Wi-Fi IP address - if that is your preference.



ASCOM AP V2 COM Setting

Select "IP Addr" from COM Port Details. The IP address will display. We suggest that you record these numbers for future reference. Refer to Connection Details in the AP V2 Driver manual for more information.



Determine Your IP Address

You will need the IP address in order to access the CP4/5 webpage in your browser. If you have already used APCC or the AP V2 Driver, as described below, you may have recorded those numbers on page 3 of this manual. If not, you can launch them again or use one of the methods described below.

First, power up the CP4/5, and connect the Ethernet (i.e. Cat 5e or later) cable to the CP4/5 on one end, and to your computer, router, or network switch (port) on the other end.

IMPORTANT: Allow at least 30 seconds for the connections to be fully established. Once the connection is made, communications are nearly instantaneous.

We suggest that you read all of the options first to determine which one will be most appropriate for your situation.

Default IP Address Calculator

The easiest way is with the [IP Address Calculator](#) that is on the flash drive that came with your mount or in the [Support](#) section of our website. The Default IP Address is what the CP4/5 was shipped with, but since it can be changed from the default to something else, we offer other options below for recovering the IP address.

ASCOM Ethernet Wi-Fi Poll Utility and FindMounts.jar

A handy ASCOM Ethernet Wi-Fi Poll utility as well as the FindMounts.jar Java applet have also been provided on the flash drive that shipped with your mount and on our Support page. These will assist finding the correct IP address for ASCOM users. They will even open up the CP4/5 web Interface in your system's default browser. **Use your software download user name and password when asked.** These were provided in the welcome letter that you received with your mount. If you can't remember your user name and password, contact Astro-Physics and be sure to jot them down. The Java applet will also work from non-Windows computers. You must have Java installed on your computer to use this applet: <https://java.com/en/download/manual.jsp> ,



Do the Math Yourself

The CP4/5's internal default IP address is in the form of 169.254.X.Y. The values for X and Y will depend on your CP4/5's serial number. Remember, x and Y can be values from 0 to 255. If you prefer to calculate, here is the underlying formula:

- Locate your CP4/5's serial number on the side of the control box. Drop any preceding zeros of your serial number. In our example, 0869 becomes 869.
- Note how many times you can subtract 256 from your serial number. In our example:
 $869 - 256 = 613$ – $256 = 357$ – $256 = 101$
So 256 is subtracted from 869 a total 3 times, with a remainder of 101.
- The X portion of your IP address is the number of times you were able to subtract 256; in this case, 3. If your serial number is 255 or lower, then the number entered is zero.
- The Y portion is the remainder; so in this case, 101. If there is no remainder, then the number entered is zero. You might notice this is long division, keeping the remainder.
- Therefore, your IP address is 169.254.3.101.

$$\begin{array}{r} 3 \\ 256 \overline{)869} \\ \underline{-768} \\ 101 \end{array}$$

Use the Hostname

Windows users can often find the mount in their browser using the Hostname. This can be very useful if your IP address has been changed from the default. For a CP5, the factory default Hostname is GTOCP5_X, where X is the serial number of the GTOCP5 without leading zeros. The hostname is user-configurable.

Use of the hostname as the URL will only work with NetBIOS enabled. By default NetBIOS is enabled on all Windows machines through Windows 10 as of 2020, but is essentially depreciated and is only default for fixed-IP nodes like the CP4/5. To use the hostname as a URL and not perform a browser search, use the form **http://GTOCP5_X** and press enter.

Other operating systems like Mac and Linux will not resolve a NetBIOS hostname without other modifications..



Set Ethernet Parameters Through Your Browser

For point-to-point (peer-to-peer or P2P) direct connection of your CP4/5 to your computer, simply enter the IP address that you determined earlier into the browser URL and gain access to the CP4/5 Web interface. We suggest that you write the IP address into the note section on page 3 for future reference.

Alternatively, if you connect to an existing network, its router should assign an IP address to the CP4/5. A typical IP address on your home network might be 192.168.0.101, but it will NOT be the same as the default IP address of your CP4/5.

The CP4/5 Web interface will provide easy configuration of your Ethernet and Wi-Fi connections. It also provides the only way to upload software updates. A sample Main Page is shown at right. The Load New Software button and a button linking to the Help with New Software Update have been indicated.



The webpage has buttons that will take you to more in-depth Ethernet connection settings. There you can do things like change the DHCP settings, the default IP address, the hostname and hostname resolution settings, and more. Only make changes to these settings if you are confident in your networking abilities, or you are attempting to troubleshoot a connection issue.

Commanding Your Mount from the GTOCP4 or GTOCP5 Home Page

Once you open the CP4/5 home page, you can issue commands to the mount via the terminal command interface, which serves as a terminal emulator. Command language documentation will be released at a later date. See above illustration.

Technical Information and Terminology Regarding Ethernet

It is important to keep in mind that unlike the serial connection, which is used by a program on the computer, Ethernet is between the computer itself and the CP4/5. The computer will send packets to the CP4/5 during the initial DHCP handshake and send packets regularly to make sure the CP4/5 is still there.

All of this is handled by the computer's Ethernet card before you ever run a telescope control program like APCC, the AP V2 Driver, or any of the other myriad programs that can send commands to the CP4/5 on an Ethernet connection. Information is being sent the very moment you plug the Ethernet cable into the CP4/5, and is still being sent until the very moment you unplug the cable or turn the power off.

Compared to the Serial and USB connections, Ethernet and Wi-Fi are ALWAYS in communication. You can unplug a serial cable from the CP4/5 and the computer will never notice; unplugging Ethernet from the computer is instantly noticed.

Ethernet connection will work with any device that supports Ethernet. This means Mac, Linux, Windows, and even another CP4/5 could be connected over Ethernet. As stated earlier, Ethernet connection is between the computer and the CP4/5, NOT between the software and the CP4/5. APCC and the V2 driver can access the Ethernet connection, but they are not the only software that can. The most basic way to connect over Ethernet is to open the CP4/5 home page. In this case, the browser program is interacting with the Ethernet connection, sending data to and from the CP4/5.

Over Ethernet, the CP4/5 can not only communicate using the AP Command Protocol, but it can act as a client and send files to and from the computer. This is how you can connect the CP4/5 to a computer and pull up the CP4/5 home page:

- The computer sends a query for the index file at the IP address typed into the browser.
- The CP4/5 gets the query and sends the HTML file for the home page.
- The browser window displays the HTML file.
- Clicking buttons on the page will send a command in the AP Command Protocol.
- When the CP4/5 gets those commands, it performs the respective routine.

Computers can send large files over Ethernet very quickly, like the CP4/5 firmware updates and license files. Other software like APCC, the AP V2 Driver, and others behave just like the browser; they tell the computer to send a packet, and the computer replies with what comes back.

With this all in mind, here are some important terms you need to know to make the most out of your CP4/5 Ethernet connection.

Term	Definition
Client	A client is a computer connected to a network that requests information from other systems. Clients initiate connections to servers and await requests. Most computers behave as a client, and will try to request information from the CP4/5.
DHCP	DHCP (Dynamic Host Configuration Protocol) is the protocol used when the CP4/5 is connected to a live Ethernet cable. It establishes who talks first, and settles what IP address clients and servers will use while connected to the network. Before any further communication can occur, these important topics need to be settled.
Hostname	A label or name that is assigned to a device connected to a computer network and that is used to identify the device.
IP Address	This is the address by which your computer and CP4/5 talk to each other. Both the CP4/5 and computer will have an IP (internet Protocol) address, and any packets sent by one will be sent to the IP Address of the other. It is important to note that devices connected with multiple Ethernet and Wi-Fi will have an equal number of IP addresses to differentiate the different communication ports.
LAN	LAN (Local Area Network) is the name given to a network not connected to the internet, or a network connected to but behaving independently from the internet.
NetBIOS	A protocol passed down from old Windows point-to-point connections. This protocol wraps a hostname around each TCP packet, so that computers can refer to each other by a human readable name (hostname), among other reasons. Other operating systems will require modification to read the NetBIOS protocol. NetBIOS is not routable, so if your CP4/5 is connected to a router the hostname will no longer show up on your computer.
Network	A network is a connected set of clients, sometimes with routers and servers. A network can be anything from a computer wired directly to a CP4/5, to a CP4/5 connected to a router that can access other routers and computers, and possibly the entirety of the internet.

Term	Definition
Network Switch	A device that can connect multiple nodes on a network. You may use a network switch so that a computer with one Ethernet port can connect to both a router and a CP4/5 at the same time. The network switch will only send information to an address if it pertains to that address. This is NOT the same as an Ethernet splitter. An Ethernet splitter should never be used.
Node	A network node is any connection between cables. Nodes process information, deciding what to forward, reject, or send back. Clients, servers, routers and switches are all types of nodes. Note: with Ethernet, the term switch is used for a node that acts as a hub. A router is also normally a switch, but a switch isn't necessarily a router.
Packet	This is the data packet sent over an Ethernet connection. While communication protocol like serial will send encoded bytes one at a time, a packet contains an entire message and will be sent all at the same time.
Peer-to-Peer Point-to-Point	This is a connection comprised of two nodes. An example would be a CP4/5 with an Ethernet cable running straight to a computer. It is the simplest network possible.
Router	A router will pass on packets to the requested destination, preventing congestion in large networks. Routers can also allow communication with a Local Area Network (LAN). When connected to a router, the CP4/5 needs to be in Client mode so it can initiate conversation with the router. Computers can use a router to access the internet and CP4/5 at the same time, making it an ideal method for connection. A typical residential router generally also contains a switch, a DHCP server, a Gateway (to internet), and even a host of its own (used for configuration and network management).
Server	A server hosts clients by sending them the information they request. For example, when you connect a client computer directly to a CP4/5, the CP4/5 needs to be set to Server mode in order to communicate properly. Two clients and two servers will simply ignore one another, like hosts and customers at an uptown restaurant.
TCP	TCP (Transmission Control Protocol) is a layer around a packet, telling the recipient what order the packets go in. Then, the recipient sends an acknowledgement that the packet has been received. It serves as a layer of security when packets are routed through large networks, and over the internet. If a packet is lost in transit or fails to maintain integrity, the packet will be resent.
UDP	UDP (User Datagram Protocol) is a simpler form of TCP, where there is no confirmation that a packet has been received, and dropped packets are not resent. This is a much faster connection protocol with its own advantages from TCP. For a CP4/5 that is connected directly to a computer, there is no real advantage between TCP and UDP.

Wi-Fi Connection



Wi-Fi is essentially a protocol for using radio waves instead of physical cables to communicate. The CP4/5 is equipped with a powerful built in Wi-Fi antenna, as well as a secondary adjustable antenna that protrudes from the aluminum housing to boost signal even further. This makes the CP4/5 Wi-Fi signal not only strong enough to communicate flawlessly with the control room, but even communicate with devices well outside your observatory. The antenna can be adjusted, if needed, to provide even more signal.

While the speed is on par with Ethernet, Wi-Fi dominates in its ability to be mobile. With Ethernet, cables have to be run from port to port, creating tripping hazards and they can be accidentally pulled and cut. A wireless device can be moved all around without fear, and requires no physical interaction to set up. Wi-Fi can be used to connect mobile devices to the CP4/5, so you can control the mount with just a smartphone. Each method of connecting has its advantages, and Wi-Fi has plenty to offer.

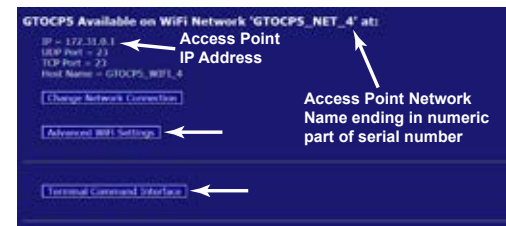
Since Wi-Fi communicates on the same protocols as Ethernet, a lot of what is covered in the Ethernet section applies here as well. If you are not very familiar with networking and the associated terminology, we suggest you read through "Technical Information and Terminology Regarding Ethernet" on page 15 as a primer for this one. Here are some additional terms that will be used in this discussion.

Term	Definition
Access Point	Access Point - Access Point is exactly what it sounds like: a point of access to a device. Devices behaving as an Access Point will broadcast their Access Point name and Wi-Fi IP address. Other Wi-Fi devices can pick up this signal and establish a connection. When a point-to-point server device is connected over wireless, it is called an Access Point.
Station Mode	Station Mode - When a network client is connected on wireless, it is called a Station. As opposed to an Access Point, a Station must be connected to a router. This could also be referred to as a 'client mode' for wireless.

Term	Definition
Wi-Fi	Wi-Fi - A family of wireless communication protocols, typically used for short range connection between devices, designed as a sibling to Ethernet.

The CP4/5 can be connected to your computer using Wi-Fi in two ways; either having the computer connect to the Wi-Fi Access Point of the CP4/5, or by having the CP4/5 connect to the network of a Wi-Fi router in Station Mode.

- Access Point: By having the CP4/5 acting as an Access Point, there is no need for other equipment, like a router. This is optimal for connecting to the mount in the field with your smart-device or laptop, and in some cases can be used in troubleshooting a CP4/5.
- Station Mode: Routing the CP4/5 to a network with Station Mode is optimal for observatories with lots of mounts using the Wi-Fi, so you can connect your computer to the network and have all of the mounts available. Further, having the CP4/5 connected to a network allows you to protect the CP4/5 with your network security; in this way it is harder for others to potentially access the CP4/5.



Access Point Configuration

Your CP4/5 has the capability of acting as a Wi-Fi access point. This is the default Wi-Fi setting when a new control box is programmed at Astro-Physics. The access point setting will allow you to connect another wireless device to your CP4/5 even without the presence of a wireless router and established wireless network. As an access point, the CP4/5 must then take on some of the responsibilities normally carried by the wireless router. This is why the access point mode is less efficient than station mode. However, since a Wi-Fi router may not be available at a star party or at some locations, the access point capability is quite a valuable asset.

We have already assigned an IP address for Access Point mode. That address is: 172.31.0.1 We suggest that you not change this IP address unless you have a compelling reason to do so. Multiple CP4/5s in the same location will not conflict with each other even though they share the same IP address. Remember that it is the network itself that is unique. Because each network name will include the serial number, each CP4/5 creates a unique access point network, thus won't conflict.

If you configure your Wi-Fi connection from a wireless device, start by joining the CP4/5's wireless Access Point network.

1. To connect to the CP4/5 through its Access Point, simply turn on the CP4/5 and wait about 30 seconds.
2. In your wireless device (laptop, smartphone, tablet, etc.), open the device's wireless settings page.
3. Find the network for the CP4/5 in your device's list. For a CP5, it will be named: GTOCP5_Net_X where the X at the end represents the numeric portion of the GTOCP5's serial number without leading zeros.
4. Connect your device to the network. You will be prompted for a password. The default password that we have provided during our initial programming will be: Xadmin12345 where again, the X represents the numeric portion of the serial number without leading zeros. For the GTOCP5 with the serial number CP5-0004, the password would be: 4admin12345
5. When the Wi-Fi connection is established, you can do one of the following:
 - a) Control the CP4/5 using telescope control apps. For apps that use a port number, like Sky Safari, use port number 23.
 - b) Open the CP4/5 home page in the device's browser.
 - i) In the browser's URL address bar, enter the following IP address: 172.31.0.1 and then the equivalent of "Enter".
 - ii) This will bring up the CP4/5 Main webpage just like the Ethernet version. From this page, you can move on to the Change Network Connection or Advanced Wi-Fi pages. On these pages, you can choose the default Wi-Fi connection, and you can change the Access Point Network Name if you wish.

It is important that you consider security when using your CP4/5 as an access point. We have provided a default password that is reasonable for getting started. However, you may want to change it to something more secure **since anyone with access to this manual and knowledge of your serial number can determine the factory default password.** The new

password will NOT take effect until the CP4/5 is power-cycled.

Passwords - Important Note: Most devices will ask you for the new password when you try to connect after you have made a password change. This is unfortunately not the case with Windows 7 and some later versions as well. Once a Windows computer has made a connection with your original password, it may simply fail to connect instead of asking you for the new password.

To remedy this in Win 7, click on the little Wi-Fi symbol at the far right of the task bar. This will open a small box with the listing of all the currently available Wi-Fi Networks. Find the CP4/5's Wi-Fi name and right-click on it. Select Properties. In the next window that opens, go to the Security Tab. Here, you can enter your new password where it says Network Security Key. To make it easier, check the box to show the characters - just remember to un-check it when you are finished. Once the password is entered, click OK. Now you should be able to connect using Windows.

In Win 10, you will access the Network & Internet section of the new Settings App. This can be done by either opening the app or by clicking the same Wi-Fi icon mentioned above for Win 7, and then clicking the settings link at the bottom of the list. First, try connecting to the CP4/5 from the settings page. It will hopefully present you with a request for additional information (this means the password). If it does not, then click Manage Wi-Fi Settings at the bottom, select the CP4/5 from the list and tell Windows to forget it. Now power-cycle the CP4/5, allowing at least a minute or so between power-off and power-on. (Windows needs to lose, and then re-find the new network.) Go back to the main Wi-Fi page and you should see the CP4/5 again. Now this time, it should allow you to enter your password and connect.

Keep in mind that the Wi-Fi module in the CP4/5 is NOT a router-class wireless device. Although it can take on some of a router's duties in Access Point mode, it cannot be expected to substitute for a wireless router in supplying internet and network connectivity to a number of devices.

Station Configuration



When configured as a station, the CP4/5 joins an existing wireless network like the wireless home networks many of us have. The existing wireless network has a wireless router that supervises the flow of data within the wireless network. From the CP4/5's point of view, this is by far the most efficient and desirable wireless mode. It is what would be typical for most people who have wireless networks for their various devices like computers, smart phones and tablets. The CP4/5 would then simply "join the network" in the same manner as your smart phone does.

Like your other smart devices, once you have configured your CP4/5 for your home network, it will remember the network and the password and will connect automatically every time it is powered up, as long as the network is available. The CP4/5, however, will not remember multiple networks. If you take your system to another location with a different network, it will need to be re-configured to join that network.

It is assumed that you have a secure home network that you will be joining. Bear in mind that anyone with access to the same network also will have access to your CP4/5.

Change Your Wi-Fi Settings

As mentioned earlier, your CP4/5 default Wi-Fi setting was programed at Astro-Physics to be the Access Point setting. In order to configure your Wi-Fi connection to Station Mode via a wireless device, follow the procedure below. You may also make these changes from an Ethernet connection as described in section "Set Ethernet Parameters Through Your Browser" on page 14.

1. Follow the procedure outlined in the "Access Point Configuration" section to open the CP4/5's home page.
2. Find the Wi-Fi section and change the setting to use the CP4/5 in Station Mode. Select a network and enter the network password. It will immediately find your Wi-Fi network and connect. The home page will display the network connection, as well as the IP address and port number for the network connection. Typing the CP4/5 network IP address into a browser window will also open up the home page to verify the connection. Use the displayed IP address and port number for connecting to software that requires it.
3. Finally, you can also choose between "Create Access Point", "Remain Idle", and "Retry Network Connection Periodically". Only change this if you are certain how you will connect to the CP4/5 for some time going forward. The CP4/5 is not capable of router functionality on its own. While it can function as a single Access Point, it is not for use in directing traffic from multiple clients; let alone internet traffic.

Ethernet and Wi-Fi Best Practice Recommendations

- If you do not plan to use Wi-Fi, turn Wi-Fi OFF from the Change Network Connection page of the CP4/5 internal webpage set. There is no way to break into a wireless connection that is turned off, making this more secure.
- If you will not be regularly using Ethernet, leave the DHCP mode on BOTH in the Advanced Ethernet Settings page of the CP4/5 internal webpages. This will allow you to connect a cable either directly or through a network for uploading new CP4/5 software.
- If you plan to use Ethernet permanently, set the DHCP mode to CLIENT to connect the CP4/5 to a Local Area Network (LAN). Set the DHCP mode to SERVER ONLY if you will be connecting directly, peer-to-peer with a computer. Change these on the Advanced Ethernet Settings page of the CP4/5 internal webpage set. By selecting your specific application, the 30 second wait time during connection will be eliminated, saving time.

Upgrading to New Software

The CP4/5 will require software updates as time goes by. It is important to keep the CP4/5 up to date, because software updates usually contain bug fixes and new features that you don't want to miss. Be aware that software updates require the CP4/5 be connected directly to a computer via Ethernet.

New software releases will be available from the [Software Updates](#) section of our website and major releases will be announced on our forum at this link: <https://ap-gto.groups.io/g/main> . We encourage you to become a member of our forum in order to keep up to date as well as to share your experiences and ask questions. Note that there are two Astro-Physics forums. PLEASE use the ap-gto forum for all things mount related.

Instructions for upgrading to the latest software version are in "Appendix A: GTOCP5 Software Update" on page 48. and are also available when you download the new version.

CONTROLLING YOUR GTOCP5 MOUNT

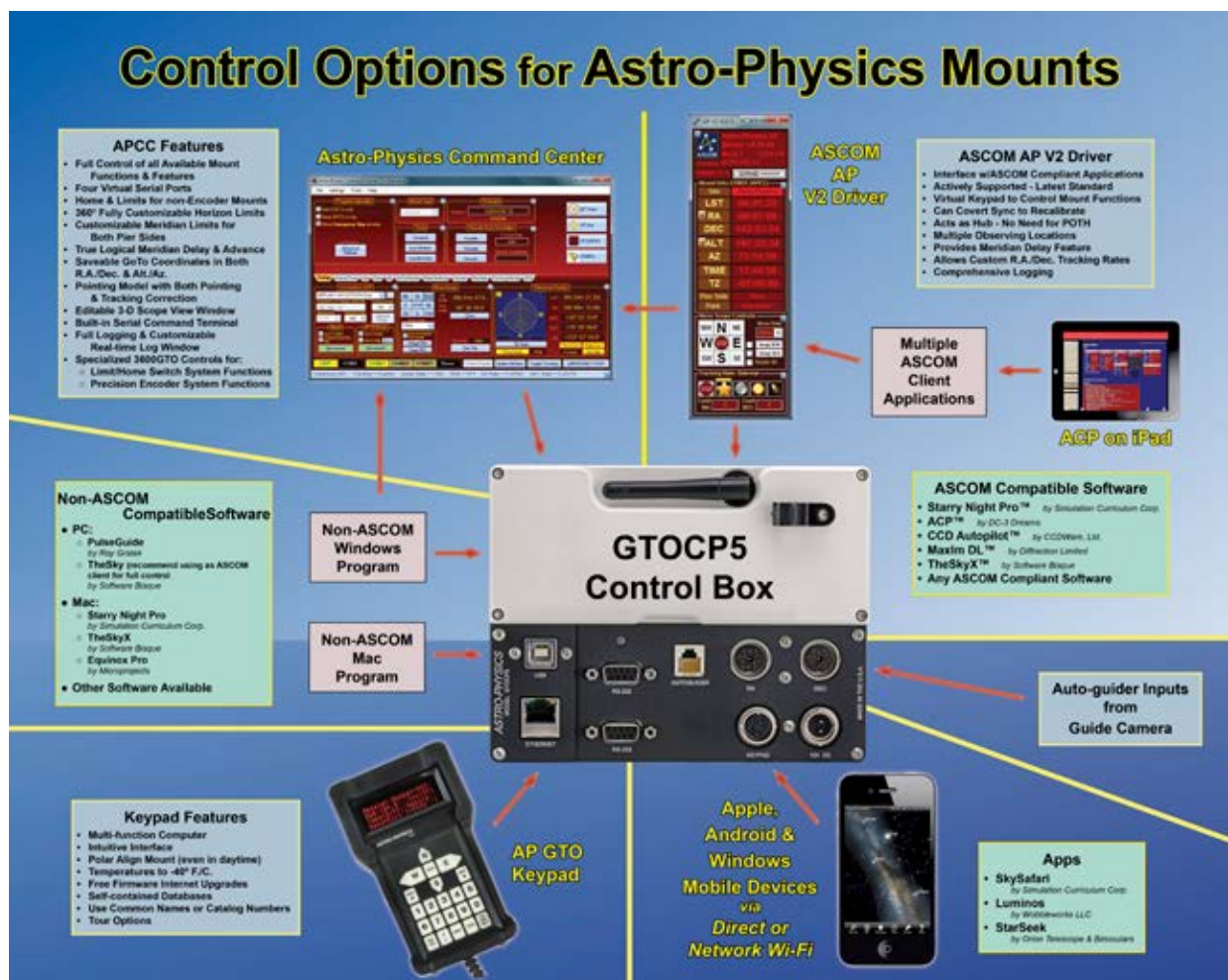
Your Astro-Physics GTO mount has a remarkable servo control system that combines with the precise mechanics of the physical components to give the mount its superb performance. Contrary to popular assumption, the brains of the mount are not found in the keypad, nor are they in an external computer that is used to send the mount pointing here or there. The real brains of the Astro-Physics GTO Micro-step Servo System are in the CP5 control box. Simply think of your Keypad or computer as being an input device for the CP5. If you understand this from the start, you will always have a better concept of how things work, and you will be less likely to make operator errors.

We divide the types of control functions that the CP5 control box performs into three principal categories. The parameters and values for these control functions along with the commands to execute certain functions are given to the CP5 control box by the input device(s) that are in use.

1. **Primary Control Functions.** Primary control functions include all the functions that define HOW the servo will make decisions. In particular, these are the initialization functions – time, date and location – along with Park, Meridian Delay, ReCal and Sync. These are the most important functions to get right. Primary control functions allow the servo to know where the meridian is and to determine whether a slew requires a meridian flip.

It is of vital importance that your input device handles primary control functions correctly, and that input for primary control is limited to just one device. The concept of initialization is introduced on page 21 and discussed more fully in "Initialization and Shut-down" on page 36.

2. **GoTo / Move Functions.** GoTo / Move functions include coordinates, move commands, and rate commands. All of the listed input devices provide some way to command the CP5 to move the mount. Most provide pretty complete movement inputs. The exception is the guider signals from a guide camera, which, of course, cannot command a GoTo slew. Most of what you do during a typical night under the stars uses the GoTo / Move functions.
3. **Absolute Encoder Functions.** PEC curves are no longer needed. One of the most advanced features of the Mach-2GTO mount is the integration of the absolute encoders with the micro-step motor servo system. The CP5, via the absolute encoders, constantly monitors the servo positioning and provides near-instantaneous feedback correction with



sub-arc second precision. PEC cannot provide the accuracy provided by absolute encoders. Additionally, Dec backlash is eliminated in the Mach2GTO.

The graphic on the previous page provides a summary of the many different approaches to providing input to the CP5. Some of these, like the Astro-Physics Command Center (APCC), the Astro-Physics V2 ASCOM Driver, and the Keypad will provide ALL of the Primary Mount Control Functions, the GoTo and Move Functions, and the Absolute Encoder Functions to fully control the mount. Other control items in the chart may not fully support all of the CP5's more important functions and capabilities.

What is Meant by "Initialization"?

In simplest terms, Initialization is the process of giving the mount's servo controller the information that it needs to know: Where is it? What is the time? How is it supposed to operate? In the process, it also un parks the mount and calculates the current pointing position. This is the information you entered into your software when you first installed and set it up. For Keypad users, it is the information you entered when you followed the instructions for your first session in the Keypad manual. These four points are outlined below.

1. Latitude and longitude coordinates tell the mount where it is located on Earth. The GTOCP5 will remember your location when last powered down, but can't know if you have moved to a new location unless it is told.
2. Time, date and time zone give the mount the necessary time information. Time information is required to calculate the mount's current pointing position if it hasn't been moved, and it is needed to calculate the meridian and the horizons. The mount's servo does not have an internal battery to maintain time between power-ups, so time is an essential part of every initialization.
3. Commands to establish the tracking, guiding, centering, and slew rates tell the mount how it should operate.
4. The command to unpark the mount is sent. This command both ends the parked state and it also calculates the mount's current pointing position. The unpark command will have resulted in extremely accurate calculation of the current pointing position without further calibration being necessary.

For additional detail, refer to "Initialization and Shut-down" on page 36.

Keypad Operation

The Keypad is all that you need to operate your mount. Even advanced imagers can perform all of the necessary mount control and GoTo functions with the Keypad alone. With the Keypad, a DSLR and a stand-alone guider (such as the SBIG SG-4), you can enjoy a full night of productive, guided imaging without the need for a computer! With our new v5.xx firmware's high-tech modeling routines, unguided imaging is also possible. Please refer to the separate manual for the Keypad for complete instructions on Keypad operation.

The Keypad can perform all three types of control functions including initialization and shut-down. See page 36 for more details.

- The Keypad can be set to automatically initialize the mount upon power-up by selecting Auto-Connect: YES. This is a very handy method, and is preferred for any permanent setup where another device is NOT also being used to control the mount.
- It can be set to allow manual selection of initialization parameters by selecting Auto-Connect: NO. This is the method for portable setups that will be primarily controlled with the keypad.
- It can be set to allow a different device like a computer to perform the initialization functions by selecting Auto-Connect: EXT. This method is recommended for users who will be using their computer or other devices for primary control of the mount.

The Keypad's extensive databases and intuitive structure make it a joy to use. When people become familiar with the keypad and its simple operation, they wonder why they ever needed to drag a computer into the field!



Using Your Keypad and PC in Harmony

Keypads Using v5.xx firmware

When using the Keypad with version 5.xx software, your PC and Keypad will talk and share information. Previous versions of the software utilized a one-way channel of communication which occasionally created issues that in the past would cause the mount to be lost. With v5.xx, the Keypad will poll the mount (i.e., CP5 control box) for information so that any updates that were made via the PC will be known to the Keypad. Refer to the Keypad manual for additional information.

Keypads with the v5.xx firmware require the GTOCP5 (or GTOCP4 as used with our other mounts) control boxes.

The above advances in Keypad / computer communication are the reason for our **STRONG** recommendation to update your Keypad to the version 5.xx firmware. However, if you have additional mounts that have GTOCP3 or earlier control boxes, then it will not be possible to share the v5.xx Keypad with them. Those earlier control boxes do not have the more advanced functionality of the CP4 and CP5 that is required.

The Astro-Physics V2 ASCOM Driver

Astro-Physics began the development of a company-supported V2 ASCOM Driver in 2009. Please see the Astro-Physics website for the most current version: <https://www.gralak.com/apDriver/>

This driver provides full mount control for all of the Astro-Physics GTO mounts when used in conjunction with any PC-based planetarium or other client software. It is a driver, and per ASCOM rules, it is NOT a stand-alone program that can be used by itself. It does, however, include several convenient utilities which make it usable without other expensive software.

The AP V2 Driver has been developed with remote operation in mind, and its functions were designed to be highly robust. It features a very user-friendly graphical user interface (GUI) and also provides fully automated initialization and shut-down functions.

The AP V2 Driver is a hub. Almost all Windows-based astronomy software that includes mount control are ASCOM compliant and can therefore use the AP V2 Driver. The popularity and versatility of the ASCOM Platform has had a large role in making Windows the dominant OS for astronomy. This driver is, by far, the preferred method for controlling a mount with any PC-based planetarium or other client software. See a partial list of compatible software on "Workflow When Using TheSkyX™ with the AP V2 Driver" on page 33

At publication time for this manual, The Astro-Physics V2 driver is version 5.30.10. This AP V2 Driver requires version 6.4SP1 or higher of the ASCOM platform:

<http://ascom-standards.org/index.htm>

Use the ASCOM V2 Driver Rather than Other Native Drivers

The question often arises: If I have a choice between using an external program's native driver (as in *TheSkyX™*), or connecting the software through the AP V2 ASCOM Driver, which should I choose? We strongly advise using the AP V2 ASCOM Driver. *Many third-party software programs do not have the command language to support their use with a GTOCP5 control box.*

Here are some reasons:

- The AP V2 ASCOM Driver is a full-fledged hub. It will accommodate a very large number of programs all connected at the same time, and will do so without any problems. As a single hub, the driver will minimize the serial traffic between the software and the mount by eliminating redundancy.
- The AP V2 ASCOM Driver takes advantage of the current set of Astro-Physics servo commands, many of which were developed specifically for either the driver or for APCC. Since these new commands are not being published, the native drivers found in other software will be limited to the older set of published commands.
- The AP V2 ASCOM Driver can create log files for troubleshooting any issues that you may have.
- We can provide a certain amount of support if you encounter issues with a program that uses the AP V2 ASCOM Driver. We, of course, cannot fix a problem that is in someone else's software, but we may be able to figure out what is happening to cause the problem. If you use a native driver, you will be limited to the support that the software provider can give you. We can't support someone else's driver.



Setting Up the Astro-Physics V2 ASCOM Driver

One of the first things that must be done is to set up the Astro-Physics V2 ASCOM Driver. This is extremely important, as the settings that you enter will be used to initialize the mount once you power up and connect to the mount with your third-party software.

Please note that the ASCOM Platform rules require that the AP V2 Driver only becomes active when a third-party ASCOM compliant software connects to it. When disconnected, the AP V2 Driver will automatically close.

The image at the right shows the Setup Telescope for the AP V2 Driver. It is here that you enter your settings.



Entering basic settings to get started

1. Mount Configuration *Image immediate right.*

- Select Mount type.
- Select GTOCP5 control box model.

2. COM Port Details *Image far right.*

- Check box only if APCC is being used.
- Select Port.
 - If APCC is not being used, then use the real COM port in the computer's Device Manager and enter it here or check the IP Address box and enter the address of your control box. Do Not check APCC Virtual Port box.
 - If APCC is being used and you have checked the box above, then choose a random port number that is high enough not to have a chance conflict with an existing port. This chosen port will be a virtual port in APCC in the Virtual Ports tab. Using COM15 or COM21 is usually a safe way to go.
- Leave the other settings in this window at default settings and check the ASCOM Serial Object box.



3. Default Park / Unpark Positions

- Unpark From - The Mach2GTO always knows where it is pointing. Your choice will be to unpark from Last Position or not to unpark.
- Park To - Will be chosen based upon convenience and personal preference. For example, covering your scope at a star party is usually best done at Park 3; however, mounting and removing your scope is easier from a Park 2 position. Park 5 will provide the most clearance for a roll-off roof observatory.

Reference the Park positions in "Appendix B" on page 51.

4. Site Setup

- Click the New button and enter a site name.
- Enter the Latitude and Longitude in degrees, minutes and seconds by clicking in the appropriate box each time (don't forget the N/S and E/W boxes). Then enter the Elevation, if known (optional).
- Click the Save button to retain the site. You can enter multiple locations for future use.

Click the Advanced Button in the lower right corner of the AP V2 Driver's Setup Telescope.

5. Initialization Setup - Check all the boxes in the top right window.

- Sync Mount to PC Time - recommended to be checked.





- b) Set Latitude / Longitude - default is to leave it Checked.
 - c) Enable Mount Tracking on Unpark - under normal circumstances this is usually Checked.
 - d) Set Slew Rate - this may be set as you like. In colder weather it is generally set to a slower speed. Also, remember that you will need to use 24 volts to achieve the fastest speed.
 - e) Set PulseGuide / Guide Rate - **This should always be set at 1.00x.**
 - f) Connect Time Out and Window Priority - use default settings.
6. Other Options - recommended settings
- a) Enable Debug Logs - Checked.
 - b) Keep Mount Time Synced to PC Time - Checked.
 - c) Convert Syncs to ReCals - Checked.
 - d) Minimize Control Window on Connect - Unchecked.
 - e) Show in Task bar when Minimized - Checked.
 - f) Check for New Version when Starting - Checked.
 - g) Auto-enable Tracking when ASCOM Clients Send Certain Commands - Checked.
 - h) Calibrate Move Directions on First Slew - Checked if NOT using APCC.
 - i) ASCOM RA MoveAxis = 0 Stops Tracking - Unchecked.
 - j) Set Driver Window on Top - Unchecked.
 - k) Async Park - Unchecked. (Check if using with control programs, such as ACP™)
 - l) Remember Last Window Position - Checked.

Workflow When Using the AP V2 Driver with Third-party Software (examples: **Starry Night™**, **MaxIm DL™**, **Sequence Generator Pro™**, etc.) (*TheSkyX™* is discussed on page 33)

1. Be sure that you first install the current ASCOM Platform and AP V2 ASCOM Driver. Having all software and drivers current is important in order to avoid connectivity issues.

- a) ASCOM Platform 6.4SP1 or newer - install first
<http://ascom-standards.org/index.htm>

Click on the download button and install the full download. Once the download is complete, you are done; there are no settings to make.

- b) Astro-Physics V2 ASCOM Driver - install second
<http://www.gralak.com/apdriver>



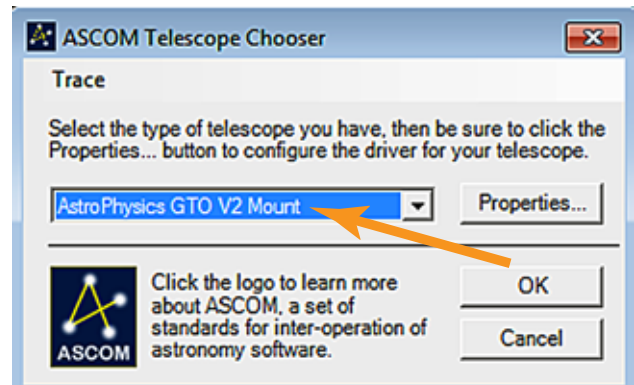
Please check frequently to ensure that you are using the current version of this driver. Important updates and bug-fixes are made periodically to ensure that your mount functions safely.

Pro Tip: Clicking on the “?” in the upper right corner of each window in all the screens found in both the AP V2 Driver and APCC will immediately jump you to that specific section of the Help Menu!

2. Open the Setup Telescope in the AP V2 Driver folder and enter the required settings. Reference the previous section entitled "Setting Up the Astro-Physics V2 ASCOM Driver".
3. Install your third-party software.
4. Locate the Telescope Chooser or Settings in the third-party control software - all ASCOM compliant software will have a chooser or settings drop-down menu.
5. Select the AP V2 Driver. The driver will be called Astro-Physics GTO V2 Mount. *See image at right.*

Once you select it, you may be asked to click Properties... If you click Properties..., you will be shown the AP V2 Driver's Setup Telescope window that you filled out earlier. You can review it if you wish. Then click OK once or twice and you are done.

The Astro-Physics V2 ASCOM Driver is a hub through which all third-party ASCOM compliant software can be connected. Planetarium, camera control, and focusing software, etc. can be connected to it and operated simultaneously.



6. Polar align and power up the mount.
7. Start your control software and have it connect to the mount. It will start the AP V2 Driver which will initialize the mount. You are now ready to go to your first object.
8. After finishing your night's observing (or day's solar observing) park the mount to your chosen Park position.
9. Disconnect and close the active software programs (the AP V2 Driver will close automatically).
10. Power down the mount.

The Astro-Physics Command Center - Standard & Pro Versions

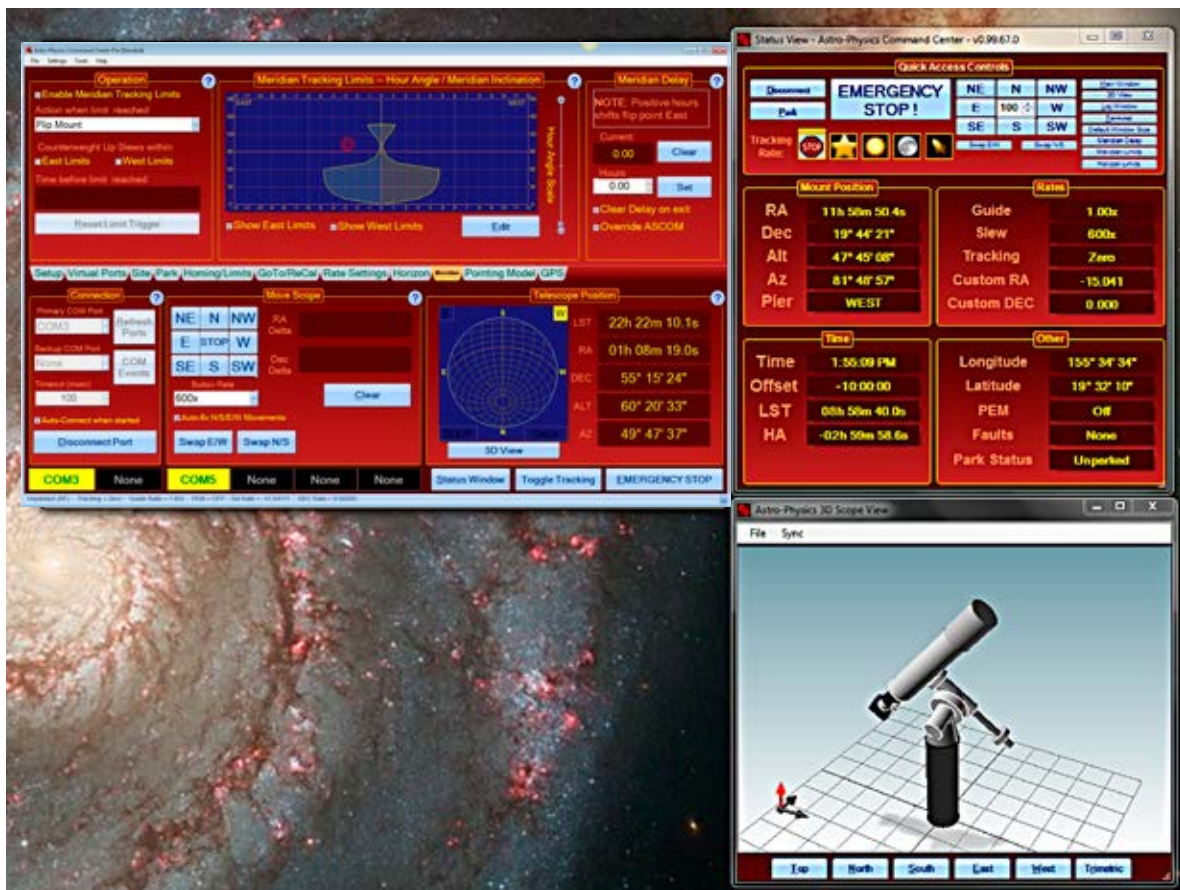
The Astro-Physics Command Center (APCC) adds many features and extended functionality to the control system of the mount and it will act as a serial hub for the use of additional applications. It takes remote operation to the next level with safety and convenience that you won't want to be without. There are two versions: APCC Standard and APCC Pro.

APCC takes its place as the final arbiter between all of your software and the mount. It is the program to which the mount directly connects, and everything else connects through APCC. It was designed from the beginning to integrate perfectly with the AP V2 ASCOM Driver. APCC connects directly via Ethernet or Wi-Fi.

APCC is the master when it comes to mount initialization and shut-down controls. See "Initialization and Shut-down" on page 36. It should be the first piece of mount-related software that is opened, and the last one that is shut down.

Features of APCC Standard are too many to list, but include the following:

- Direct Ethernet and / or Wi-Fi connection to the mount from your PC. No Ethernet to serial emulators required!
- Virtual Serial Ports to connect multiple applications. The first port is optimized for the AP V2 ASCOM Driver.
- Customizable Meridian Limits that work in conjunction with an improved meridian delay feature.
- Customizable Horizon Tracking Limits stop tracking or park the mount when horizon is reached.
- Full support for the Mach2GTO and GTOCP5.
- Errant Sync / ReCal prevention.
- Editable and customizable 3-D viewer showing the orientation of the scope and mount for remote users – includes warning for deviations over 5 degrees between mechanical and celestial coordinates.
- GoTo – ReCal tab for custom RA/Dec, HA/Dec, and Alt/Az target coordinates with saveable targets for precise return to that perfectly framed object.
- Horizons Program for tracking comets, asteroids and satellites.
- Complete mount control including terminal interface.

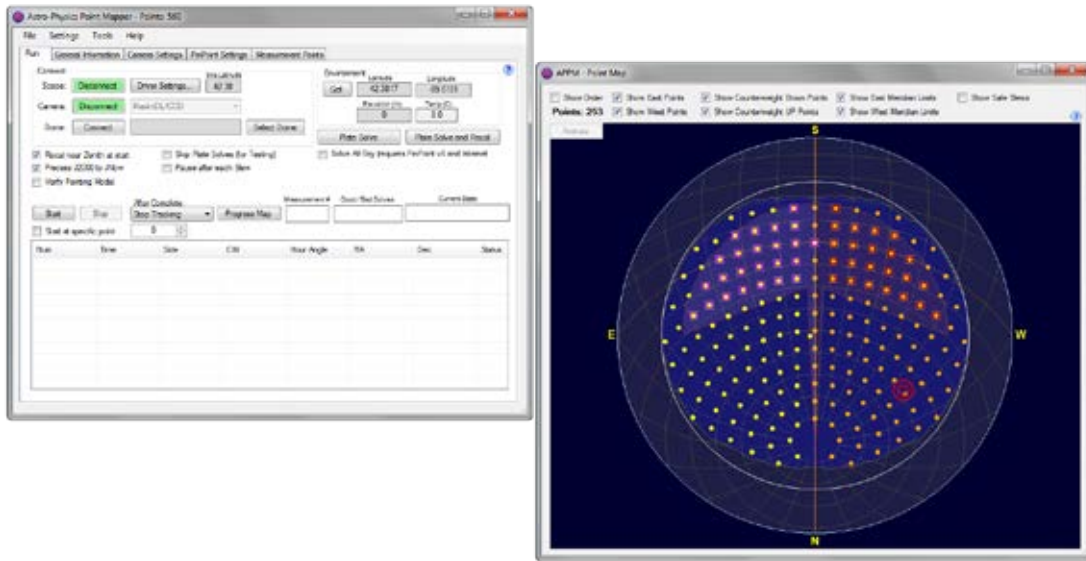


- Advanced logging features for troubleshooting.
- Much more !!!

The APCC Pro version includes the following additional features:

- Highly-sophisticated pointing model and variable tracking for both axes; includes the Astro-Physics Point Mapper (APPM) for automated collection of pointing data.
- Camera options: Maxim, Sequence Generator Pro, ASCOM camera and SkyX Image Linking camera Add-on (part of APPM).
- Plate solving choices: PinPoint, Sequence Generator Pro (tested with PlateSolveX), SkyX Plate Solving. Note: these programs must be purchased separately.(part of APPM).
- Supports THUM temperature reading sensors.

We suggest that you keep an eye on the [APCC page](#) of the website and the [ap-gto users group](#) for updates and details.



Some APCC Thoughts

- Launch APCC first. APCC should always be the first software started and the last to be closed at the end of the evening. Starting it first will ensure that the mount is properly initialized.
- It connects directly to the mount on its physical interface: RS-232, USB, Ethernet or Wi-Fi.
- It then creates virtual COM ports for the AP V2 ASCOM Driver. Two high number COM ports are recommended, such as COM21 and COM22 (two ports in case an administrative version is accidentally created).
Note: Other program connections, such as *Starry Night*™, *TheSkyX*™, *MaxImDL*™, etc. should connect to the AP V2 Driver.
- Since it can create multiple virtual COM ports, multiple programs can connect to the mount at the same time, even programs that don't normally want to share a connection to the same mount with other programs. (Note that the AP V2 ASCOM Driver is a hub and normally only needs its virtual ports even with several client programs running.)

Setting Up the Astro-Physics Command Center

APCC can be as simple or as complex as you wish to make it. This Quick Start guide will only touch upon the Setup of this software. The Help menu will provide more detailed information. Don't forget to click of the "?" in the corners for specific information in that window!

Entering Basic Settings

1. Program Operation window

- a) Ask if OK to Exit - Checked (uncheck for remote).
- b) This Form is Always on Top - Unchecked.
- c) Show Emergency Stop Window - Checked.

2. Advanced Settings (click Advanced Settings button).

- a) Auto Initialize (secs) - Check & set to "0".
- b) Auto Shutdown (secs) - Unchecked.
- c) Enable Logging (to disk) - Checked.
- d) Show Status Window when Starting - Unchecked.
- e) Prevent Errant RECALS - Checked.
- f) Exhaustive COM Port Search - Checked (Uncheck only if start up is slow)
- g) Keep Mount Time Synced to PC Time (enabling will override driver's setting) - Checked.
- h) Enable Tracking Rate Tweak Window - Unchecked.

3. Virtual Ports Tab

- a) Virtual Ports - randomly choose high COM numbers for the first two Virtual Ports (COM 21 and COM 22) so that they do not conflict with real COM ports. Once you have chosen them, click the Create button to the left of each.

- b) Once you have selected these Virtual COM ports, you will need to go to the AP V2 ASCOM Driver and check the box APCC Virtual Port and change the selected Port to agree with your top Virtual port in APCC (we chose COM21 in the example).

Remember: APCC will connect to the mount with the real port and the AP V2 Driver will connect to the virtual port. Third-party software will connect to the AP V2 Driver, which is a hub. In third-party software the AP V2 Driver is called AstroPhysics GTO V2 Mount.

4. Edit Initialize Mount Settings window (choose from Setting in the Menu Bar)

- a) Initialization Site and Unpark will fill in automatically from the other tabs.
- b) Optional Initialization
 - i) Set Tracking Rate - Sidereal.
 - ii) Set Guide Rate - 1.00x (always).
 - iii) Set Slew Rate - your favorite speed. It is recommended to use slower speeds in cold weather.

5. Site Tab - Site Information

Be sure that it agrees with AP V2 Driver. Updating one does not update the other.

- Click Manage Sites button.
- Create a Named Site.
- Enter Latitude and Longitude.
- Click Time Offset button (at right).
- Enter Elevation, Temp (approximate) and default Pressure.



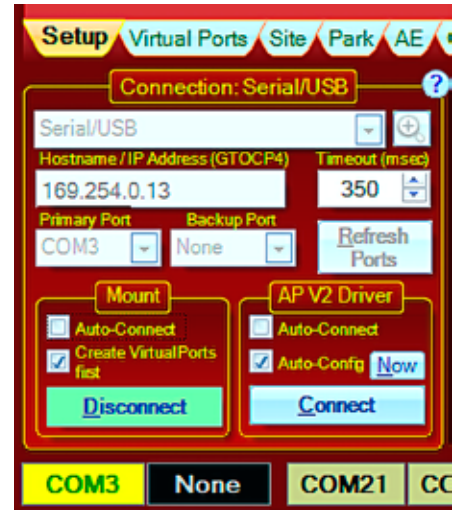
6. Connection (reference the Help file by clicking

the “?” in the top right corner) Additional information can be found by going to the [Software Updates](#) page of our website and selecting APCC Current Version. There you'll find the up-to-date copy of APCC Installation and Getting Started Quick Guide - PDF Documentation.

The most robust and recommended methods of connection are Ethernet and Serial. These will also allow greater computer-to-mount connectivity distance (up to 100' or more).

The GTOCP5 uses an industrialized and self-powered USB connector and its robustness will only be limited by the USB of your computer (the weak link). Avoid using USB hubs which can reduce reliability. If you must use a hub, then buy a high-quality, powered hub.

- Create Virtual Ports first - Checked.
- Auto-Config - Checked.
- Auto-Connect - these are a personal choice (generally checked).



Workflow When Using APCC & the AP V2 Driver with Third-Party Software

(examples: *Starry Night*™, *MaxIm DL*™, *Sequence Generator Pro*™, etc.)

(*TheSkyX*™ is discussed on page 33)

1. Be sure that you first install the current ASCOM Platform and AP V2 ASCOM Driver. Having all software and drivers current is important in order to avoid connectivity issues.

- a) ASCOM Platform 6.4SP1 or newer - install first

<http://ascom-standards.org/index.htm>

Click on the download button and install the full download. Once the download is complete you are done. There are no settings to make.

- b) Astro-Physics V2 ASCOM Driver - install second

<http://www.gralak.com/apdriver>

Detailed information regarding setting up the AP V2 ASCOM Driver are found on page 24. Please check frequently to ensure that you are using the current version of this driver. Important updates and bug-fixes are made periodically to ensure that your mount functions safely.

- c) Astro-Physics Command Center (APCC) - install third

Please refer to the [APCC Installation and Getting Started Quick Guide](#) (PDF) located in the same section of our website as the APCC downloads files. We suggest that you download this PDF and the full manual for future reference.

Pro Tip: Clicking on the "?" in the upper right corner of each window in all the screens found in both the AP V2 Driver and APCC will immediately jump you to that specific section of the Help Menu!

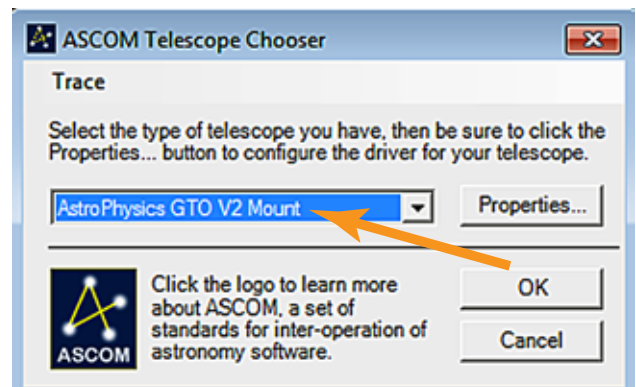
2. Open the AP V2 Driver's Setup Telescope and enter the required settings.

Important: When using the AP V2 Driver with APCC, you will need to change some settings in the driver's Setup Telescope. The box APCC Virtual Port will need to be checked and a high number COM port (for example COM21) will need to be chosen so that it does not conflict with real COM ports. This will be a Virtual COM port. You will need to create a Virtual port in APCC that corresponds with the chosen number. Detailed information is found in the APCC Help Menu.

3. Install your third-party software.
4. Locate the Telescope Chooser or Settings in the third-party control software - all ASCOM compliant software will have a chooser or settings drop down menu.
5. Select the AP V2 Driver. The driver will be called Astro-Physics GTO V2 Mount. *See image at right.*

Once you select it, you may be asked to click Properties... If you click Properties... you will be shown the AP V2 Driver's Setup Telescope window that you filled out earlier. You can review it if you wish. Then click OK once or twice and you are done.

The Astro-Physics V2 ASCOM Driver is a hub through which all third-party ASCOM compliant software can be connected. Planetarium, camera control and focusing software, etc. can be connected to it and, operated simultaneously.



6. Polar align and power up the mount.
7. Start APCC and have it connect to the mount. APCC will be the software that initializes the mount with the settings that you have set in APCC. It will also start the AP V2 Driver if you have it set to auto-connect.
8. Start your third-party software and connect it to the mount. You are ready to enjoy the evening.
9. After finishing your night's observing (or day's solar observing) park the mount to your chosen park position.

10. Once the mount is parked disconnect and close the active third-party software.
11. Close APCC. The AP V2 Driver will automatically close.
12. Power down the mount.

Important note: If you are starting the mount and initializing from APCC, then it will override what has been set in the AP V2 ASCOM Driver.

Workflow When Using TheSkyX™ with the AP V2 Driver

1. Be sure that you first install the current ASCOM Platform and AP V2 ASCOM Driver. Having all software and drivers current is important in order to avoid connectivity issues.

- a) ASCOM Platform 6.4SP1 or newer - install first
<https://ascom-standards.org/index.htm>

Click on the download button and install the full download. Once the download is complete you are done. There are no settings to make.

- b) Astro-Physics V2 ASCOM Driver - install second
<https://www.gralak.com/apdriver/>

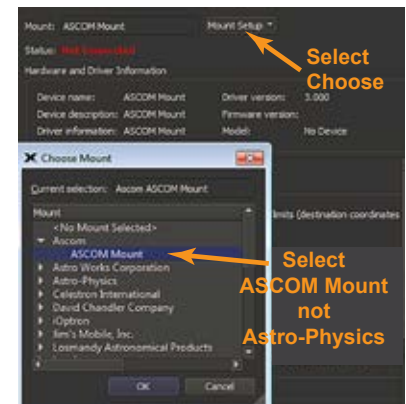


Detailed information regarding setting up the AP V2 ASCOM Driver are found on page 24. Please check the link above frequently to ensure that you are using the current version of this driver. Important updates and bug-fixes are made periodically to ensure that your mount functions safely.

Pro Tip: Clicking on the "?" in the upper right corner of each window in all the screens found in both the AP V2 Driver and APCC will immediately jump you to that specific section of the Help Menu!

2. Open Setup Telescope in the AP V2 Driver and enter the required settings. Reference the section entitled "Setting Up the Astro-Physics V2 ASCOM Driver" on page 24
3. Install TheSkyX™ and any other third-party software.
4. Go to Telescope in the menu bar and locate the Telescope Chooser in the drop-down menu. Then select ASCOM Mount. *See image at right.*

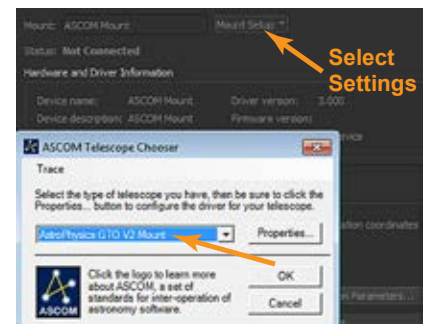
Important Note: Do NOT select Astro-Physics from that list. These are TheSkyX™ native drivers and NOT Astro-Physics drivers. They will NOT connect through ASCOM and the AP V2 Driver, nor through APCC; consequently, you will not be able to take full advantage of the functionality, precision and safety that is available through our software.



5. Go back to the drop-down menu and select Settings. It will open the ASCOM Telescope Chooser and you will select AstroPhysics GTO V2 Mount. *See image below right.*
6. Once you select it you may be asked to click Properties. If you click Properties, you will be shown the AP V2 Driver's Setup Telescope window that you filled out earlier. You can review it if you wish. Then click OK once or twice and you are done.

The Astro-Physics V2 ASCOM Driver is a hub through which all third-party ASCOM compliant software can be connected. Planetarium, camera control and focusing software, etc. can be connected to it and operated simultaneously.

7. Polar align your mount using any of the methods outlined in the manual that came with your mount. .
8. Power up the mount, and then start TheSkyX™. When TheSkyX™ connects to the mount, it will start the AP V2 Driver which initializes the mount.
9. After finishing your night's observing (or day's solar observing), park the mount to your chosen park position.
10. Disconnect and close the active software programs (the AP V2 Driver will close automatically). Power down the mount.



Workflow When Using Mobile Smart Devices and Non-Windows PCs

- [SkySafari](#)™ for iOS and Android by Simulation Curriculum Corp – This software is offered through the App Stores in three versions.
- [Luminos](#)™ for iOS by Wobbleworks LLC – This software is offered through their internet website.
- The SkyX™ for Mac by Software Bisque – This software is offered through their internet website.

Note: Smart Device companies are currently revising their software to be able to utilize the unique start-up features of the Mach2GTO and the GTOCP5. We expect that SkyX for Mac will also become available for use in the future, but at this time, it is unavailable. We will update the manual in PDF form on the Technical Support page of the website when we have more information from them. Be patient...it is coming!

Planetarium, Imaging and Observatory Software from Other Vendors

There are a number of planetarium and camera control programs that can be used to control the Astro-Physics GTO Servo System. Many of these use the ASCOM interface and will take advantage of the V2 ASCOM Driver mentioned previously. Any software that can use the AP V2 ASCOM Driver will have extensive mount control capabilities because of the driver's Virtual Keypad features. Other programs employ native drivers that the software designers wrote based on our publicly available command set. The list that follows is certainly not exhaustive, but does offer some resources.

Resources for PC users:

- [Starry Night Pro/Pro Plus](#)™ from Simulation Curriculum Corp. (Windows with ASCOM support).
- [TheSkyX](#)™ from Software Bisque (Windows with ASCOM support and native driver).
- [Earth Centered Universe](#)™ from Nova Astronomics (Windows with ASCOM support).
- [Sky Tools 4](#)™ by Skyhound (Windows with ASCOM support).
- [Voyager](#)™ from Carina Software (Windows). This product does not use the ASCOM interface.
- [MaxIm DL](#)™ from Diffraction Limited (Windows with ASCOM support).
- [ACP™ Observatory Control Software](#) by DC-3 Dreams (Windows with ASCOM support).
- [Sequence Generator Pro](#)™ by Main Sequence Software (Windows with ASCOM support).
- [CCDWare™ Product Suite](#) (Windows). The suite includes *CCDNavigator*™, *PEMPro*™, *CCDInspector*™, *FocusMax4*™, *CCDAutoPilot*™ and *CCDStack*™ software. They all use the ASCOM interface. These products can also be purchased individually.
- Any other ASCOM compliant software. *Be sure to update to the most current AP V2 ASCOM Driver (supported by Astro-Physics).*

Resources for Mobile Smart Devices and Mac Users:

See notation in previous section regarding Using Mobile Smart Devices and Non-Windows computers.

UNDERSTANDING THE GTOCP5 SERVO LOGIC

To avoid some of the more common operator errors that people make, we will attempt to describe and explain some important aspects of the servo logic that govern the movement of the mount as you perform the various operations involved in a night of astronomy. The discussion that follows will address several areas of the GTOCP5's control logic and tie those areas into the three control categories as discussed in "Controlling Your GTO Mount" on page 20.

- Initialization and Shut-down
- The Role of Time and Location Data in the Servo System
- Safety Slew Logic
- The Concept of "Pier Side" as it Relates to the Servo
- Tracking Past the Meridian
- Meridian Delay or Meridian Advance
- Recalibrate and Sync
- Parking Your Mount

Initialization and Shut-down

As briefly discussed on page 21, Initialization functions are probably the most important subset of the group of primary control functions. It is vitally important that your mount be properly initialized when it is first powered on. There is nothing magical or mysterious about proper initialization. It is simply the process that allows the mount to recalculate its position and commence operations.

Initialization should only be performed once per power cycle when the mount is first powered ON. Full initialization should not be repeated while a mount is powered on because it accesses information from the last power-down to determine its current position. That information is no longer valid in the middle of a session.

1. Latitude and longitude coordinates tell the mount where it is located on Earth. The last location entered will be remembered through a power-cycle, so this only needs to be sent if your location has changed. .
2. Time, date and time zone (GMT offset) give the mount the necessary time information. GMT offset will be remembered, but time and date need to be supplied each time the mount is powered on. Time and date should be supplied by the control device that is being used for primary mount control.
3. Commands to establish the tracking, guiding, centering, and slew rates tell the mount how it should operate.
4. The command to unpark the mount is sent. This command both ends the parked state and it also calculates the mount's current pointing position. The unpark command will have resulted in extremely accurate calculation of the current pointing position without further calibration being necessary.

Because of the design of the Astro-Physics Servo System logic, no special shut down procedures are required. Although many people choose to park the mount at the end of a session, this is entirely unnecessary from the mount's point of view. If you wish, you can simply "pull the plug" and leave the mount where you left off. When you power back on, a proper full initialization will restore the pointing without any further ado. Park positions can be handy, but they are not a requirement. With the Astro-Physics system, think of "park" as a state where the drive motors are de-energized - not a "place" where the mount goes. The park positions are simply convenient coordinate positions to use before entering that "parked" state.

The Keypad, the AP V2 ASCOM Driver and APCC all fully handle all the initialization and shut-down tasks discussed above. They do so in a manner that is simple, automatic, and virtually fool-proof. Other software can also perform these tasks, but Astro-Physics cannot guarantee that they do so correctly all of the time.

If using APCC, it should be the first piece of mount-related software that is opened and the last one that is shut down.

The Role of Time and Location Data in the Servo System

There seems to be an obsession among astronomers with accurate time and location data. Many of our customers use *Dimension4™* or some other similar time server to keep their computer clock accurate to the millisecond. GPS units are employed to precisely nail down time and location data to the second. However, for most of your mount's operation, accurate time and location are really somewhat irrelevant. You don't want to be way off, but you probably don't need to be dead-on either. Here are some thoughts on time and location as it applies to the Astro-Physics servo system.

- The obsession with time and location accuracy probably comes from people who started with Alt/Az mounts. When a mount is set up as an Alt/Az mount, it must convert its native Alt/Az system to RA/Dec for celestial viewing. To make this conversion, the more accurate the time and location data, the more accurate the conversion. Time and location are critical to the Alt/Az astronomical mount.
- Time and location come into play during initialization as discussed above. They are necessary for calculating the current RA value at start-up. Precise time at power-off followed by precise time at the following initialization will lead to a more accurate calculation of the RA. However, think about it: How important is to-the-second accuracy of your first GoTo of the evening? If your first target is off by 30 seconds of RA, or even a minute, won't it still be within the field of view? After centering and doing a ReCal, the time relevance is over.
- Time and location are used to determine the meridian (aka z-value, LST, overhead hour, etc.). They are also used to then determine the horizons. Again, the more accurate time and location are, the more accurate the meridian and horizon values will be. As above, the question to ask is how important is it if the calculated meridian or horizon is off by a little bit. You would probably never know it during a normal observing or imaging run.
- Time and location accuracy is VERY important for satellite tracking, and for astrometry. If you are using APCC's Horizons program, or you are doing research on NEOs, by all means, use a time server and GPS!!
- Once you are calibrated on a star, apart from determining the flip-point, precise time and location play almost NO ROLE WHATSOEVER in normal GoTo slews or pointing accuracy.

Many client software programs like planetarium programs and observatory control programs will demand that the mount time matches the computer clock. This is necessary for coordination among the programs. However, if you are away from an internet connection or GPS unit, and your computer clock is off from the atomic time in Boulder, CO by a little bit, you really shouldn't worry about it.

Safety Slew Logic

Safety Slew Logic is designed into the GTOCP4 and GTOCP5 firmware and functions with all of our GoTo mounts. Its purpose is to protect your scope from a possible crash into the pier when slewing out of some counterweight-up positions.

Our mounts have the unique ability to track past the meridian while imaging, such that the counterweight will move higher than the scope (counterweight up). Normally when a GoTo slew is made, both the RA and the Dec axes begin moving simultaneously. However, there are some counterweight-up areas from which a slew with the Dec axis moving simultaneously with the RA axis would cause the scope to hit the pier before the RA axis can take it safely into a counterweight-down position.

The Safety Slew Logic knows when the mount is in a counterweight-up position and will initiate an RA-only slew to bring the mount back into the counterweight-down safe zone where it will pause momentarily. The mount will then automatically make a second slew using both axes simultaneously to continue to your object.

Conversely, when using Meridian Delay to begin with a counterweight-up imaging session, the reverse happens. A dual-axis slew will take place until the meridian is reached where the RA will stop and the Dec axis will continue to its position. When the Dec has reached its position and stops, the RA will make its second slew to the final position.

It is even possible that a three-part slew may take place if you are slewing from a counterweight-up position and into another counterweight-up position.

Having this firmware logic in the GTOCP5 control box means that it will work regardless of whether you are using computer software or the keypad to control your mount.

The Concept of "Pier Side" as it Relates to the Servo

Pier side is something that would seem intuitively obvious at first glance, but it ends up getting confusing to many people. The conventions and rules used for pier side are NOT the invention of Astro-Physics, but are standard through the industry and are mandated by ASCOM as well. Pier side gets confusing because the correctly reported pier side can differ from what our eyes are telling us if we look at the mount. The Astro-Physics reference Park 1 position is the classic example of this. We have fielded countless support calls from frantic customers who were convinced that their mounts were lost because the scope was most assuredly on the west side of the pier in Park 1, and yet the servo (and the control software) were all reporting a pier side of East!

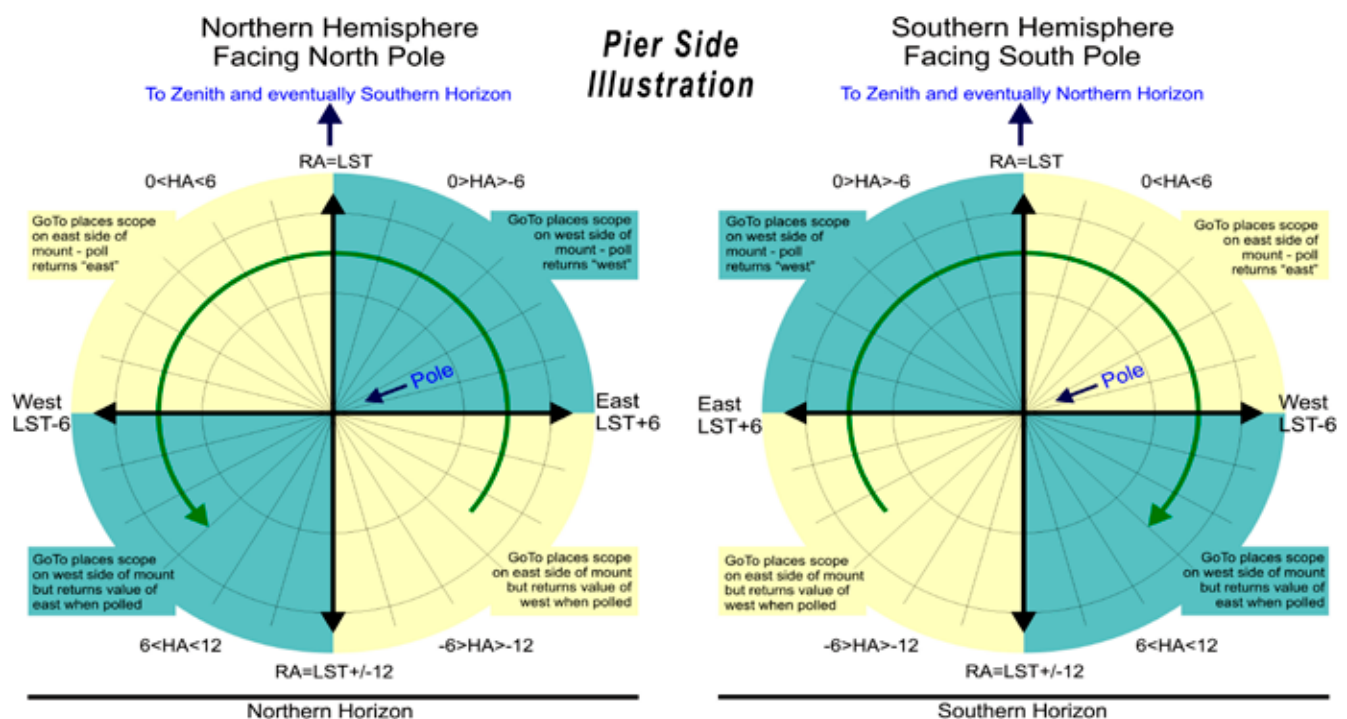
The reason for the confusion is that pier side has nothing to do with right ascension or hour angle. It is entirely a function of declination. The problem is that for any physical position of the mounts' RA axis there can be two declination values.

This is apparent near the pole. Think of a Dec coordinate of 80 degrees. Without moving the RA axis, you can slew the Dec from 80 to 85; cross the pole at 90; and then keep on going through 85 and back to 80. The two pointing positions are 20 degrees apart, yet both have the same declination, and both share the same physical position of the RA axis. To distinguish the two positions, we do two things: 1. We report one position as having a pier side of East, and the other as having a pier side of West. 2. The RA value (and therefore also the hour angle) are different by exactly 12 hours.

In terms of the pier side, the reported side is what one would consider the "normal" side for a mount where the declination was on that particular side of the pole. Most observing is done with the scope pointing above the pole, so that is considered the normal side. For example:

1. Start with the mount in the classic German Equatorial pose (the Astro-Physics reference Park 3 - scope pointing at the pole and counterweight shaft pointing down).
2. Rotate the declination axis toward the east (clockwise from above in the northern hemisphere, counterclockwise down under).
3. You will immediately see that the normal orientation for the RA will be to rotate it to the west placing the scope on the west side of the pier.
4. Likewise, if you rotate the Dec to the west of the pole, you will want to take the scope to the east side.
5. Things only get backward when you are pointing below the pole as you do in the AP reference Park 1 position.
6. To see this, take a mount in the normal position, and take the RA axis across the meridian without moving the Dec. You will see that the scope is pointing below the pole.

The illustration below will hopefully help to clarify this. If it is still fuzzy, the easiest way to really grasp the concept is to work with a mount and scope and actually run through the steps above.



Tracking Past the Meridian

Unlike other German Equatorial mounts, Astro-Physics GEMs do not require a flip at the meridian in order to follow an object in its nightly journey across the sky. Tracking through the meridian is a unique function of AP mounts. Most objects that are located south of the zenith (northern hemisphere) can be imaged without interruption from horizon to horizon. The mount will happily track with the counterweights high in the air.

A visual observer will not be overly inconvenienced by the mechanics and delay of the flip; however, this becomes much more complicated for an imager! Here is the normal sequence of events other mount owners must do when their mount flips during an exposure: stop the imaging session (often with the loss of a 20 to 30 minute sub-exposure that has reached 19 or 29 minutes), flip the mount and reposition cables, rotate the camera so that you can use the same guide star, re-center the object to your desired composition, re-acquire the guide star and then recalibrate it, begin the new imaging session. Aren't you glad you don't have to flip?

Remember, it is the GoTo slew that will flip the mount...not tracking!

Please note that with this convenient feature comes the responsibility of preventing your scope and camera from striking the pier when imaging an overhead object or one more northerly. Fortunately, APCC software that safeguards against this mishap! A custom contoured Meridian Limits outline can be created with APCC that keeps everything safe and sound. You may wish to take a little extra time to set this up.

Meridian Delay or Meridian Advance

The Meridian Limits (Delay or Advance) are one of the most powerful and useful features of Astro-Physics mounts. They open up the possibility of imaging on both sides of the meridian WITHOUT wasting time on a pier flip at declinations where the scope will not strike the pier. The limits, when properly configured, allow you to track safely past the meridian up to the limits you set based on your unique instrument package. In addition, they allow you to begin an image ahead of the meridian by safely slewing you into a counterweight-up position to start an imaging series that can then simply continue through the meridian. However, like any powerful feature, you MUST understand how the meridian limits work. It is vital that you understand what they CANNOT do as well as what they can do!

The AP V2 ASCOM Driver and the mount's keypad each have the ability to set a meridian delay which controls the flip point of the mount. These are hour angles that follow the full north-to-south meridian line, as opposed to the custom contoured meridian flip lines that are possible in APCC. The advantage is that they can be set up quickly, though one must take care to be sure that your scope will clear the pier when changing the timing of the flip.

APCC adds some powerful capabilities. Three of the features outlined in bullet points below apply to West Meridian Limits. The West Limits come into play when a scope's counterweight is in the up position (scope under the mount) and the scope is pointing west of the meridian. This normally occurs when the scope is allowed to track past the meridian. The fourth feature below applies to East Meridian Limits and provides a unique and powerful tool for safely starting images in the east from the east side (counterweight up) using the meridian advance.

- Instead of just a single meridian limit for all declinations, you can configure an arbitrary number of different limits at different declinations. This is useful because at each declination there can be a different hour angle at which the telescope will touch the pier. In declination regions where the telescope can theoretically go the full 6 hours past in the west, the meridian limits can establish horizon tracking limits for the practical distance past the meridian where you can reasonably continue to work. Likewise, in the east, they can set the practical horizon ahead of the meridian where you can reasonably start an image.
- When a meridian tracking limit is reached, tracking can be automatically stopped, the scope can be flipped, or the scope can be parked.
- Meridian tracking limits can also be used to create a safe zone around your pier if it interferes with reaching the zenith. Remember that an APCC Meridian Limits safe zone that does not allow the scope to reach the Meridian must be stopped or parked. It cannot be flipped.
- When East Limits are properly configured and employed, slews to targets within the east limits will

automatically be made using meridian advance and APCC's safety slew logic to place the system in a counterweight-up position with the scope on the east for uninterrupted imaging through the meridian. The safety slew logic ensures that all mount movement with the counterweight up is with the RA only. Using the East Limits, the scope can image through the meridian and on for another 6 hours before the telescope reaches the horizon.

- A Pier Flip button has been added to the APCC software that will allow an automatic flip to the other side of the mount when the button is clicked. Provided that you are within the safe limits, you can flip and view the same object from either side of the pier...either counterweight up or down.

The ability to work past the meridian into the west, or to start ahead of the meridian in the east, has always been a hallmark of Astro-Physics mounts. Both the Keypad and the earlier PulseGuide program provided the ability to work beyond the meridian. However, with both of these control methods, the user would want to be present at the mount for safety. APCC creates meridian limits that can allow the user to safely exceed the meridian without hovering over the mount to protect the scope and imaging equipment from a potential crash. Remotely controlled observatories can now also safely image through the meridian (where declination permits it).

Recalibrate and Sync

The concepts of Recalibrate (ReCal) and Sync have caused a lot of confusion over the years. Users familiar with our previous GTOCP1,2,3 or 4 control boxes will remember that sync and recalibrate represented very distinct meanings for Astro-Physics mounts and, confusing the two, could send your mount slewing the wrong direction and, in the worst case scenario, ending with a pier crash. However...no more!

This is no longer an issue with the Mach2GTO mount! The unique encoder-mount design liberates it from Sync / ReCal concern!

Feel free to use Sync or ReCal interchangeably in Keypad or computer. The effect will be to fine-tune your pointing accuracy. It will have no affect on your scope / counter weights orientation. Freedom!

Parking Your Mount

There is no need to go to a park position for any of our mounts. You can just remove the power cable (or turn off your power supply), then next time plug it back in (or turn it on). The mount doesn't care, and that includes the Mach1, Mach2, 1100, 1600, 900, 1200 etc.

For all of our mounts, except the Mach2GTO, parking simply gives you a reference in case you tear your mount down and want to build it up again next time close to what you had before and don't want to go thru a lengthy setup routine. That way you can use a level to set one of the park positions where you last left it and simply resume from present position.

The Mach2GTO is even easier to operate. It never needs to be told where it is even if you don't put it back the way you had it before. Simply resume tracking. It remembers the absolute encoder positions and thus, where it is.

For instance, a simple workflow is just this: open SkyX™ and press "Connect Telescope." That's it. Done! The cursor on SkyX™ shows where the scope is pointed. Right click on an object that you want to slew to and the mount will move there. When you are done, leave the scope wherever you want and simply press "Disconnect Telescope" in SkyX™. Then turn off the power.

You can do the above with any of our mounts if you don't loosen the clutches. On the Mach2GTO, you can loosen the clutches and move the axes without causing any kind of issue for the next setup. It doesn't matter where the scope is pointing when you click on "Connect Telescope"; the cursor on your planetarium program will show you exactly where the scope is pointed.

We tried to make this mount, and all our mounts, as easy to operate as possible. The problem is that people go through all kinds of steps that are extraneous. Parking is nice for certain operations, but it is not necessary.

All of the park positions are illustrated in "Appendix B: Pre-defined Park Positions (Northern & Southern Hemispheres)" on page 51

AUTOGUIDING TIPS AND NOTES

Autoguiding is an art. It is the most complicated, yet most important, part of imaging. If it is not mastered, images will suffer. Anything you can do to make your autoguider's job easier will make imaging more fun. Here are some suggestions and things to keep in mind.

How Do Autoguiders Work?

All any ST-4 compatible guider does is to close the circuit to cause the desired motion and then open the circuit to stop the motion. There is nothing more to it from the mount's perspective.

- Autoguider port relay commands do not involve the AP V2 ASCOM Driver or APCC at any level. They cannot be logged.
- Autoguider commands that go through the AP V2 ASCOM Driver are timed commands. The precise timing is a part of the command itself so no external action to precisely stop a command is required.
- Autoguider commands through APCC can actually be isolated in the log window in real-time for troubleshooting. You can watch the correction blip up on the guider graph and see the corresponding timed move command that is sent AS IT HAPPENS! Reference the [APCC Pro PDF documentation](#) for more information.

Important Misconception on Autoguiding

The directions represented by the X+, X-, Y+ and Y- in your guiding software do not necessarily correspond to any given cardinal or equatorial directions. To the guiding software, X and Y simply refer to the rows and columns of pixels on the guide chip...nothing more. They do NOT mean RA and Dec!

The act of calibration tells the guiding software how to relate a guide star's drift along the columns and rows to move directions in the mount, but it does not make it so that X is necessarily always right ascension and Y always declination. To further complicate this, each time you alter the camera's orientation, you effectively change the relationship between X / Y and RA / Dec.

Your very first step in diagnosing any type of guiding problem should be to determine the actual current relationship between the X and Y of the guiding software and the RA and Dec of your mount. This is easily done in your camera software by making a manual move in one axis during an exposure and see which direction the stars streak.

We have seen imagers waste countless hours (not to mention dollars) trying to fix a guiding problem on an axis that was performing perfectly. Meanwhile, their true problem remained, all because of this axis mix-up.

Use AP V2 Driver for Your Autoguiding Moves

The autoguider port remains a popular way to use an autoguider system, but you might want to consider making your guiding moves through the serial or Ethernet connections via the AP V2 ASCOM Driver instead. Guiding moves require millisecond timing to be accurate. When you guide through the autoguider port, you are depending on the system to operate the guiding relays with this very accurate timing. Guiding through the AP V2 Driver on the other hand sends a timed move command. There are no relays to open and close at an exact moment in time. The command itself contains the precise time interval in milliseconds for the move.

Autoguiding Tips

- Ensure that your autoguider calibration is a good one:
 - Perform the calibration near the meridian and celestial equator. As you move towards the pole, RA becomes increasingly compressed and less accurate. This is a significant problem near the pole.
 - Calibrate for sufficient time so that the star travels at least $\frac{1}{4}$ to $\frac{1}{2}$ across the guide chip for a good arc seconds / pixel calculation. Your software's calibration numbers should agree with the following numbers.
Guider calibration formula: Sidereal rate (arc sec / sec) x guide rate ÷ guide system image scale
example: $15.04107 \times 1.0x \div \text{guide system image scale (arc sec / pixel)} = (\text{pixels / second})$
- Use a 3-5 second sub-exposure for guiding. This will reduce the scintillation effect of the air. If you have good polar alignment, even longer sub-exposures can be used as long as a saturated star is not chosen.
- Choose a star in the brightness mid-range...not too dim and not saturated.

- Calibration and guiding should always be done at 1x guide rate.
- Turn all backlash to zero (Keypad and computer software) and turn off "stiction."
- Since the Mach2GTO has absolute encoders, PE correction is no longer needed. The encoder eliminates all periodic error, so no need for doing PE compensation. Autoguiding works superbly well with the encoder mounts.
- With an encoder mount like the Mach2GTO as well as the 1100GTO or 1600GTO mounts with absolute encoders, you want to have a delay between guide pulses. The reason is that it takes a moment for the axis to fully respond and reverse in Dec when a command comes in. In an encoder mount, each command will be fully accommodated by the encoder loop, whereas in a non-encoder mount it may take several move commands for the axis to finally fully reverse. If you start sending the same move command in an encoder mount without waiting for the first one to finish, you will definitely overshoot.

A 2 - 3 second delay between commands is a good recommendation. There is no periodic error that you need to chase in RA and the Dec axis isn't going anywhere. This assumes that you don't have very poor polar alignment that causes the axes to drift at high rates.

MaxIm DL™ Guiding Recommendations

- In MaxIm DL™, you want to use "Telescope" for guiding. However, you first have to connect to the mount via your USB cable,. Click on the little Observatory Dome icon to bring up the Setup window. Press the Telescope Connect button. This will then allow the program to send direct move commands which are more accurate than the Pulse Guide commands.
- For setting the guide delays in MaxIm DL™, bring up the Guider Settings - Advanced window. Set the "Delay After Corrections" to 2 seconds or 3 seconds. You can also set your Min Move and Max Move in that window.

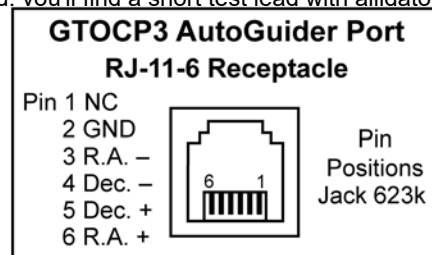
PHD2 Guiding Recommendations

- Set a delay of 2 to 3 seconds between guide exposures. No need to chase gear errors because there aren't any.
- Use whatever exposure time you want to get a good signal/noise ratio (usually from 1 to 5 seconds).
- Use Guiding Assistant to gauge the seeing and set your MinMove to what is recommended. It will tell you all the vital information about how your mount is reacting
- Depending on seeing, the aggressiveness can be set between 50% to 90%.
- Be sure that your guide scope focal length is set properly in PHD2 in the scope setup window.
- Each time that you change the guide scope or set up new you first must perform a calibration run in PHD2.

How to Test an Autoguider Port

Here is the test for the autoguider port. To perform the test, you will need a foot or so of 6 conductor flat phone cable with a standard RJ11-6 plug on the end. Remove the insulating material from 3 – 4 inches of the bare end of the cable to expose the six colored wires. Remove the insulation from about 1/4" to 3/8" of the ends of each of these wires, although you could skip the wire corresponding to pin #1 if you wish. The #1 wire will typically be either the white or the blue, depending on how the plug was attached. In addition to the cable just described, you'll find a short test lead with alligator clips on each end to be very handy. *Note the pinout diagram.*

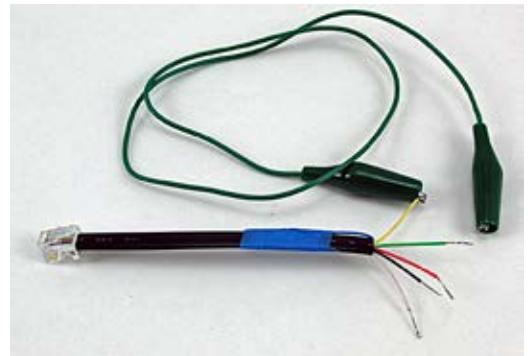
You may find it helpful to list the wire numbers and color codes before you start. Most likely, you will have: blue, yellow, green, red, black & white or else the exact reverse of this. If you hold the test cable so that you are looking at the bottom of the plug with the plug's clip away from you, you can see the colored wires in order exactly as they go into the jack illustrated here.



To test:

1. Power up the mount.
2. Remove the covers from the gearboxes that cover the reduction spur gears.
3. If you have never done so before, set the keypad button rate to 1x and press the direction buttons to familiarize your-

self with just how slow the gears actually are turning at 1x. Note also that in the RA, you have default rotation at sidereal. Pressing the East button at 1x simply stops the tracking rotation. Pressing the West button turns the gears at 2x. The Dec axis is more straightforward. This process can also be done by using the AP V2 Driver or APCC Move buttons.



4. Set the guide rate to 1x.
5. If you have a test lead, attach one of the alligator clips to the #2 wire of the cable you have made. Make sure that none of the bare wires are touching.
6. Plug the cable into the auto-guider port of the AP control box.
7. Take the other end of the alligator clip test lead and clip it on the bare #6 wire from your test cable. If you don't have the test lead, simply hold the #6 wire's bare end in contact with the #2 wire's bare end. This method goes for all the steps below using the relevant wire and the #2 wire.
8. Observe the gears in the RA axis gearbox. They should be stopped as you observed in step #3.
9. Remove the test lead from wire #6 and attach the alligator clip to wire #3 on your test cable.
10. Observe the RA gears again. They should be turning at 2x sidereal in the same direction as normal sidereal tracking.
11. Remove the test lead from wire #3 and attach it to wire #4.
12. Observe the Dec gears for rotation at 1x. Be sure to note the direction of rotation.
13. Remove the test lead from wire #4 and attach it to wire #5.
14. Observe the Dec gears for rotation at 1x. The direction of rotation should be opposite of the direction observed in step #12.
15. Note any differences from the expected performance for communication with the technical staff at Astro-Physics. If the mount performs as expected, then the issue must lie elsewhere.

UNGUIDED IMAGING WITH THE GTOCP4 AND GTOCP5

Unguided imaging is the holy grail for many imagers. It requires the right combination of mount capabilities, modeling software and attention to your equipment setup.

All of the Astro-Physics mounts are capable of unguided imaging if they have the GTOCP4 or GTOCP5 servo control boxes. This includes the non-encoder mounts and as well as the AE or AEL mounts that have the Renishaw absolute encoders. Unguided imaging requires good polar alignment, very low or zero periodic error and some degree of modeling using either APCC-Pro or version 5.xx of the keypad software.

Non-encoder mounts will have inherent periodic error which can be compensated with a good clean PE compensation curve that is stored in the GTOCP4 memory. PE curves can be generated using PEMPro software, a program that produces the best possible result and lets the user also analyze the tracking performance of the mount. A typical tracking error with PEM turned on can be 1 arc sec or less over a 6.4 minute worm period. Modern astro cameras can produce excellent results with exposures between 3 to 6 minutes, and so it may not be necessary to guide a short-to-medium focal length imaging setup.

The Astro-Physics 1100 or 1600 AE or AEL mounts and the Mach2GTO have high-resolution and high-accuracy Absolute Encoders that produce excellent tracking over long time periods. With these mounts, there is no periodic error and the tracking errors are very small, well below 1 arc second over 30 minutes or more.

Good tracking by itself will not produce round stars because the stars will drift slightly minute by minute due to many factors (polar misalignment, atmospheric refraction, differential flexure and other effects). Modeling does two things - it can result in good pointing, but more importantly, it can be used to compensate for drift in both the R.A. and Dec axes.

We have developed several methods for modeling that the user can implement for unguided imaging, depending on the equipment used for imaging. APCC-Pro can be used for partial or full-sky modeling, and the results are stored on the laptop. We now also have a keypad program (v5.x) which can be used to produce a partial or full-sky model by measuring the position of bright reference stars on both sides of the meridian.

A second method in the Keypad does not model the sky. Rather, it measures the actual path used by the object to be imaged over a multi-hour time period and compensates automatically for any drift. This method is fast and easy to do with a cross-hair eyepiece or a cross-hair image.

The keypad models do not need a laptop computer, and they are stored in the GTOCP4 or GTOCP5 control boxes for future use. This makes it possible to do astro-photography with minimal equipment, no guider or guide scope and just a stand-alone camera on the main telescope. Refer to the Keypad manual for a full description of these two methods.

TROUBLESHOOTING, TIPS AND SUPPORT

Troubleshooting and Tips

Additional troubleshooting questions are in the individual mount manuals and in the Keypad manual. Some of the issues discussed in the Keypad manual also relate to mount communication issues whether you use the Keypad or control the mount with a planetarium program. Please refer to them. We will add to this section as we become more aware of issues that users encounter.

Can I use the GTOCP5 control box with my other Astro-Physics mounts?

No. The GTOCP5 control box is designed to only work with the Mach2GTO micro-step motors. The other mounts use servo motors that require a different electronics design. Additionally, the GTOCP5 control boxes are matched to the individual Mach2GTO that they ship with. You'll note that they have the same serial number. You cannot use a GTOCP5 control box from one Mach2GTO with any other Mach2GTO mount.

The LED on the GTO control box changes from red to yellow.

1. The voltage of your battery has probably gone below 10.5 to 11 volts or the current rating of your AC-DC power supply is too low.

NOTE: The most common problems are due to inadequate power supply!

Additional explanation:

We provide a 24-volt, 10 amps continuous, universal 85-240V power supply. Please use it only for your mount for best performance. All other equipment (CCD cameras, dew heaters, etc.) should be powered from another power source.

2. You may have a poor connection at the supply pins or excessive distance between the power supply and mount servo. What's important is NOT the voltage at the supply pins, but the voltage at the CP4 or CP5 control box. If there is a poor connection at the power supply pins, you can easily have a couple of volts drop in the line going to the control box and still read 13.7 at the power supply pins. We recommend that you keep your power supply close to your mount to avoid a large voltage drop from a power supply that is placed too far away using a long cable. Do not add an extension cable to the power cable that was supplied with your mount.
3. The motors are overloaded, probably due to an unbalanced load on your mount.

Rebalance your telescope, and then press one of the N-S-E-W buttons on your Keypad or computer program to reset. Re-enter the last object and the scope will slew to the correct position. Even though your motors had stopped, the logic in the control box retained the scope position in memory.

Additional explanation: The GTOCP5 drive circuit includes logic for detecting a stalled motor on the two axes. The primary cause is a severe unbalanced load in RA. If the extra load opposes the motor rotation, the motor must work harder to track at the sidereal rate. If the motor stalls because of excessive load, the logic will shut the motor off and tracking stops. Micro-stepper servo motors can not be damaged with overload. They simply begin falling behind their commanded tracking speed, which is then detected by the logic. The amount of current drawn by the motor remains the same for any load from zero to maximum overload before the stall point. Therefore, a stalled micro-stepper servo motor will not heat up when overloaded or stalled.

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 sites (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 and accumulates over time.

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. Just because you have done a classic drift alignment, it does not mean that the stars will now be moving at the sidereal rate everywhere in the sky. Depending on sky location, there will also be star movement along the Dec axis.

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. The amount will depend on what your latitude is. The other approach is to vary the tracking rate for different parts of the sky.

The [Astro-Physics Command Center \(APCC\)](#) includes tracking and pointing correction based on calculations from atmospheric refraction all the way up to sophisticated real-world models based on plate-solve data for your specific instrument package.

I'm trying to track down what I believe is a small backlash in Dec. At some elevations, stars show tiny trails (not full brightness) on the Dec axis, and I attribute those to backlash.

Firstly, the Mach2GTO will not exhibit mechanical backlash due to the action of the absolute encoders. Secondly, backlash by itself does not produce trails.

Backlash is a term used to describe clearance between the teeth of a pair of gears. The correct term for Dec is actually delay in reversing the axis (Reversal Delay), which is highly dependent on what guide speed settings you are using. At 1x guide speed it might take 0.5 seconds to fully reverse the Dec axis motion. At .25x guide speed it will take 2 seconds, which would cause considerable delay if you are dithering. Under normal guiding, neither of these would impact the guide software to properly guide the mount.

If you are guiding, the guider software automatically handles any Dec backlash. If unguided, backlash has no effect at all. For guiding purposes, the best thing is to leave Dec backlash compensation at zero otherwise you risk overshoot and constant oscillation back and forth on the Dec axis.

The mount will not go to the park 3 position.

Normally a mount will never do what you are describing, even if you have a power loss during a slew. However, this situation can occur if, during a session, you did a ReCal on a wrong position. It can occur if you did a time change during your session, or changed the daylight savings time. For each hour of time change or daylight savings the parks will move 15 degrees.

The mount is not tracking at the correct sidereal rate.

The sidereal rate is very precisely determined with a quartz crystal in the GTOCP5. If you really want to check your RA driving rate you can set the rate to Stop, place a piece of tape across the stationary and moving part of the RA axis. Cut the tape at the seam between the axis. Get an accurate timer, set it to the sidereal day (23hrs,56min, 4.09sec). Push the timer and set the rate to Sidereal at the same instance and let the axis track until the next day. Check when the tape lines up exactly with the timer. Or you can set it to Solar rate and set the timer to 24 hrs. We have done this a number of times with mounts that people swear are running fast or slow and every time the results are within a small fraction of a second.

For a more detailed, illustrated explanation of this procedure, please refer to [Potential Causes of RA Drift](#) in the [Technical Support](#) section of our website.

I am experiencing RA drift.

There are numerous potential causes for RA drift. Please refer to [Potential Causes of RA Drift](#) located in the [Technical Support](#) section of our website.

I think my CP5 Ethernet port is broken.

Plug in the Ethernet cable to the computer and CP5, then power on the CP5. Look at the Ethernet port on the CP5 when you do this to verify that the amber LED is on continuously and the green LED is flashing sporadically for a while before stopping. If the amber light is off, there is no physical link being made to the computer, and the cable is likely at fault. If the amber light is on but there is no green flashing, then the computer and CP5 are not handshaking.

APCC (or any other program) can't find the CP5 over Ethernet.

Check to see if you can open the home page in a browser. If you can, the computer and CP5 are connected properly and the issue is with the software. Consult the manual for the software to see if they have more specific instructions. If you can't open the home page, you might have an IP overlap. This can be solved by changing the CP5 IP address. For example, changing from 169.254.3.101 to 169.254.3.102 might solve the issue.

The Wi-Fi signal is inconsistent and my mobile device is not communicating.

Some users have reported issues with the Wi-Fi randomly dropping or having trouble even when right next to the CP5. This may happen if the CP5 Wi-Fi signal is too strong at that distance, and is causing temporary deafness in the receiver of your device. Steps to take include keeping the CP5 antenna folded down and standing further away. In extreme cases aluminum foil may be used to shield the external antenna. You may also try disconnecting the external antenna.

Alternatively, you may need to move the antenna or even your GTOCP5 to another position for a clear line of sight to your modem. The heavy metal mass of your pier could interfere with the signal. Be sure that your antenna is free of other

harnesses and cables. Some people have found that recessing the antenna, rather than extending it can help. You may need to experiment a bit to find the optimum position.

I can't find the Wi-Fi signal at all.

Check the CP5 home page over an Ethernet connection to verify that the Wi-Fi is both on and in "Retry Network Periodically" mode, then try again. If this doesn't work, try to fold down or cover the Wi-Fi antenna to reduce the signal a bit.

My USB port isn't working.

The most common issues with USB are simply cable problems. This can be solved with a powered USB hub or an active cable. Other problems include running too much data through a single USB port. For instance, if you are trying to run cameras, a mount, dew heaters and a separate computer all through one USB 2.0 cable, the cable will be unable to carry all of the data on its own. Remember, USB 2.0 is limited to about 15 to 16 ft. (5 meters).

Additional Support

For additional information regarding the Astro-Physics GTOCP5, refer to the [Support](#) section of our website. We also encourage you to participate in our forum: <https://ap-gto.groups.io/g/main>. The members of this group are very knowledgeable about the operation of their mounts, CCD and CMOS imaging, and other related issues. The staff of Astro-Physics also participate and you will find a wealth of information in the archives.

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 email: 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.

ASTRO-PHYSICS, INC
11250 Forest Hills Road, Machesney Park, IL 61115
Telephone: (815)-282-1513, Fax: (815)-282-9847
support@astro-physics.com
www.astro-physics.com

APPENDIX A: GTOCP4 AND GTOCP5 SOFTWARE UPDATE

Field Download of GTOCP4 or GTOCP5 Software

One of the advantages of the GTOCP4 or GTOCP5 (referred to as CP4/5) over the previous GTOCP1, 2 or 3 that updates to the software can be downloaded over the internet and then uploaded to your control box. There are two methods of updating CP4/5 software. The preferred method uses a standard Web Browser. The other involves the use of a serial or USB port and a terminal emulator (HyperTerminal or TeraTerm). These instructions are for the Browser update. Terminal emulator instructions may be prepared in the future, but they are significantly more complicated, and the process is slower.

At this time, we require that you update software using the Ethernet connection. Currently, download over the Wi-Fi is slower and more error prone, so we are not allowing Wi-Fi updates.

Download the Package If you have not downloaded the zipped software package yet from the [Software Updates](#) section of our website or email you received, please do so now. We recommend that you create a folder in a location where it will be easy to find, and unzip the package contents into this folder. The contents **MUST** be unzipped prior to loading and cannot be run from the zip folder. Additional instructions for the download are on the website's downloads page.

IMPORTANT! Park your Mount to a defined position. Do this BEFORE you start the upgrade. You will need to resume from that same defined position after the upgrade to reestablish your calibration. If you are using the keypad, first switch to auto-connect = NO, and then park the mount.

Note: After parking the mount, you can remove the CP4/5 if you wish to perform the software upgrade; it does not need to be connected to the mount. This may make establishing an Ethernet connection easier.

Determine Your IP Address

You may have already determined your IPv4 cabled Ethernet IP address. If you know this address, you can skip the following and proceed directly to "Upgrade Using a Browser" on page 48. If you have not determined the Ethernet IP address, please refer to "Determine Your IP Address" on page 13.

The Find_Mount.jar file and Ethernet WiFi Poll utility will be included with the download package along with the new version of the CP4/5 software.

Upgrade Using a Browser

These procedures are for ALL USERS, regardless of operating system.

1. **Save the program files.** If you have not already done so, save the new program files that you downloaded from the [Software Updates](#) section of the Astro-Physics website or from an email or the user group to a directory on the computer that will be running the web browser.
2. **Connect the CP4/5 via Ethernet and power up.** Connect the Ethernet (i.e. Cat 6) cable to the CP4/5 on one end, and to your computer or a router or network switch (port) on the other end. This direct peer-to-peer connection is the simplest and most reliable connection for software uploads.

IMPORTANT: Allow several minutes for the connections to be fully established.



3. **IMPORTANT!! Disconnect ALL other cables and software from the CP4/5 for the remainder of this procedure. Simultaneous activity can disrupt the download. Disconnect APCC if you have it, and any other programs. Be sure that your Wi-Fi devices and programs are not connected to the CP4/5.**

The only cables that should remain connected are the:

- **Power Cable** – The CP4/5 will remain powered during this procedure.
- **Ethernet Cable** – The only Ethernet connection should be the CP4/5 webpage.
- **RA and Dec Cables** – To the back plate of the Mach2GTO (optional – not required, but won't hurt).

4. **Start your browser.** Once you know the cabled IP address, start up your browser: Internet Explorer, Fire Fox, Safari, etc. If you used the E-net_Wi-Fi_Poll program above, it will open an instance of Internet Explorer for you already connected to the CP4/5. Use of Google Chrome may be a little more difficult because Chrome is optimized for the World Wide Web, and may skip any search for local hosts.

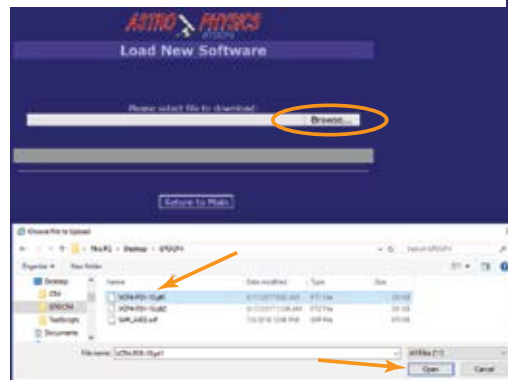
5. **Enter IP address.** On the URL line of your browser, enter the IP address of the CP4/5. (As mentioned above, Windows users may be able to simply enter their Host name.) The CP4/5 will place the following page in the browser window.



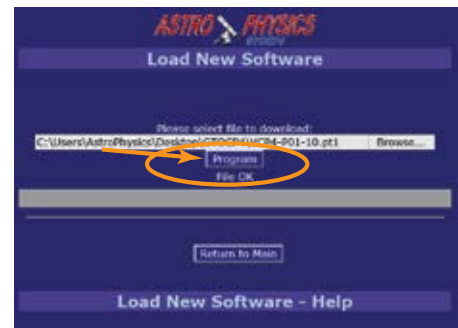
6. **Click on the Load New Software button.** The next Web-page will look like the screenshot below. Note that summary instructions are also included on this webpage.

7. **Click on the Browse button and browse to the folder where the new software has been saved.**

8. **Choose file: VCPx-xxx-xx.pt1.** This is the file that you will load first.



9. **File OK should display in a moment or two.** There will be a delay since the file is inspected by the CP4/5. If it is a valid CP4/5 code file, the indication "File OK" will appear, as shown below and the Program button will also appear.



10. **Click the Program button.** This will begin programming "part 1" of the new software. Programming the first file should only take a few seconds when using the CP4/5 Ethernet connection.

11. **Wait several seconds for Resume Operation to be displayed.** Programming the first file should only take a few seconds when using the CP4/5 Ethernet connection. When the download begins, the status Programming... will be shown.

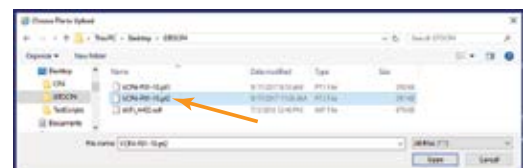
1st When the programming has finished, an indication of Download OK will be shown.

2nd A Resumed Operation message will also be shown that indicates the CP4/5 is fully functional again.



12. **Again, use the Browse button to re-open the same directory path.** This is noted as 3rd in the screenshot above. Re-open the same directory path.

13. **Choose file: VCPx-xxx-xx.pt2.** This file will be "part 2" of the new software, and will have a file extension of "pt2".



14. **File OK should display within a moment or two.** The Program button will also appear.

15. Click the Program button.



16. Wait approximately 10 seconds for Running New Program to be displayed. When programming “part 2” of the CP4/5 software, an indication of Preparing Unit... will appear. This means that the CP4/5 will need to re-boot and execute “part 1” software while it over-writes the old part 2 software with the new. “Part 2” contains the mount control functions. At this time, the front panel LED on the CP4/5 will begin to blink rapidly to indicate that the mount functions are not active.

When the CP4/5 is ready, the Programming... indication will be shown.

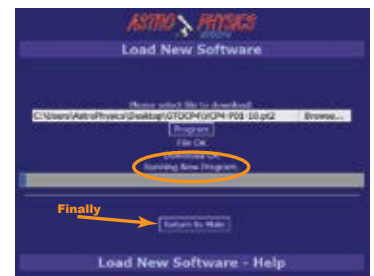
When the “part 2” file has been programmed successfully, the indication Download OK will be shown, followed by another indication of Preparing Unit... This means that the CP4/5 must reboot itself again to execute the software that has just been loaded.

When the CP4/5 is running the new software, it will indicate so by displaying, Running New Program. This will also be indicated by the CP4/5's front panel LED, which will stop blinking at this time.



In some cases, a software update may include additional parts, such as a “Wi-Fixxxx”, “part 3”, “part 4”, etc. If another part has been provided in the distribution, browse to it and load it by repeating the steps above for each additional part provided in the software release.

- Browse to file
- Open
- Allow verification
- Program
- Wait for Running New Program or Resumed Operation message.
- IMPORTANT! Please note that some parts like the Wi-Fi update may take several minutes to complete!



17. Click the Return to Main button to go back to the main window. The completion of the software update can be confirmed by clicking the Return to Main link.

18. Confirm that the version shown has incremented to the new version loaded. The original screen may be shown, but will indicate the newly loaded CP4/5 software version. As the browser screens are improved over time, the main page may look different following a software update.

19. Re-activate serial port connections to the CP4/5 and resume normal operation.



20. IMPORTANT!! After Installing the new CP4/5 software, you will need to do a full initialization of the mount INCLUDING resuming from the defined Park Position you selected when you started the upgrade in order to reestablish calibration.

APPENDIX B: PRE-DEFINED PARK POSITIONS (NORTHERN & SOUTHERN HEMISPHERES)

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 = $(-90 + \text{Latitude})$ South: Dec = $(90 + \text{Latitude})$

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 counterweight 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 = $(90 - \text{Latitude})$ South: Dec = $(-90 - \text{Latitude})$

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 C: REGULATORY INFORMATION FOR TRANSMITTER MODULE

FCC Notice (USA)

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: reorient or relocate the receiving antenna, increase the separation between the equipment and receiver, connect the equipment into an outlet on a circuit different from that to which the receiver is connected, or consult the dealer or an experienced radio/TV technician for help.

RF Exposure

WARNING: To satisfy FCC RF exposure requirements for mobile transmitting devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operations at closer distances than this are not recommended.

IC Notice (Canada)

The term "IC" before the certification/registration number only signifies that the Industry Canada technical specifications were met.

Le terme "IC" devant le numéro de certification /d'enregistrement signifie seulement que les spécifications techniques Industrie Canada ont été respectées.

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Cet appareil est conforme avec Industrie Canada RSS standard exempts de licence (s). Son utilisation est soumise à Les deux conditions suivantes: (1) cet appareil ne peut pas provoquer d'interférences et (2) cet appareil doit accepter Toute interférence, y compris les interférences qui peuvent causer un mauvais fonctionnement du dispositif.

This device complies with Health Canada's Safety Code 6 / IC RSS-210. The installer of this device should ensure that RF radiation is not emitted in excess of the Health Canada's requirement. Information can be obtained at: http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/radio_guide-lignes_direct-eng.php

Cet appareil est conforme avec Santé Canada Code de sécurité 6 / IC RSS-210. Le programme d'installation de cet appareil doit s'assurer que les rayonnements RF n'est pas émis au-delà de l'exigence de Santé Canada. Les informations peuvent être obtenues: http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/radio_guide-lignes_direct-eng.php

CE Notice (Europe)

This device has been tested and certified for use in the European Union.

If this device is used in a product, the OEM has the responsibility to verify compliance of the final product to the EU standards. A Declaration of Conformity must be issued and kept on file as described in Annex II of the Radio and Telecommunications Terminal Equipment Directive.

APPENDIX D: COUNTRY CODES FOR WI-FI

If you are operating the GTOCP5 in a country other than the United States, locate the appropriate Country Code in the table below, and enter it in the Country Code field in the Advanced Wi-Fi Settings webpage of the GTOCP5's built-in webpages. When entered, click Change next to the entry box. The country code accounts for differences in regulations such as the availability of channels or Access Point transmit power.

<u>Country</u>	<u>Country Code</u>	<u>Country</u>	<u>Country Code</u>	<u>Country</u>	<u>Country Code</u>
Afghanistan	AF	Botswana	BW	Croatia	HR
Albania	AL	Bouvet Island	BV	Cuba	CU
Algeria	DZ	Brazil	BR	Cyprus	CY
American Samoa	AS	British Indian Ocean Terr.	IO	Czech Republic	CZ
Andorra	AD	Brunei		Denmark	DK
Angola	AO	Darussalam	BN	Djibouti	DJ
Anguilla	AI	Bulgaria	BG	Dominica	DM
Antarctica	AQ	Burkina Faso	BF	Dominican Republic	DO
Antigua and Barbuda	AG	Burundi	BI	Ecuador	EC
Argentina	AR	Cambodia	KH	Egypt	EG
Armenia	AM	Cameroon	CM	El Salvador	SV
Aruba	AW	Canada	CA	Equatorial Guinea	GQ
Ascension Island	AC	Cape Verde	CV	Eritrea	ER
Australia	AU	Cayman Islands	KY	Estonia	EE
Austria	AT	Central African Republic	CF	Ethiopia	ET
Azerbaijan	AZ	Chad	TD	Falkland Islands	FK
Bahamas	BS	Chile	CL	Faroe Islands	FO
Bahrain	BH	China	CN	Fiji	FJ
Bangladesh	BD	Christmas Island	CX	Finland	FI
Barbados	BB	Clipperton Island	CP	France	FR
Belarus	BY	Cocos Islands	CC	French Guiana	GF
Belgium	BE	Columbia	CO	French Polynesia	PF
Belize	BZ	Comoros	KM	French Southern Territories	TF
Benin	BJ	Congo	CG	Gabon	GA
Bermuda	BM	Congo, Democratic Republic	CD	Gambia	GM
Bhutan	BT	Cook Islands	CK	Georgia	GE
Bolivia	BO	Costa Rica	CR	Germany	DE
Bosnia and Herzegovina	BA	Cote D'ivoire	CI	Ghana	GH
				Gibraltar	GI

<u>Country</u>	<u>Country Code</u>	<u>Country</u>	<u>Country Code</u>	<u>Country</u>	<u>Country Code</u>
Greece	GR	Korea, Dem. Peoples Rep. of	KP	Mongolia	MN
Greenland	GL	Korea, Republic of	KR	Montenegro	ME
Grenada	GD	Kuwait	KW	Montserrat	MS
Guadeloupe	GP	Kyrgyzstan	KG	Morocco	MA
Guam	GU	Lao, Peoples Dem. Rep of	LA	Mozambique	MZ
Guatemala	GT	Latvia	LV	Myanmar	MM
Guernsey	GG	Lebanon	LB	Namibia	NA
Guinea	GN	Lesotho	LS	Nauru	NR
Guinea-Bissau	GW	Liberia	LR	Nepal	NP
Guyana	GY	Libya	LY	Netherlands	NL
Haiti	HT	Liechtenstein	LI	Netherlands Antilles	AN
Heard or McDonald Islands	HM	Lithuania	LT	New Caledonia	NC
Holy See (Vatican City-State)	VA	Luxembourg	LU	New Zealand	NZ
Honduras	HN	Macao	MO	Nicaragua	NI
Hong Kong	HK	Macedonia	MK	Niger	NE
Hungary	HU	Madagascar	MG	Nigeria	NG
Iceland	IS	Malawi	MW	Niue	NU
India	IN	Malaysia	MY	Norfolk Island	NF
Indonesia	ID	Maldives	MV	North Mariana Islands	MP
Iran	IR	Mali	ML	Norway	NO
Iraq	IQ	Malta	MT	Oman	OM
Ireland	IE	Man, Isle of	IM	Pakistan	PK
Israel	IL	Marshall Islands	MH	Palau	PW
Italy	IT	Martinique	MQ	Palestinian Terr.	PS
Jamaica	JM	Mauritania	MR	Panama	PA
Japan	JP	Mauritius	MU	Papua New Guinea	PG
Jersey	JE	Mayotte	YT	Paraguay	PY
Jordan	JO	Mexico	MX	Peru	PE
Kazakhstan	KZ	Micronesia	FM	Philippines	PH
Kenya	KE	Moldova	MD	Pitcairn	PN
Kiribati	KI	Monaco	MC	Poland	PL
				Portugal	PT

<u>Country</u>	<u>Country Code</u>	<u>Country</u>	<u>Country Code</u>	<u>Country</u>	<u>Country Code</u>
Puerto Rico	PR	Svalbard and Jan Mayen	SJ	Virgin Islands, British	VG
Qatar	QA	Swaziland	SZ	Virgin Islands, US	VI
Reunion	RE	Sweden	SE	Wallis and Futuna	WF
Romania	RO	Switzerland	CH	Western Sahara	EH
Russian Fed.	RU	Syria	SY	Yemen	YE
Rwanda	RW	Taiwan	TW	Yugoslavia	YU
Saint Helena	SH	Tajikistan	TJ	Zambia	ZM
Saint Kitts and Nevis	KN	Tanzania	TZ	Zimbabwe	ZW
Saint Lucia	LC	Thailand	TH		
Saint Pierre and Miquelon	PM	Timor-Leste	TL		
Saint Vincent and the Grenadines	VC	Togo	TG		
Samoa	WS	Tokelau	TK		
San Marino	SM	Tonga	TO		
Sao Tome and Principe	ST	Trinidad and Tobago	TT		
Saudi Arabia	SA	Tristan Da Cunha	TA		
Senegal	SN	Tunisia	TN		
Serbia	RS	Turkey	TR		
Seychelles	SC	Turkmenistan	TM		
Sierra Leone	SL	Turks and Caicos Island	TC		
Singapore	SG	Tuvalu	TV		
Slovakia	SK	Uganda	UG		
Slovenia	SI	Ukraine	UA		
Solomon Islands	SB	United Arab Emirates	AE		
Somalia	SO	United Kingdom	GB		
South Africa	ZA	United States	US		
South Georgia and Sandwich Islands	GS	US Minor Outlying Islands	UM		
Spain	ES	Uruguay	UY		
Sri Lanka	LK	Uzbekistan	UZ		
Sudan	SD	Vanuatu	VU		
Suriname	SR	Venezuela	VE		
		Viet Nam	VN		

APPENDIX E: NETWORK PROTOCOL LICENSE

The GTOCP5 implements the network protocol stack using Light Weight IP (LwIP):

LwIP's License

LwIP is licenced under the BSD licence:

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