

English manual version 1.20

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Many thanks for purchasing the Mgen-3!

The Lacerta Mgen-3 is the new generation of the proven Mgen-2 autoguider. It contains new and important improvements like multistar guiding, self-parameterizing and an easy one push autoguiding start feature. Less hassle and more precision was our goal. The Mgen-3 can be used as a stand-alone guider, includes a timer for DSLR and similar cameras, or it can be controlled remotely via USB access. It can be connected via Ascom to various programs for synchronizing with CCD/CMOS cameras when dithering is needed (in progress, mgen.app will soon be released).

It combines a number of well established and some innovative **features**:

- programmed directly on the microprocessor, thus not relying on a non-astro operating system
- direct USB access, usually with automatic driver installation. Powered via 5V USB port
- increased sensitivity via optimized dark frame calibration
- multistar guiding (up to 100 stars, auto selection and weighting)
- self-optimizing and adjusting to changing conditions (A.I.)
- extreme subpixel precision not affected by seeing variations
- one push mode for fast autoguiding start
- dithering after a specified number of exposures (can be combined with Lacerta Motorfocus)
- DSLR/DSLM timer integrated, various modes can be controlled fully either standalone OR remotely ASCOM compatible via mgen.app – visit <https://mgen.app>
- north polar alignment via digital Scheiner method

Development:

With firmware version 1.00 the Mgen3 has about the same functionality as the Mgen-2, but has some important improvements. Numerous other features are in planning, such as platesolving and related features (micro GoTo via ST4, polar alignment, etc). There is an onboard WiFi module that will allow wireless connection to PCs or mobile phones and apps, adaptive optics, measuring of field rotation and derotator, and more. Please send us your ideas. Suggestions are always welcome.

Contents of the box:



- Mgen-3 Handbox
- Mgen-3 Camera (with M28.5x0.6 1.25" filter thread)
- Adapter Nr.2 for camera thread to T2
- Adapter Nr.1 for camera thread to 1,25" barrel (31.7mm) with filter thread
- 2x USB cables
- ST4 guiding cable
- 4GB SD card

Connecting the Camera to the guidescope:

The camera is extra lightweight (40grams) and designed to fit any guidescope. The camera body has the M28x0.6 common 1.25" filter thread. There is a screw-on barrel that can be used for fitting it to 1.25" focusers. A second adapter can be used to fit the camera to T2 threads. With the T2 adapter the backfocus is 9mm. See the various possibilities here:



Connection ports of Mgen-3:



Power: The Mgen-3 is powered via the USB port on the bottom right of the handbox (see picture). You may use a normal mobile phone wall adapter, a power bank or a USB port on your PC. The current drawn is typically about 240mA/1.2W.

The Mgen-3 can be used **standalone or remotely** via USB, using a Windows app that you can download to your PC. We have set up an **Mgen-3 specific Support Website** and invite you to visit it and register your device. You will get the firmware upgrades free for a year (extensions will be possible for a small contribution), and all the accompanying apps, manuals and videos are available there.

<https://support.mgen-autoguider.com/>

Manuals and apps are also free to download at the Mgen-3 product website at lacerta-optics.com
<https://lacerta-optics.com/Mgen-3#nav-support>

accompanying apps for the Mgen-3

in case of an error at opening please install Microsoft Visual C++ redistributable 2010
in case of an error "file xxx missing" place the needed file in the same folder as the app.exe

- virtual interface for full control via PC
- Sky Emulator for getting to know the functions indoors via PC
- API server mode for parallel access via multiple apps, access to the SD card
- Text Editor for translating the menu language

Comments and howtos for the apps can be found as readme files in the zip Files to download.

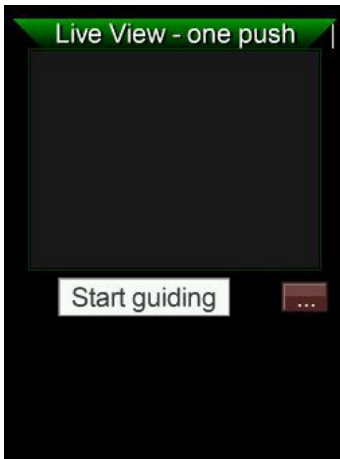
the Windows driver (FTDI)

In order to communicate with your PC it is necessary to have a driver installed. In most cases this will happen automatically if you are connected to the network. If your Mgen-3 is not properly recognized, please download the [setup.exe](#) file from here and install it ([available to the right under comments](#))

<https://www.ftdichip.com/Drivers/D2XX.htm>

The Mgen-3 is an easy guider – Guiding at the push of a button

Connect the hand controller to the camera via the USB cable, and to your mount's ST4 port via the ST4 cable (both provided). Power your Mgen-3 via the second smaller USB port (bottom right on the handbox), using the second included USB cable (normal 5V USB power). You can use a mobile phone wall adapter, a power bank or a USB port on a PC.



A short press of the **ESC** button turns on the Mgen-3, and after the splash screen the **One push** screen is displayed. What you see here is a live picture from the camera, containing stars. It's a black and white picture because the Mgen-3 camera has a very sensitive monochrome sensor.

Right below the screen there is a button, **Start guiding**

If the cursor is not yet on **Start guiding**, push the **DOWN ▼** directional button. Then press **SET** to start the sequence that leads to autoguiding.

The Mgen-3 automatically starts a **star search**, identifying and selecting many stars, goes through the **calibration** procedure with your mount (must be already tracking!), and **autoguiding** will be started immediately after that.

If Mgen-3 hangs at calibration, remember to plug in your ST4 cable. It always happens to me ;-)



The live picture is then replaced by the guide graph, and at the bottom, **Autoguiding** is displayed in red blinking letters. You may now start the exposure sequence with your camera, and the status is shown here, too.

The Mgen-3 will monitor the guiding, create its internal statistics and optimize the guiding values by itself. The multistar feature greatly reduces seeing effects on the guiding, and helps to get not only rounder, but also a little smaller stars in your pictures.

This one push autoguiding saves a lot of time! No need to check pictures, select proper guide stars, calibrate, change screens and press lots of buttons to take the same necessary steps every single time.



At the **onepush** screen, to the right of **Start guiding**, there is a little box containing three dots. Set the cursor onto it and press **SET** to enter a submenu, which allows to quickly enter some basic values if needed. It's a **shortcut**, we will discuss and set these values now at the menus that are their homescreens.

Because **at first use**, some preliminary steps need to be taken, like focusing your guidescope, setting some basic values, and getting to know your Mgen-3. We will now guide you through these steps.

Interface, menu and operating the Mgen-3

The Mgen-3's menu is divided into four main groups, dropdown menus containing several entries. Using the directional buttons **UP ▲** and **DOWN ▼** the cursor can be shifted through these items, while using **LEFT ◀** and **RIGHT ▶** the main groups can be selected. To enter a page use the **SET** button, and to leave it for the main menu use the **ESC** button.

The four main menus are:



DSLR Timer - here you find the exposure control for DSLRs and related cameras. Different sequences can be programmed. For now we offer four presets that can be edited according to your needs.



Live picture of the Mgen-3 camera, its settings and exposure time, and some related functions, as well as the one-push guiding page.



Autoguiding and related functions, like calibration, dithering and more (see page 16)



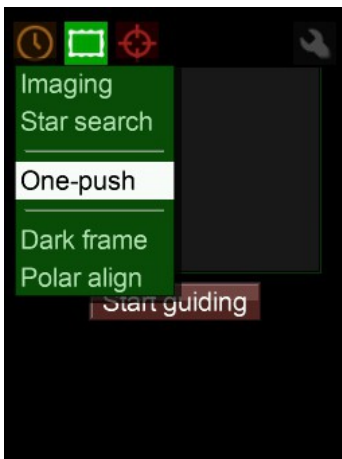
Options: Settings of the display, day/night modes, colors, languages, SD card, system and boot for firmware upload, and switch off. The ID number of your device used for registration can be found under System.

There is a shortcut to switch between pages directly: On any particular page, press and hold **ESC**. On the bottom a line appears **◀ change page ▶** and by pushing **LEFT ◀** or **RIGHT ▶** one can enter the adjacent pages.

Basic steps for using the Mgen-3 for the first time

To use the Mgen-3 you need to attach the camera firmly to a guidescope and focus it. You may connect to any scope, but we recommend using a small 30mm or 50mm guidescope. This allows for a bigger field of view, and the subpixel precision of Mgen-3 is so ample that it can accommodate practically any focal length. To achieve focus you can use the stars, but its also possible to do it in the daylight aiming at a very distant object (you will need to lower the gain and exposure time for this).

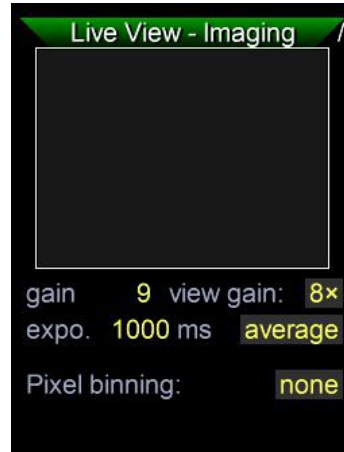
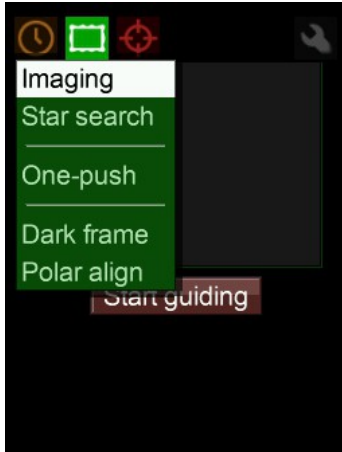
In order to focus the guide scope accurately you must switch to the live-view window where you can also make certain adjustments if necessary. You can zoom in to get a close view. First, press **ESC** to leave the one push page and enter the main menu:



Here you can shift the cursor by pressing the directional buttons **UP ▲** and **DOWN ▼**.

By **LEFT ◀** and **RIGHT ▶** you can change to other main menus.

For focusing we choose **Imaging**, and by pressing **SET** you enter the Live View-Imaging page:



On the **Imaging** page we find some values that need to be adjusted, and we can also zoom into the picture to get a much closer view of a star.

gain means the amplification of the signal coming from the sensor (recommended: 9). **View gain** is the extra amplification used just for the display (8x recommended). **Expo.** is the exposure time of the image (1000ms recommended for night sky, during daylight around 5ms). **Average:** Here, three modes are available that determine how the picture is calculated if the zoom factor is less than 1:1. Leave it at average.

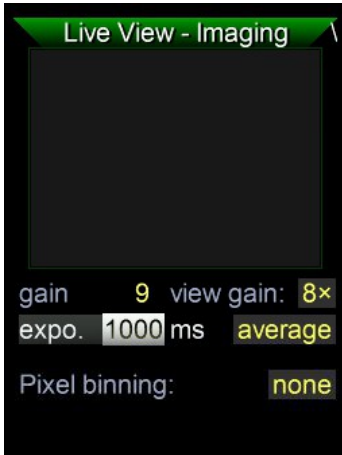
Pixel binning: Leave it at none (1x1) for the usual guidescope. For longer focal lengths or use with OAG's we recommend settings from 2x2 to 4x4, to keep the multistar's FWHM between 2 and 4 (see page 19). Well-sized stars also cause less artefacts to be found at long focal lengths.

Find more information on Mgen-3's image acquisition and processing in the tech. Doc. "**imaging**" at Mgen-3's support website.

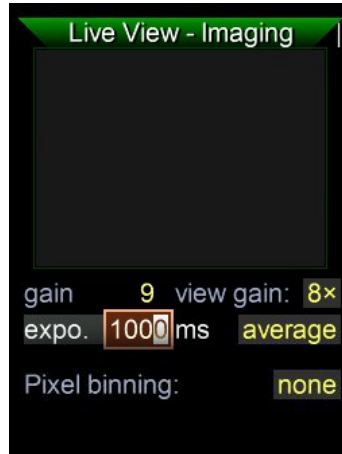
Editing numbers on the Mgen-3

To begin with the cursor rests on the live image, and by pressing **DOWN** ▼ twice it can be shifted onto...

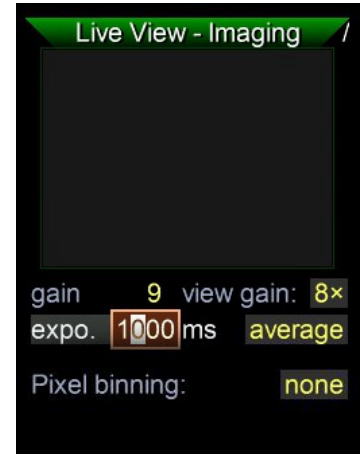
the value for the expo time:



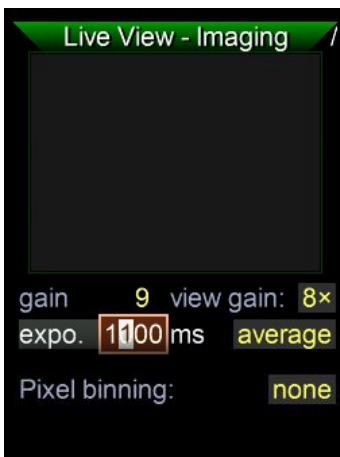
press **SET** to activate:



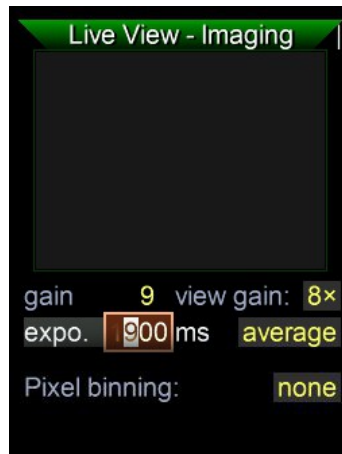
press **LEFT** to move cursor:



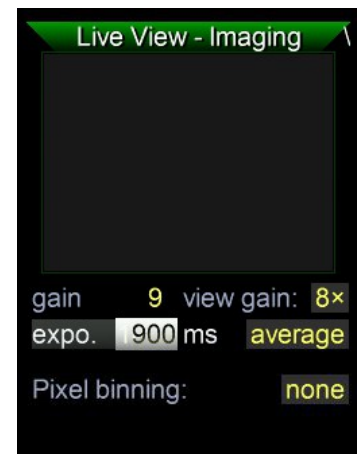
UP increases the number



DOWN decreases the number



and press **SET** to confirm



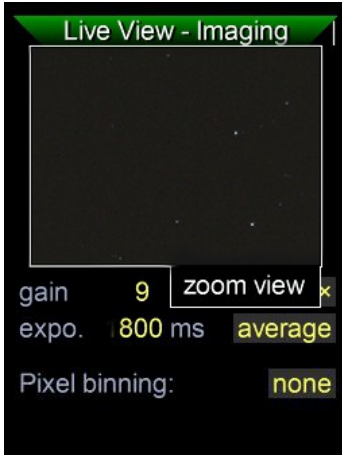
For finding focus it is helpful to estimate where to place the sensor of the Mgen-3 camera, especially if you need to use adapters. If you know the focal length of your guidescope, measure that distance from the lens backwards to find the approximate position. Another way is to point the guidescope at the moon, take a sheet of paper and move it back and forth behind the focuser until you find the spot where the moon is smallest. Place the sensor near that point.

With the default setting the camera is sensitive enough that you will probably already see some defocused star disks. Now you just need to focus your guidescope to make these disks as small as possible. Zooming in on one of those stars greatly helps.

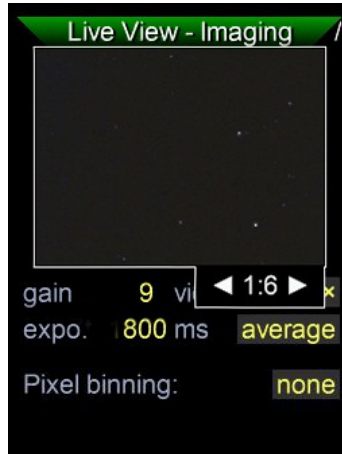
Zoom mode

Once you have achieved focus this way, you can use the zoom function to zoom into the picture for more precise focusing. Move the cursor back onto the live image and press SET to enter zoom view.

SET: enter zoom view



press and hold **ESC**,
the zoom factor shows up

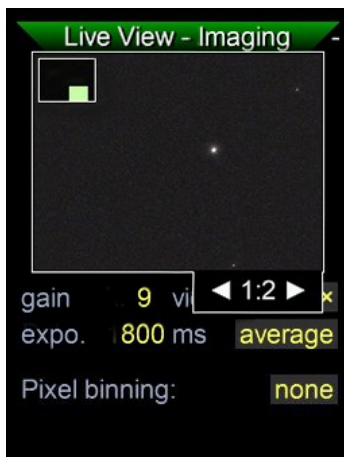


press **RIGHT** to
zoom in

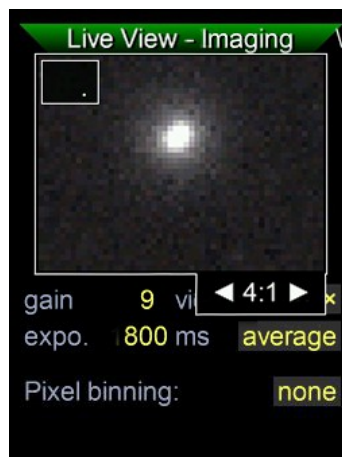


The small green area that shows up depicts the size and position of the field on the sensor.

Release **ESC**, and by using the
arrow buttons move the
selection box across the sensor.



Center on a brighter star.
By using **ESC+RIGHT** you
can zoom in up to 4:1



When done, zoom out by
pressing **ESC+LEFT** and
exit zoom view by **SET**



At this high zoom level (4:1 = 400%) it is easy to focus quickly and precisely!

Note #1: Fine focus can be precisely set using the FWHM value of the multistar – see page 17. This is the **RECOMMENDED FINE FOCUSING METHOD!**



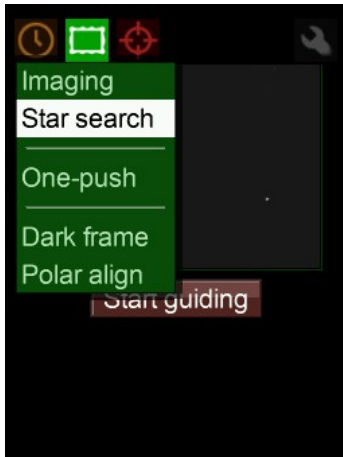
Note #2: You may also use a daytime target far in the distance for focusing. That way you save time under the stars. But you will need to adjust certain values to compensate for the much brighter daylight. See photo.

Note #3: After focusing, do not remove the Mgen-3 camera from your guidescope. That way there will be no need to focus it again and you are done for all times...

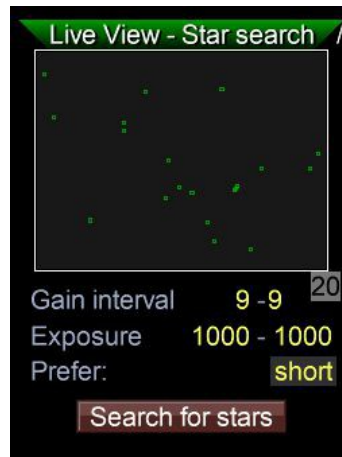
Star search is the next item after Imaging.

It is helpful to take a moment to have a look, check the settings and get to know what they do. These values are important, because they are also applied when doing a star search via the one push screen.

Select and press **SET**



to enter the **Star search** page



The little grey box at right shows the numbers of stars found at the last starsearch

Again the live image is displayed. You could even use the zoom function, but this page is actually used primarily to set the basic values for the automated star search.

Gain interval: Sets the range for the sensor amplifier used by the automated star search. If the full range 0-9 is set, Star search will use lower values if brighter stars are in the field. Brighter stars have a better signal to noise ratio, and the dimmest stars will be excluded. But a star that is too bright will also be excluded as it tends to dominate the combined multistar. If there are only dimmer stars in the field, Star search will use the full range and include more stars to compensate. Star search also does the calculation to create the multistar from all the stars found. Brighter stars get more weight than dimmer stars. We recommend leaving the gain interval at the default 0-9, but you may want to try manually and explore the effects. If there are lots of stars in the field and Star search catches the maximum 100 stars, you may try to lower the range, even down to 0-0 to find only the brighter stars. The Mgen-3 allows for full manual control.

Exposure interval: Here a range must also be set. The auto Star search then tries different exposure times from this range to find the proper exposure time best suited to the star field. Brighter stars will lead to shorter exposure time and vice versa. The time found here will also be used in autoguiding, and is the time interval when corrections are sent to the mount. If you own a mount with a less steep periodical error, corrections are less often necessary and you may allow for a longer time interval (up to 4000ms). If you use an active optics mirror you can use an extremely short interval (down to 1ms). For the usual mounts we recommend using a range of 800-1500ms (default values). With **Prefer** you further can direct the auto search if you want longer or shorter intervals.

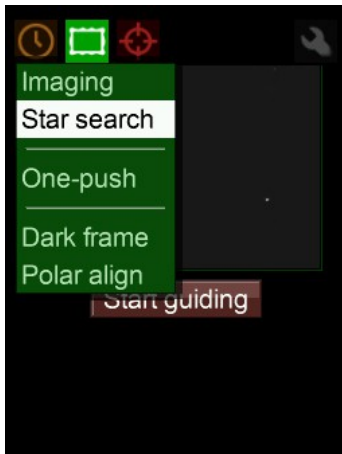
If you start a star search here, a few different exposure times are tried and you will see the numbers briefly showing up. When a suitable time is found and the stars are selected, Star search automatically switches to the **star selection** screen. This is for manual use and will be discussed later on. You have to go back to Star search to see that the found and selected stars are marked by small green squares that represent the readout areas the camera transmits to the controller. The determined exposure time can be seen in the **Imaging** page. Usually you start from **onepush**.

This exposure time also serves as a base for setting up the Mgen-3's internal statistics. It is permanently measuring the deviations and associates them with the correction pulses, and gets to

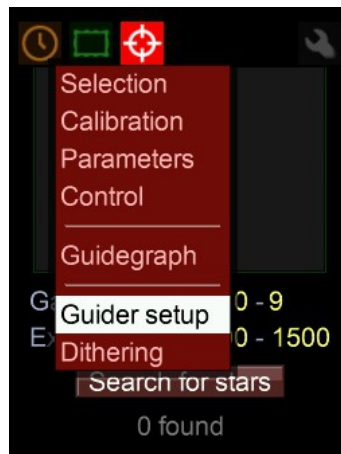
know how the mount is functioning (PE, etc). It always tries to minimize deviations and tweaks the guiding parameters accordingly on its own. If conditions change, it will go with them and adjust the values accordingly. At the start of the next session, the last values used will be recalled and be used as the new starting point, and they will then be constantly modified according to the conditions.

These values are to be set in the **Guider Setup**:

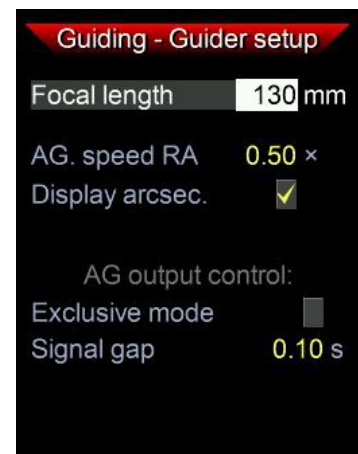
Call up the menu by **ESC**



by **RIGHT** ► switch to the neighboring menu and choose Guider setup



...and then enter by **SET**

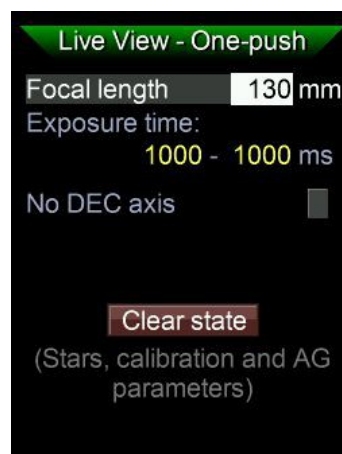
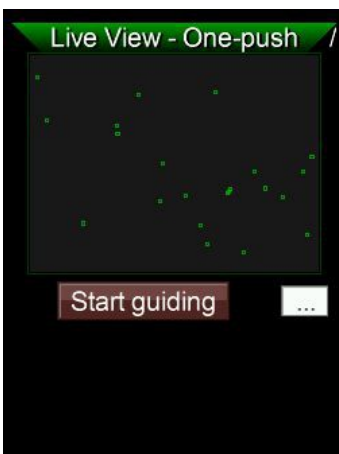


Check if the default values fit or need to be corrected for your setup. A 50mm finder usually has a focal length of 180mm, and a 30mm finder is usually 120mm. A Synta 50mm ED finder has 240mm. The autoguiding speed is usually 0.50x sidereal rate.

The Mgen-3 uses the focal length value for making calculations displayed in arc seconds, for example FWHM or rms deviation. Its useful to have them displayed this way in order to compare with different setups and have them related to a known angle unit. Therefore we recommend to have Display arcsec. checked.

Note #1: The values actually used for guiding are determined only in the calibration process, so the numbers set here only help to avoid movements that are too large or too small, and the calibration will be very quick and successful.

Note #2: These numbers are saved and only need to be set the first time you use it, as long as you do not change your setup.



Note #3: These settings may also be entered from the submenu at onepush (click the small box at right with the 3 dots):

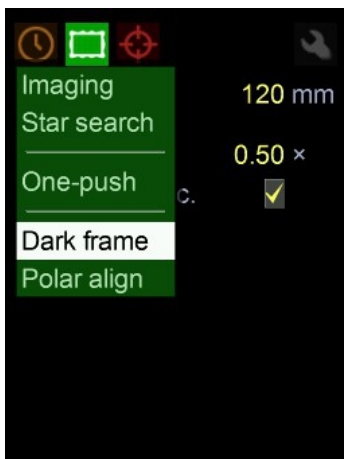
- focal length guidescope
- expo time guidecam (guide interval)
- DEC axis deactivation
- Status reset (useful when mount is changed. Autotrim parameters are reset, too)

Darkframe acquisition:

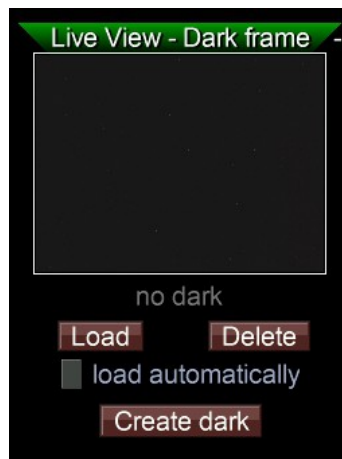
As with any camera, the Mgen-3 sensor will show some artifacts like hot and cold pixels, dark current, etc. For enhanced sensitivity and functionality, it is good to correct for these using correction frames. We call it Darkframe for simplicity, but there is more going on internally (optimized Dark, Bias, scaling, and overscan correction).

Acquiring a set of dark frames is very easy; just make sure that absolutely no light reaches the sensor. Covering it by hand in daytime, even indoors, is not sufficient. Do it at night, and make sure it is totally dark!

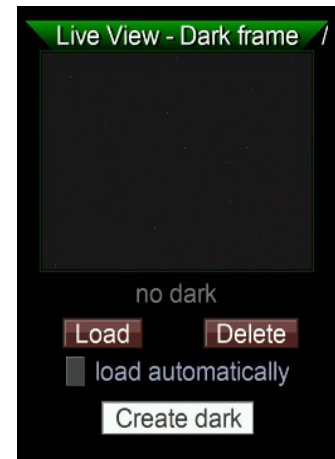
choose **Dark frame** in the menu



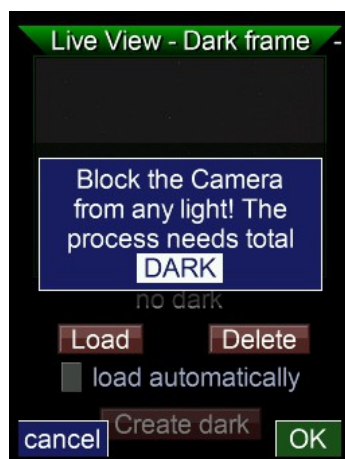
enter by **SET**



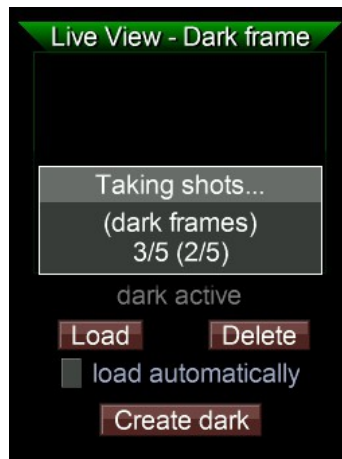
cursor on **create** + **SET**



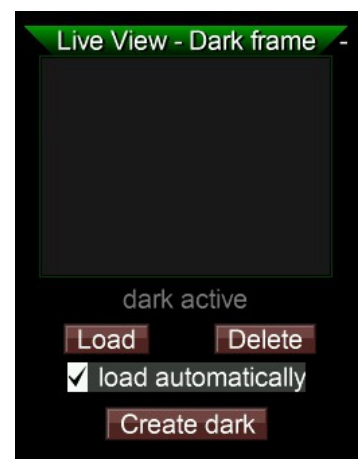
obey warning + **ok**



wait until done...



and check **load automatically**



The corrections are applied, **dark active** is displayed and the file is saved onto the SD card. If there is no SD card in the slot, there is a warning, but the corrections remain active until shutdown.

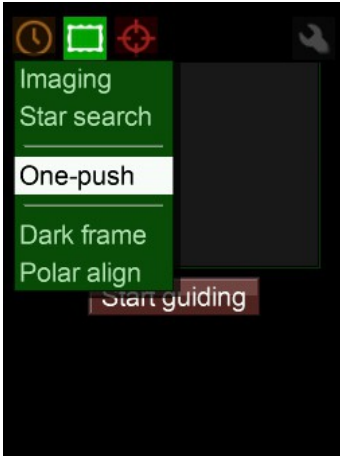
Note: Make sure to check **load automatically**, the correction file will be auto loaded every time the Mgen-3 is switched on.

After these preparations that only need to be done once before first use are completed, the Mgen-3 is fully trained to do its job. From now on you may start autoguiding right from the startup screen by one push of a button!

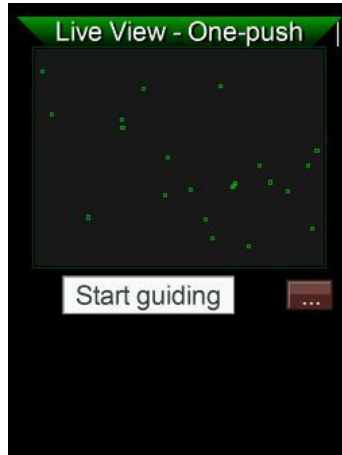
One-push – start autoguiding

After starting up the Mgen-3 the one-push page appears automatically, also showing the image from the camera. Move the cursor to **Start guiding** if it is not already there, and press SET. From the menu you can enter this page at anytime:

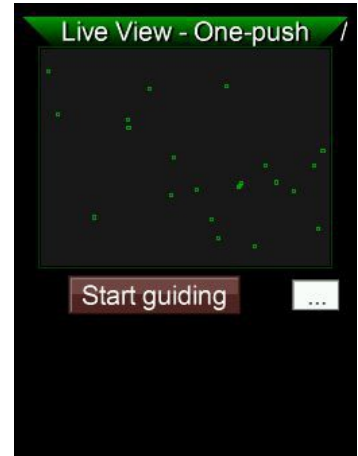
Select **One-push**



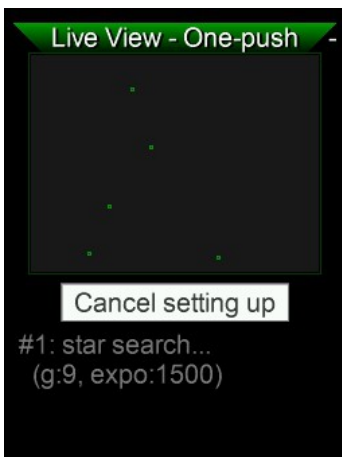
and start by **SET**



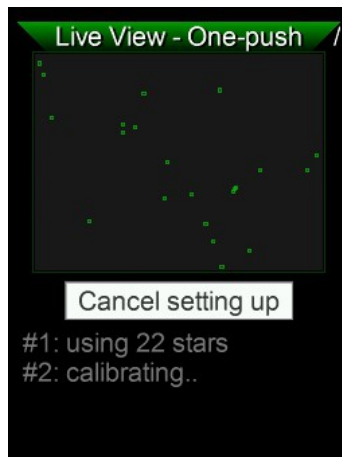
via the little box at right you can enter basic settings



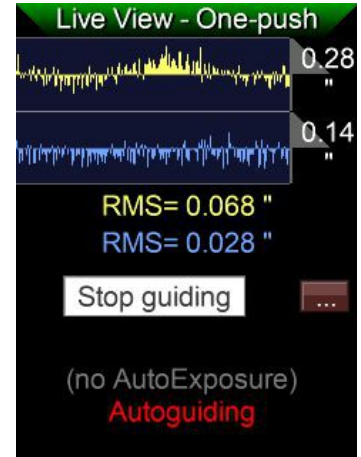
now the auto sequence takes over:
stars are being searched for...



...calibration takes place...



...and autoguiding is started



The live image is replaced by the guide graph, showing the progress of the autoguiding and displaying the rms deviations. You may also stop and resume guiding from here. If a new starfield is detected, a new star search and calibration takes place automatically. If detection fails, you may go to the Star search page and start the Star search there manually. Normally, the whole one-push sequence from start to autoguiding takes only about 30 seconds, no more.

The one-push feature helps greatly in atomizing the sequence of steps, but if you prefer, the Mgen-3 also allows for full manual or semi-manual control. The functions will be explained in detail in following chapters. But before that let's take a look at the DSLR timer and at dithering in order to have everything you need for your astrophotography session clearly understood.

Note#1: If calibration does not start automatically after star search, your focus may be too far.

Note#2: At the end of this manual you will find some important additional hints for a successful guiding.



DSLR exposure control

The Mgen-3 has a fully functional, on board remote timer. Using a proper cable for the camera model, your DSLR can be connected to the socket on the bottom of the handbox. Canon, Nikon, Pentax, many Sony and other cameras can thus be controlled via cable.

The exposure control is the menu furthest to the left. In the beginning, there is only one entry here, called Single.

enter by SET



program the timer



after starting, the remaining time is counted down



You can pause and restart the exposure sequence at any time. Two signals are sent to the DSLR: First, the focus signal (like half pressing the exposure button) and ESC lights up, then the shutter release signal and SET also lights up. If you want to use mirror lock, you need to activate it in the DSLR. The value 0.0s means no mirror lock. We do not recommend mirror lock with long exposure times. Mirror shake is more of a problem with very short exposures.

There are currently four presets that can all be programmed individually. More functions and combinations will follow (for example HDR sequences, and more).

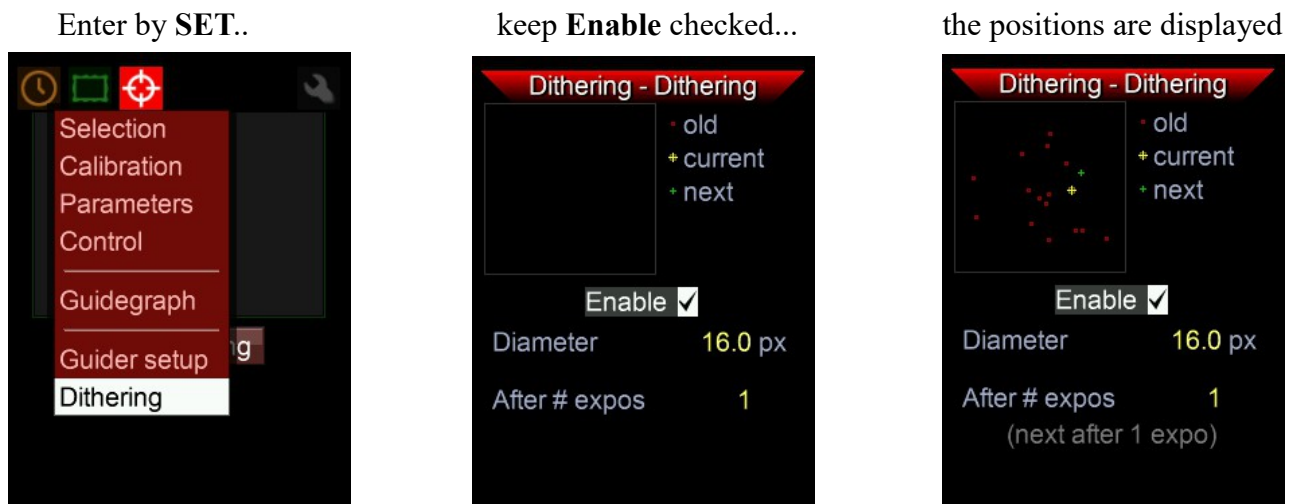
Note: The waiting time should be at least as long you DSLR needs to save the individual exposures and to be ready for the next one. We do not recommend less than 3 seconds. Below 0.4 seconds no shutter signal is transmitted.



The status of the exposure timer is conveniently also shown at the onepush screen. You see the preset number p# in the first line. The line below shows the number of the current exposure related to the total number of exposures, then the status (EXP = exposure time, W = wait time, ML = mirror lock time), and finally the counter.

Dithering 1 (basics)

Dithering means randomly shifting the guide star a short distance between the DSLR exposures. That way, hot and cold pixels, and even some of the pattern of the dark current imprinted on every frame can be practically eliminated during stacking of the frames, and a much cleaner master frame can be obtained. Stacking registers the frames according to the star positions, and hot pixels will have different positions relative to the stars when the camera is shifted – and they thus become outliers in the calculation. No more “walking noise” effect. Dithering is one of the main building blocks of modern astrophotography.



If enabled, the Mgen-3 will shift the guide star automatically a little bit after the specified number of exposures. You can observe the shifting on the active LEDs of the directional buttons when the ST4 output is activated immediately after the DSLR exposure has ended.

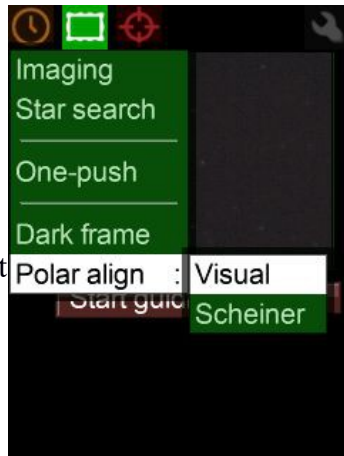
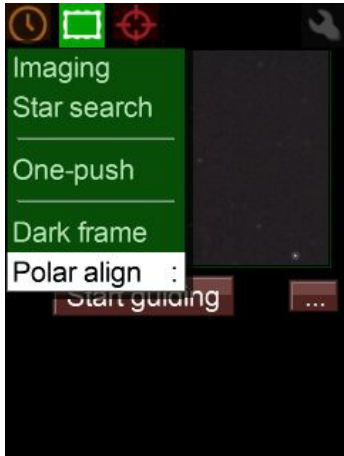
We recommend to keep dithering enabled. The diameter specifies the area the multistar is shifted around the original position, and it can be set up to 99.9 pixels. With a standard setup, 10-15 pixels are sufficient.

With a ratio of about 5:1 between the focal length of guide scope and the main scope, that is equivalent to 50-75 pixels on the DSLR (if the pixel pitch is same as the Mgen-3, 3.75 μ m). With very short focal lengths you may increase this value a bit.

If you make very many exposures, you may choose not to dither after every picture, but at longer intervals. It saves time (dithering takes a few seconds), but you won't lose the effect.

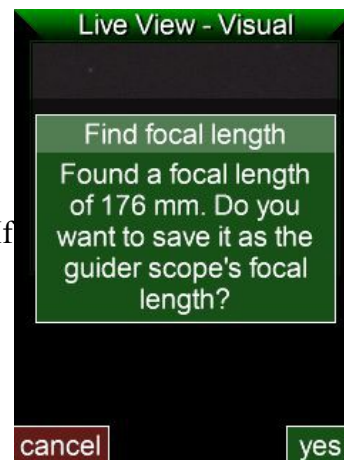
More on dithering with the Mgen-3 below in Dithering 2, (page 21).

Polar alignment with the platesolving (“Visual”) method

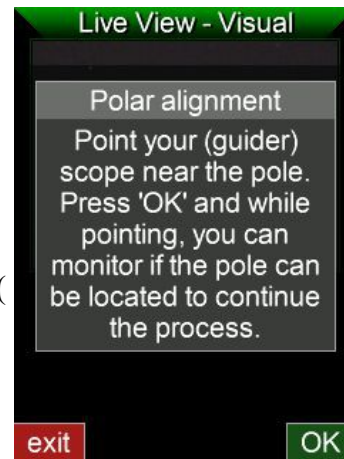


The respective screen is grouped with the Scheiner method in: Imaging menu, Polar alignment submenu. Place cursor on Polar align and press **SET** to unfold the submenu. Press SET again to enter.

The method is dubbed “visual” as it shows directly the pole and the rotation axis, and the alignment is done just the same way as using a proper polar scope.

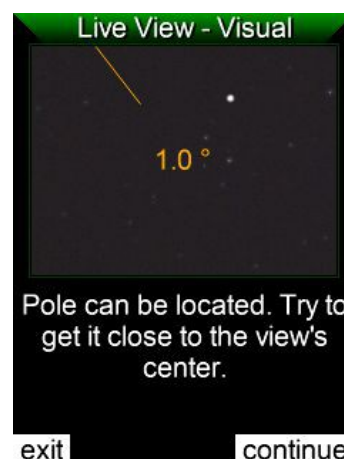


Start tracking, and point the guidescope towards the pole area. The star database covers 8 degrees radius, the view must be in this area. Choose **Hemisphere**. Run the **Find focal length** algorithm, it will search for the best fitting match from the database. Found, you can accept and store the value as the focal length of the guidescope. This alignment method must know that with ca. +/-12% precision to work well. (This measurement gives about 0.1% precision) Increase the **exposure factor** if more stars are needed.

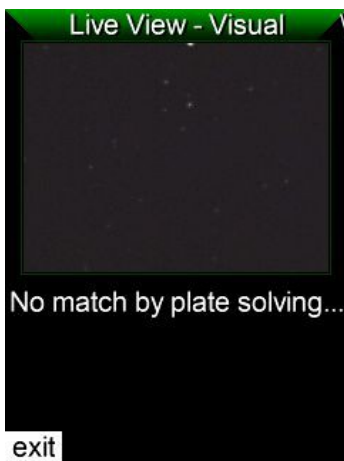


Start the alignment and follow the instructions on the display:

Point your guider scope near the pole..." - Eventually that's already done due to previous focal length measurement. Press ok (SET) to continue.



As new frames come in, they will be platesolved each and the result is displayed. If the pole is located, it's displayed on the live view as an orange cross, if inside the view. If outside the view, a line towards the pole shows what direction it is and a distance value is displayed how far it is from the view's center. Align the guider scope so, that the pole gets visible on the view and near center. Use DEC first to minimize. Press **continue** to store the pole's position and carry on.



Remark: While moving the guidescope, the exposures are constantly going on and the stars will be smeared. This screen tells you that the current frame could not be platesolved. Just wait a second to get the next frame to be measured. Also, if the guidescope is not pointed at the area covered by star data, this message will be shown.

exit will abort the polar alignment procedure.

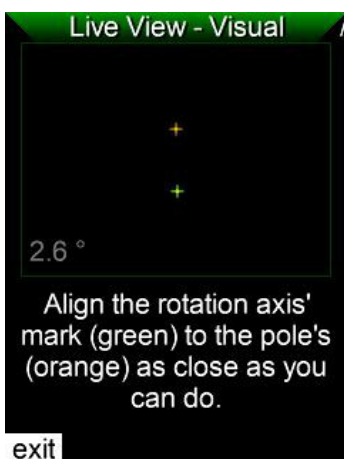


The location of the pole is now saved and the mount's RA axis' point on the sky should be determined. To do this you should turn RA for at least 15 degrees. Make sure not to touch DEC.

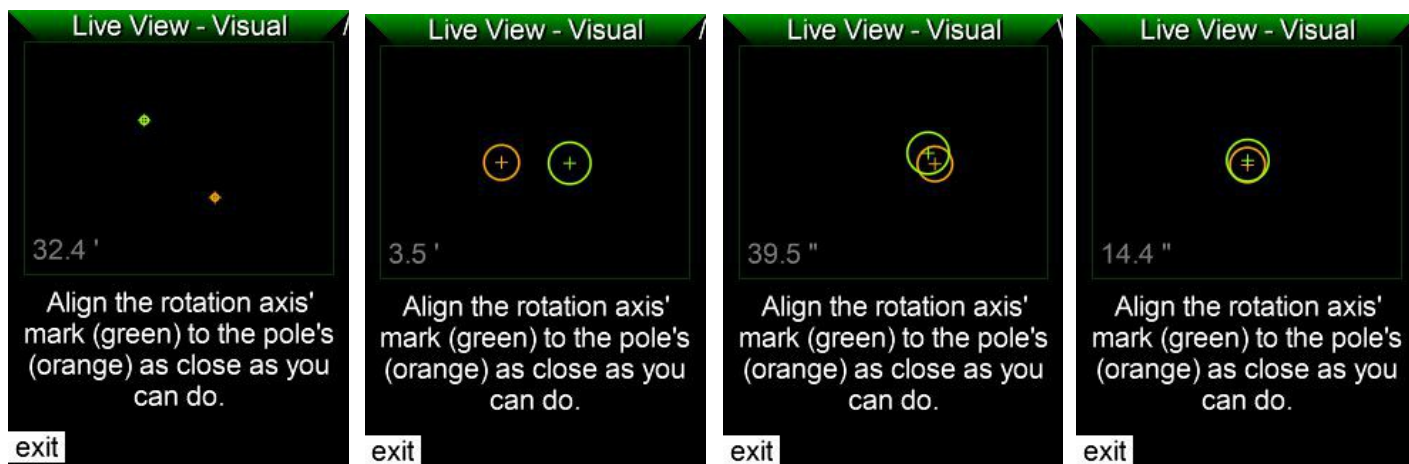
Mgen3 will tell you that the rotation is yet too low, if so.



You may turn RA 90 or even 180 degrees, all is a good option. But if the guidescope axis is much tilted to RA axis, huge rotation movements may carry the pole outside of the field. Too low an amount of rotation may lead to less precision – 15 deg is mostly satisfactory. Once you have turned it and the frame is stable (platesolving ran ok), you can see the rotation point as a green cross. Maybe you can not see it if outside the view, but the text will indicate that rotation point is known, and the grey number in the left down corner shows the distance from the pole. Press **continue**.



The live view disappears and the two points can be seen, auto zoomed. The distance between them is displayed too, so that you know if adjusting the mount's Alt/Az in a direction is good or you need to adjust it in the opposite direction. Start adjusting Alt/Az screws on your mount now and watch the points approaching each other and the number getting smaller. The goal is to get the green cross (RA axis) to match the orange one (the pole).



When getting the RA axis near the pole, the view zooms in automatically and circles appear around the two crosses. The better the match, the smaller the adjustments must be done to home in. A precision smaller than 5arcmin is aptly sufficient for astrophotography when using an autoguider, but you may try how close you can get. Press **exit** to quit.

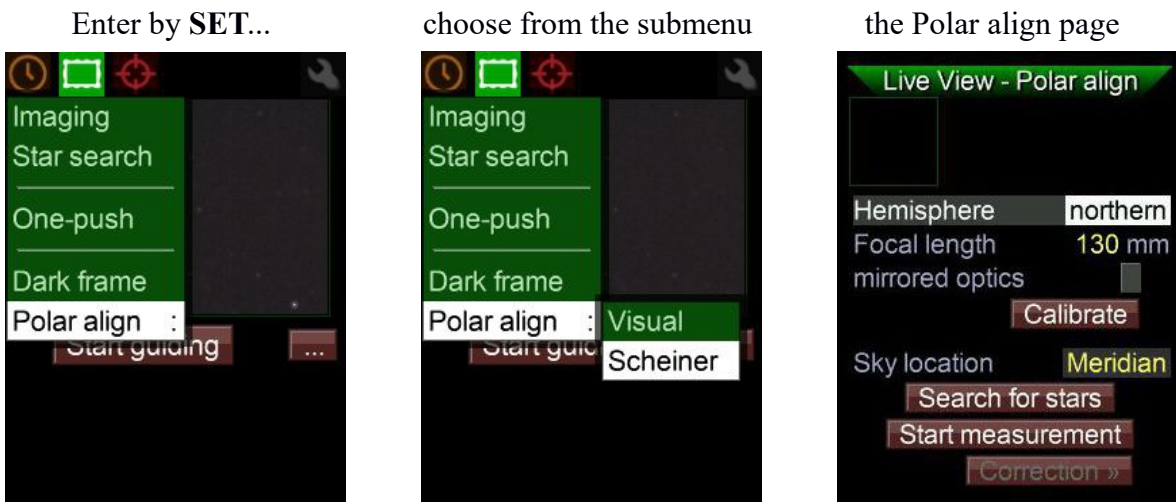
Of course, a second alignment run can be done, especially if the pole was out of the view at first and you had to align the guider scope a lot to the pole. This way the precision will be much higher for this 2nd finetuning alignment.

Some remarks and additional information:

- the firmware itself contains the stardata so it works without SD card, too
- platesolving here uses the brightest 4 stars in view to match them with the database. It will rarely fail with a precise focal length set. The sensor may be hit by cosmic rays, and these can be in the brightest 4 light sources on the image. Platesolving uses them as stars and so no match will be found. So if randomly no match is displayed, don't worry, the next frame will be good again.
- for this polar alignment, gain is always 9 and exposure time is 1 seconds. Using 1 sec is designed to work well with the following optics: 50mm @ f/4 (or faster), 100mm @ f/4.5, 176mm (Synta finder) @ f/5 and 300mm @ f/6. Faster optics will help to find matches, slower optics may need the exposure factor increased. The focal length finder algorithm works best with focal lengths from 50 to 300mm.
- optics distortion: Optics are considered to be linear (precise perspective mapping). At the 176mm Synta finder the distortion is negligible low, but optics like a fisheye lens (high barrel distortion) can be problematic.

Polar alignment with the digital-graphical Scheiner method (star drifts)

The polar alignment according to Scheiner the drift of a star is measured, that occurs when the mounts RA axis is not pointed precisely at the pole. The drifts Mgen is measuring are used to correct the axis orientation in two steps. The pole does not need to be in sight. First, a star close to the **meridian** and near the equator is chosen to adjust azimuth (left-right), and then a star either deep in the **west or east**, also near the equator, for correcting the pole height (up-down) of the mount. Finetuning by **moving the star on the display** is very quick and accurate. With the multistar feature of the Mgen-3, the influence of seeing is greatly reduced, leading to useful results in a very short time.



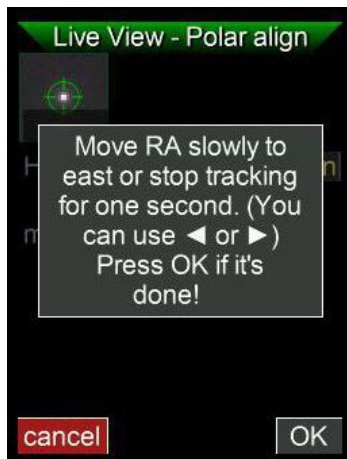
Polar aligning a mount usually is done before autoguiding, so after startup you can switch directly to this page. The screen looks loaded at first, but all entries are in a logical sequence and allow to do the adjustments in just a few steps:

- Set the hemisphere you are located, and focal length of the guidescope, and calibrate Mgen
- measure and coarse adjust azimuth error on Meridian
- fine adjust azimuth at East or West. Being there, coarse adjust altitude.
- fine adjust altitude back at the Meridian

The measurement is done where the partial drift is strongest, while the (fine) adjustment is carried out where the star movement corresponds to the calculated difference. That way a single run usually is sufficient. We now go through it step by step:

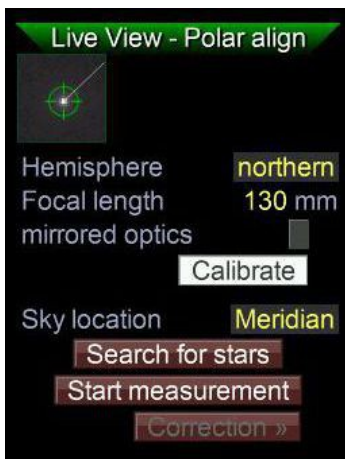
Preparations and aligning **Azimuth**:

- point your mount roughly to the pole and track with sidereal rate. If you have no sight to the pole, you may use the compass and inclination sensor of your mobile phone.
- set the **hemisphere** of your location (northern or southern)
- set the **focal length** of your guidescope (if not already entered). With OAG, tick mirrored
- set **Sky location**, where the guidescope is pointed to. Point it towards the Meridian (and near equator), because this point can mostly be reached easily, while the East or West point on the horizon are out of sight usually. That helps to adjust azimuth more precisely, avoiding it to mix later with latitude error.
- press **Search for stars** (near bottom of this page). The multistar appears in the little window (marked with green circle and cross)

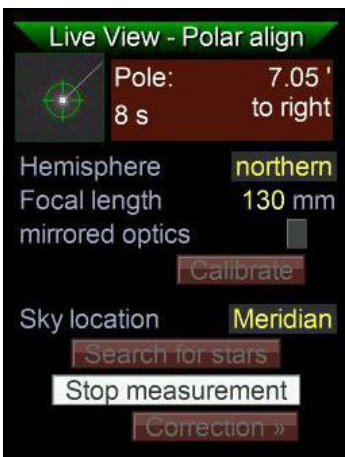


- press **calibrate**. The Mgen-3 needs to know how the pixel rows of its camera are related to the mounts axes. This is done by a small calibration routine. You only need to do it once at the beginning of every polar alignment session.

A box pops up. Follow the instructions. Your mounts RA axis needs to be slowly moved a little eastwards. Stopping the tracking for some seconds has the same effect. You conveniently may use the **LEFT** button on Mgen for about 8 seconds to manually send the respective ST4 signal.



When done, press OK (**SET**). A little line appears, stretching from the multistar pointing to the pole. Mgen3 now knows how it is aligned to the axes of your mount.

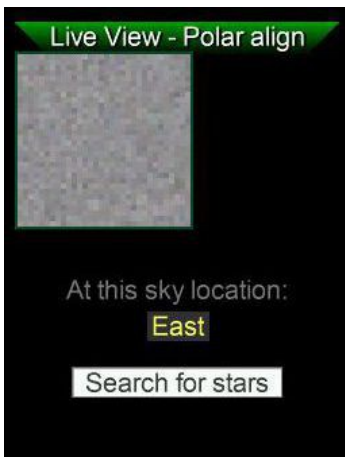


- Now press **start measurement**.

After a few seconds, results appear that are continuously updated as time goes on. The deviation is displayed in size and direction. Wait for about 30 seconds until the numbers get stable, then stop the measurement. If the pole is to the right, your pole block must also be turned to the right (imagine the point where the mount axis pierces the firmament, it must be moved to the right). But wait - what does that number mean, how much do you need to turn the azimuth screw?

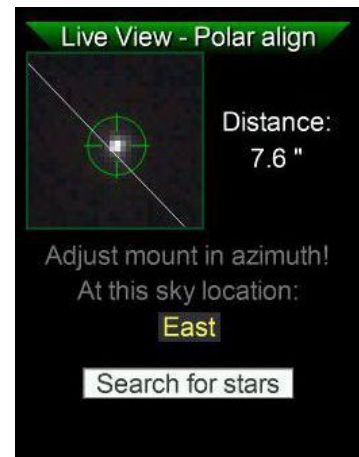
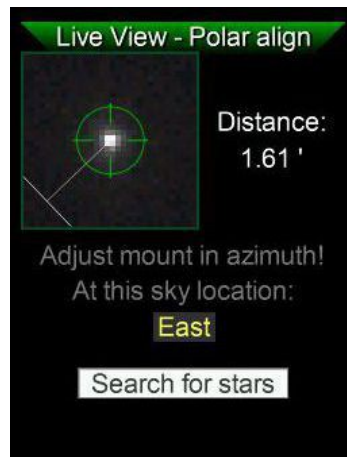
Now we start the rough adjustment by the **digital** part of the method. Note down the measured value and turn the azimuth screw a half rotation (any direction). Do a new starsearch and measurement, and note down the new value. The difference of the two values tell you how much a half rotation of the screw affects the azimuth. With AZEQ6 for example it's about 0.5 degrees. Calculate how much half turns you need to bring the last value down to zero, and adjust the azimuth screw accordingly (I found half turns to be counted most easy). Wait for a few seconds to let the mechanics settle down, start a new starseach and measurement and refine.

If you measure below about 20arcmin, turn to the **graphical** method. Right at bottom of the screen press **Correction**.



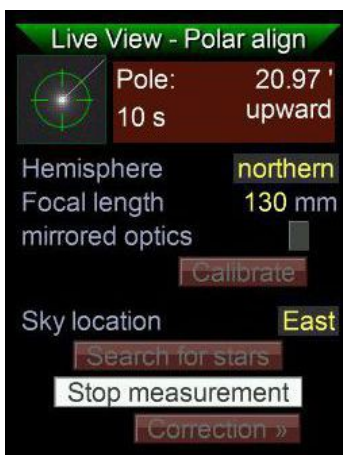
A new screen appears. Now turn the mount to the Eastern or Western point most near horizon in your reach. Keep on the equator, so do not move DEC. Select your location on this screen and press **Search for Stars**.

The multistar appears, and a line starting from it. Slowly adjust the Azimuth screw, so the star moves along the line (almost). The screen refresh rate is faster here, to help keeping the star in the window that follows the star. To the right the distance is shown, it should get smaller. Near Zero another line appears, place the star on it to home in. While displayed, its not needed with arcsecond precision.



You now have aligned the azimuth of your mount with sufficient accuracy and may proceed to the next step:

aligning the **polar altitude** of your mount, which follows the same scheme – first roughly using the digits, then fine using the graphical screen.

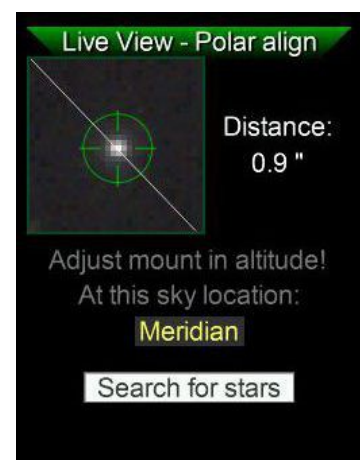
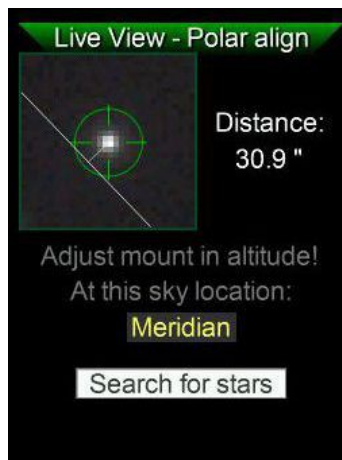
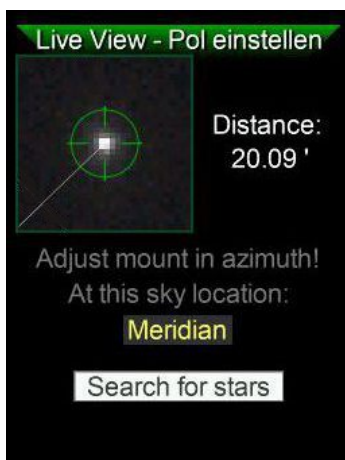


- You now already point to a starfield deep in the east or west, near equator
- press **ESC** to get back to the main screen, choose East or West accordingly
- start a star search and then a measurement

After some seconds results appear that are continuously updated as time goes on. The deviation is displayed in size and direction. Wait for about 30 seconds until the numbers get stable, then stop the measurement and note down the value. Turn your altitude screw half a turn, do a new starsearch and measurement. Calculate the difference, that value tells you how much half a rotation affects the altitude. With my AZEQ6 it's about 1.5 degrees. "Upward" means, your RA axis pierces the firmament below the true Pole and needs to be set steeper. Adjust your altitude screw according to the last measurement to get near Zero. Do a new starsearch and measurement and refine. Very quickly the error should be below about 20arcmin and you may turn to the graphical method.

Press **Correction** to enter the graphical screen.

Point your mount back to the Meridian, enter Meridian and start a starsearch. The multistar and the line appear, now slowly turn your altitude screw to move the star along the line. Near Zero the second line appears where you finally place the star:



You now have aligned the polar axis of your mount with sufficient precision. Of course you may do another run to refine precision further - but only using the finetuning with the graphical screens. Try it, but mostly this is not necessary, as.... you are using an Autoguider!

Calculations on the needed precision of polar alignment have shown, that a deviation of about 5-10 arcmin is sufficient for astrophotography. Even 20min exposures then would not show field rotation in the corners of fullframe sensors, provided you do autoguiding and the guidefield is at the exposure field. Trying to obtain better precision than necessary is not only waste of time, but also may confront you with secondary phenomena that would have no real effect on your subframes.

Note#1: Note down and archive the measured valued for half-a-turn of your azimuth and altitude screws. No need to carry out again this step in future!

Note #2: A more technical description of basics and details regarding the implementation of the stardrift method in Mgen3 can be found at the support website.

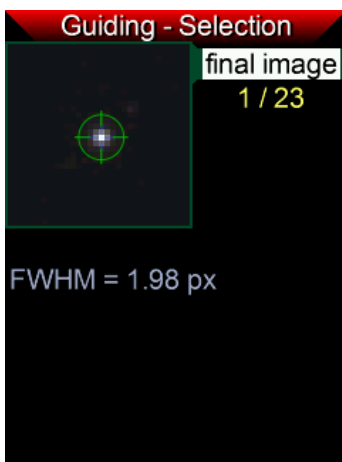


Autoguiding menu and related functions

In this menu section you find functions essential to autoguiding listed in proper succession, and you can set parameters manually. The parameters set here are also used by the one-push process, so you may do some refinements for your particular setup and benefit from using them later during one-push guiding. If you use Star search instead of the one-push function, after completion, the Mgen-3 switches automatically to Star Selection.

Guiding – Selection

The Mgen-3 measures and weights every star found in Star search, and combines them accordingly into a multistar or master guide star. Stars with a bad signal/noise ratio or very bright stars that would be too dominant are excluded automatically. This auto selection process is quite effective and reliable in most cases.



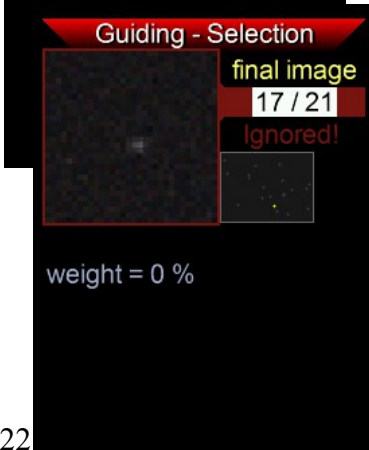
To provide manual control over this process, there is the possibility to check the found stars one by one and deactivate or reactivate them before they are combined into the multistar. If there are doubtful stars, artifacts or otherwise unwanted stars, they can be rejected. Single problem cases will not noticeably influence the multistar, but here is room to experiment if you wish to.

After Star search, the star selection appears automatically, showing the calculated multistar in the small window, centered in the green circle and cross, and its FWHM is displayed in pixels. The size of the green circle is 4x FWHM. You may also use this window for **focusing the guidescope**. It can be called up by setting the cursor on **final image** and pressing **SET**.

Note: The auto star search tries to have the multistar within a certain FWHM range. With very short focal length guidescopes it can happen that the FWHM drops below 1.5 pixels. That would start to influence the sub-pixel precision (undersampling). In such cases it is recommended to have the focus of the guidescope a little soft. A value exceeding 3-4 pixels is considered unnecessarily large (oversampling), and should be avoided by precise focusing. Using the binning modes to keep FWHM in range at long focal lengths makes sense, but focus comes first!

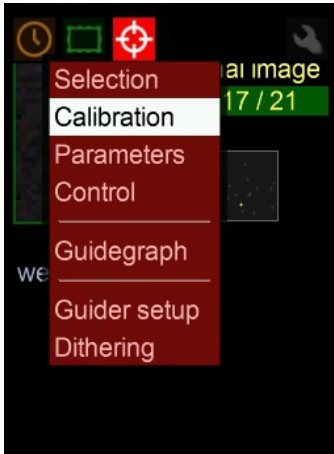


If the cursor is set to the star number and **SET** is pressed, the image of the respective star is displayed (here star 1 from 21), and the weight for its contribution to the multistar. The smaller window shows its position on the sensor.

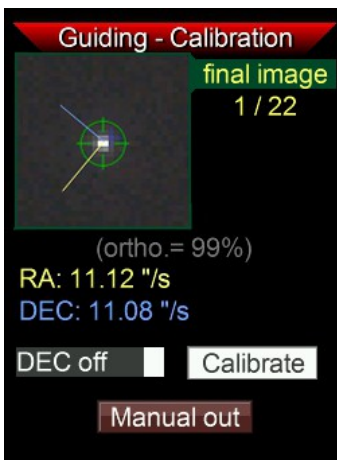


Using the buttons **LEFT** and **RIGHT** the stars can be called up one by one, and deactivated or reactivated by pressing **SET**. A deactivated star is shown against red and is ignored, and its weight is set to 0%. This procedure is not needed normally, but at high focal lengths and with a few stars only it could help removing found artefacts.

Guiding – Calibration



During Calibration the Mgen-3 measures the movements of the multistar, and ST4 signals are transmitted to each of the four direction controls. This is to determine the length and direction of the ST4 signals to be sent in order to achieve the necessary correction and restore the multistar to its reference position. Because of the many stars used, the needed calibration movements are shorter and faster than is usually the case. Setting correct values in the Guider Setup menu helps in calibrating quickly and precisely.

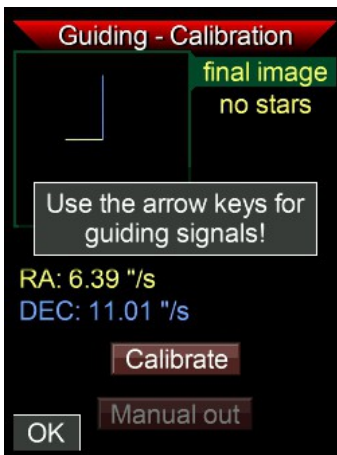


Set the cursor on **Calibrate** and start calibration by pressing **SET**. The sequence takes a few seconds and ends displaying some results. First, the orthogonality of the DEC and RA movements, and the respective speed the multistar movements in each axis.

It is good to have a look at these results. They tell you if the mount reacts precisely to the correction signals. The DEC speed is typical for the setup and stays the same everywhere in the whole sky, but the RA speed gets smaller and smaller as you approach the pole (cosinus DEC function). If a speed value looks improbable, check for connectivity. Orthogonality is influenced mostly by random backlash that occurs during the test of the other axis. 80% is already acceptable, but values over 90% would be preferred.

With **DEC off** checked, calibration will not take place in DEC. Important for RA only mounts.

Note: While calibrating, watch the directional buttons. They light up one by one, while the respective ST4 signal is transmitted to the different direction controllers. The sequence of output is DEC ▼, DEC ▲, RA ►, RA ◀. If calibrating in one direction takes unusually long, it is a hint that something is wrong. It could be, for example, a contact problem, or excess backlash in the mount.

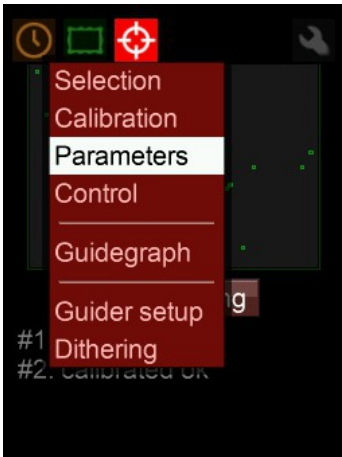


At the bottom of the page there is the **Manual out** button. This is an important tool to check the connection to the mount. Set the cursor and press SET, a box appears telling you to now transmit the ST4 signals by pressing the directional buttons. Check if the multistar moves when you output the signals manually. Exit this mode by pressing **ESC** (OK).

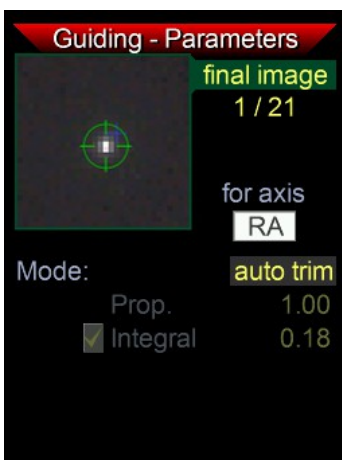
You do not need stars to do this test: In daytime, set your mount to tracking, and enter calibration/manual mode without having a star. Then transmit the signals one by one and listen to the sound of the motors. Listen if anything changes when you press the buttons. It helps to have an ear in contact with the mount's head for this. All four direction commands must respond, otherwise there is a problem.

Note: With mounts that show some backlash, it is not good to balance the scope perfectly, but to try to have a little bias. The weight pulls the tooth of the gear always on the same side of the worm, and backlash is effectively eliminated. Do that with both axes. Especially the DEC tends to start floating randomly if the scope points near the zenith.

Guiding - Parameters



The guiding parameters are values basic to guiding. Measured deviations of the multistar must be converted into correction signals, and how the Mgen-3 does that can be adjusted here. The default values are configured to work well in most situations, but with the Mgen-3 it is also possible to fully control the algorithm manually. The values chosen here apply also in one-push autoguiding.



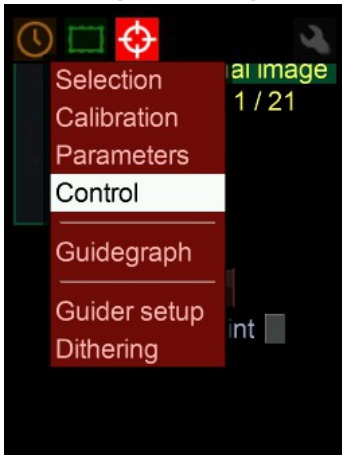
The RA and DEC axis are to be selected separately. First shown here is the **RA** display. Two modes are available, auto trim and manual. With **auto trim**, the self-parameterizing algorithm always seeks to minimize deviations by itself. So the values are grayed out. With **manual**, you can set proportional and integral values. It functions in essence like a PI control loop. Proportional corrects the measured deviation linearly, while integral is a longtime correction supplement derived from internal statistics. The interplay between them is the crucial factor to minimize deviations. Tolerance allows for some deviations before the system reacts and buffers overreaction. For advanced users only!



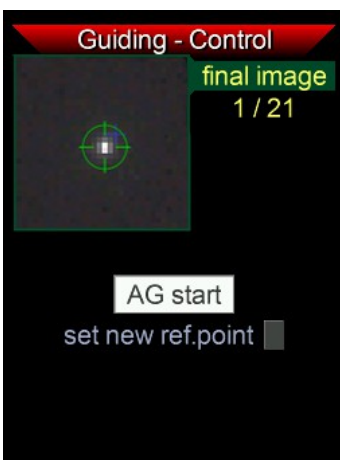
On the DEC page the standard mode is currently **manual** only. The DEC shows neither periodic error nor overtones, but static drifts or erratic movements. So an integral term does not make much sense. Instead, a value of 0.8 for proportional will suit most situations. In the case of overreaction you may lower this value to avoid oscillation of the mount. The tolerance can be left at 0.00, or increased if corrections in the DEC axis need to be dampened. For advanced users only!
Accumulate#: Numbers of pictures at Mgen-3, after which only the DEC correction signal is emitted. Good for well aligned mounts, against e.g. oscillations.

More possibilities like deactivating one guiding direction, and self-optimization here also will soon follow.

Guiding – Autoguiding Control



The next page is called Control



This is the place to start autoguiding manually (**SET**), or stop autoguiding (again **SET**)

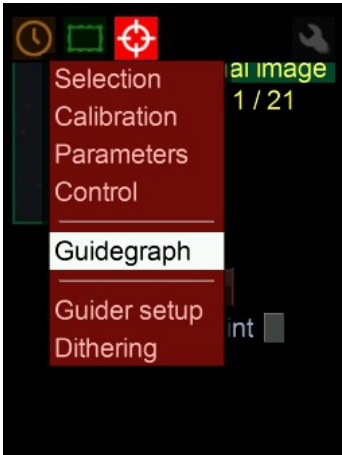


When autoguiding is started, **AUTOGUIDING!** appears and blinks, and a red cross marks the set point where the star should be kept.

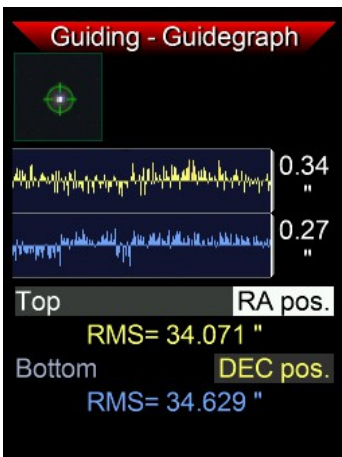
The reference point is used only during dithering. If autoguiding is stopped and the guide star shifted, and the new position will be used as the new reference point, mark the **set new ref. point** checkbox. Otherwise the Mgen-3 will inevitably move the guide star to the old position, if autoguiding is re-started.

When dithering occurs, you see an interesting interplay: The position of the multistar at the start of autoguiding is marked by a blue cross, the new position calculated during dithering will be marked by a red cross, and the multistar (marked by the green circle) is moved there, and autoguiding is then resumed.

Guiding – Guidegraph



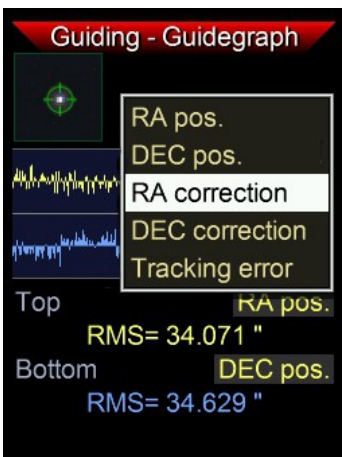
Below Control in the menu you find the page to observe the guidegraphs.



By default you see the positions of the multistar displayed, showing the deviations from the zero line. RA is the upper, DEC the lower graph. The graph is updated every guide cycle and shows about the last 220 positions.

To the right of the curves their **scale** is displayed. It is the size of the vertical white line. The **standard deviation rms** summarized from the curve is displayed below the curves.

If a measurement is considered to be a bad one, a red line is inserted into the graph, and this position is ignored for guiding. This happens if clouds obscure the stars, or for other reasons.



If the cursor is on **RA pos.**, you may press **SET** and a box pops up. Here you can choose what kind of graph should be displayed – correction means the length of the respective AG signals, and tracking error are the summarized corrections.

These choices can also be made for the lower graph.

The same graph selection will be also displayed at the one-push page, after autoguiding is started.

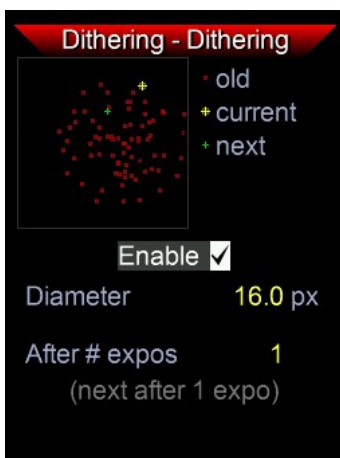
Guiding – Guider Setup

As already discussed on page 10, the focal length of the guidescope, the autoguiding speed of the mount and the display arc seconds are to be set here.

Dithering 2 – supplement

The basic settings have already been discussed on page 14. Here is some additional information.

Dithering shifts around the guide star in a random way, but not further and further away from the initial position of the first exposure, rather it stays in its vicinity. The size of this area is controlled by the dither diameter (in pixels of the Mgen-3 camera). If it is necessary to choose another position as a reference, go to the Control page and check the **new reference pos.** box. The new positions calculated during dithering will now be spread around the new initial position.



In the box in the upper left there is a graphic display: The previous positions are represented by little red crosses, the actual position by a yellow one, and the next calculated position by a green one. As dithering progresses, a little cloud of red crosses is built up showing the distribution of the points.



Options menu

Adjustments for Display, light and colors, language, SD card, Boot mode for updating the firmware, and switch off the Mgen-3

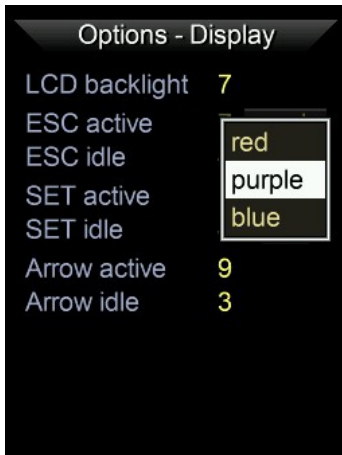
Options – Display



Backlight of the Display and the button LEDs:

LCD: backlight strength of the display

ESC and SET: active (DSLR exposure signals) and inactive directional buttons: active (ST4 signal output) and inactive



For **ESC** and **SET** buttons, 3 colors can be selected

Options – Colors

Day and night modes can be selected and adjusted in strength

Color filter modes and strength



3 color modes

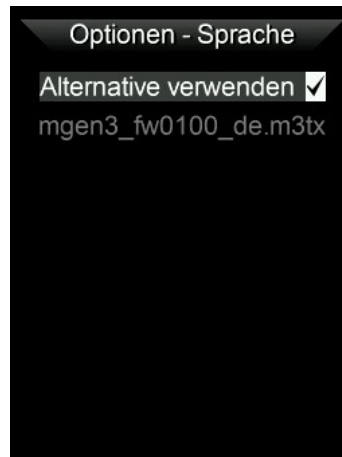


the amber filter mode



Options – Language

The basic menu language of the Mgen-3 is English. Here alternative languages can be selected, if the respective language file (m3tx extension) is found in the “Text” folder on the SD card. For now English (native) and German is available. Japanese will follow soon. Set the checkmark and the **alternative** language will be used.



There is a special translation app, that allows translating the menu texts into any language and font and save it as a m3tx file. The Text Editor is available on the Mgen-3 support site:
<https://support.mgen-autoguider.com/>

Options – Date and Time



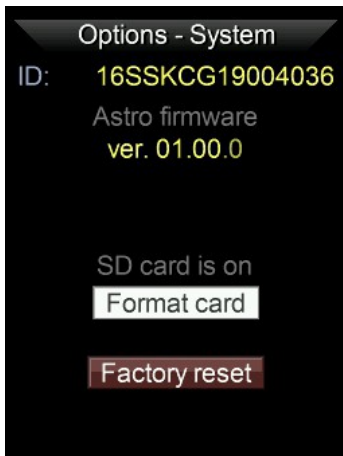
Mgen3 has a real-time clock built in, that is powered by an internal battery and continues even after shutting down. The battery is CR2032 type and can be found on the backside of the board. You need to remove the board to change it, if necessary.

Format is YYYY MM DD

If needed, you can set the time here.

Options – System

Some information is shown here, and the managing of the SD card.



The ID number you need to register your Mgen-3 on the support site.

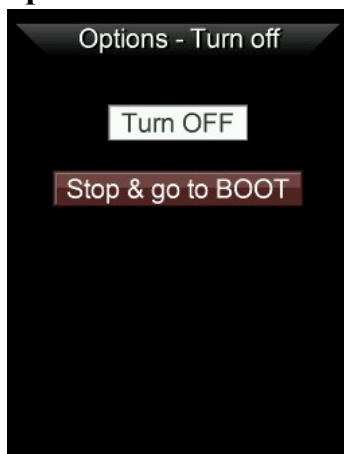
The version number of the currently installed firmware.

Information about the SD card status (ready, no card, unformatted).

Formatting the SD card will also generate the folders needed for the Guide log, Darkframe and language file. Up to 32GB cards are supported. The guide log will be written while the Mgen-3 is autoguiding, and the file is saved into the Log folder on the SD card. Currently it is only possible to access the SD card on a PC.

Factory reset will set all values to default. Use it if you get lost by unknown manual adjustments. Useful e.g. for Clubs where members often set special values and just leave them active.

Options – Turn off / Boot



Here is the switch to properly turn off the Mgen-3.

It is important to shut down all processes, and close + save the Guide log file on the SD card. Without proper shutdown, the Guide log file will not be written properly and may be inaccessible.

The Boot mode, which is important for installing new Mgen-3 firmware files, can be called up here.

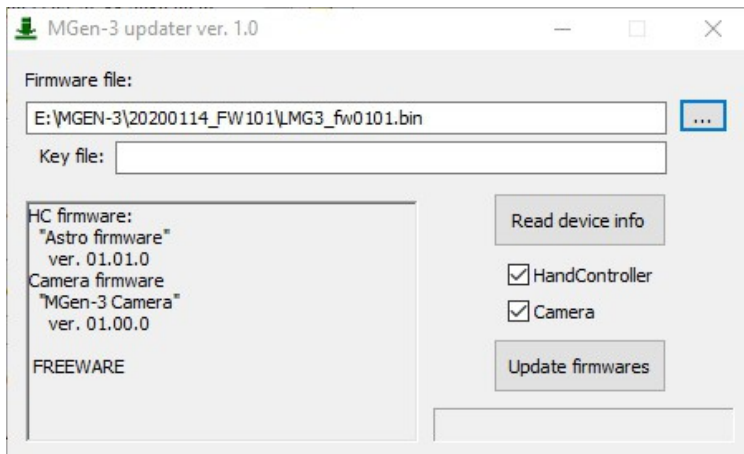
Updating the Firmware – Boot mode

to download the newest Mgen3 firmware, please visit the support site:
<https://support.mgen-autoguider.com/>

Here you may register your Mgen with its serial ID (shown on the Boot screen) and access the area for new firmware, keyfiles, Apps and documentation. At “My Devices” you can manage your Abo and download the keyfile which is generated daily. After purchase there is a year free access to your keyfiles, after that you may extend your Abo for a small charge for another year. You also may come back after a time and get a new Abo for the same charge.



Its most easy to update your Mgen3 using a Windows PC. You need to install the FTDI driver to communicate with Mgen (see page 3). Connect your Mgen3 inclusive camera and connect via USB. Enter Boot mode to get it ready for receiving the data. Place the downloaded firmware and freshly downloaded keyfile in the same folder as the updater App (that is usually contained in the firmware zip file, or download it from the support site, too).



Start the Updater.exe, the interface pops up and to the right you find a small box with 3 dots. Click on it to select the firmware.bin file and confirm. A second box pops up, here load the keyfile. Check if **HandController** and **Camera** are both ticked, and choose **Update firmwares**.

In a few seconds the process has finished, now either choose **Start Firmware** at the Boot screen or **Turn OFF**.



Alternatively: if you do not use Windows, you may download the firmware and keyfile, and copy it to the microSD card – to the basic (root) directory. Make sure the keyfile really has the .mg3key file extension and nothing else (careful with MacOS!). Insert the microSD card and enter Boot mode. Go down to device info and press the **RIGHT** key. On the new screen choose **Upload new** and browse the files on the subscreen. Tick **HandController** and **Camera**. Press **UPLOAD** to update the firmware.

Mgen-3 technical details

The Hand Controller

The handbox itself is a special platform running a custom OS on microcontroller level, and is kept simple for reliability. The Firmware on the HC is upgradeable.

The HC consists of the following components:

- Powerful 32-bit CPU with 64MB of RAM
- big, color LCD display
- six back-lit control buttons
- one USB device interface to allow control by a PC
- one USB 2.0 host interface for the Camera
- one MicroSD card slot
- one WiFi 802.11 b/g/n module embedded
- ST-4 output port (optocoupled)
- exposure (DSLR) control output port (optocoupled) auxiliary low speed I/O or communication port (optocoupled)
- real-time clock with battery

The HC is powered through the USB device interface (USB B mini 5-pin type connector).

the Camera

The Camera is a special type of raw USB 2.0 Camera designed to be used with the Mgen-3 HC. The shape enables use in any optical system and the backfocus is purposely kept very short. The aluminum case acts as a passive cooling element, conducting heat directly off of the image sensor and from other internal parts.

Firmware releases for the Mgen-3 also contain the required Firmware versions for this Camera.

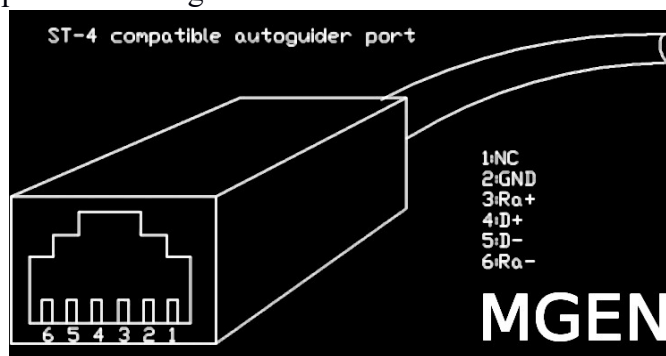
Special features of the Camera:

- raw 12-bit image
- well buffered data transfer to avoid bad/missing frames
- optical dark pixel area allows the use of optimized dark correction
- (multi-crop image transfer for high-speed, multi-zone imaging)

The image sensor used in the Camera is the monochrome version of the AR0130CS:

- 3.75 μm pixel size
- 1288 x 968 active pixel area (4.8 x 3.6 mm)
- Quantum Efficiency is almost 80% near 570 nm
- typical read noise is 4 e- at max. gain

The Camera is powered through its USB device connector.



Change log for FW 1.05

- new small menu at onepush, to fast input focal length, guide expo time, AG speed...
- polar alignment using the digital-graphic Scheiner method
- exclusive output of ST4 signals (RA, DEC not together at the same time)
- bugfixes
-

FW 1.10

- binning modes added, bugfixes

FW 1.11.2

- introduction of the API server to get multiple apps connecting to Mgen3

FW 1.20

- platesolving “visual” polar alignment
- exposure timer state written to onepush screen

FAQ and hints to a successful Guiding

We know from experience about some of the more frequent guiding problems. Here are a few hints and explanations to get things right:

- **unbalancing the mount.** With mounts that use gear and worm, there is usually a small gap in between that causes some backlash. To avoid having the mount “floating” in that gap apply a healthy dose of unbalance. On the RA its easy to shift the counterweight, so you have more weight toward the east (preferably, the worm will push the gear all the time). But it is even more important in DEC, as there is no constant pushing movement and above all the directions may change. Place a small weight in a place so that the DEC axis is always pulled toward one side, e.g. in the direction of the knobs of the tube rings.
- **Mounting the guidescope:** Make sure there is direct and firm contact with the telescope, i.e. clamp it strongly in the finder shoe. Mounting it on top of the tube rings could cause a problem, as there usually is flexible material inside the rings. It could lead to a shift between guider and main camera.
- **Fix your cables:** While tracking across the sky, the cables are moving and might become tight, and wind gusts may rattle them (apart from cats looking for play things).
- **Starfield of the guidescope:** The guidescope should be parallel to your main optics, so the starfield it “sees” is at the same position that your main camera sees. That helps avoiding field rotation by rough north alignment.
- If guiding is strange or your **mount does not react as expected**, read the calibration chapter. There you will find important hints to pinpoint the problem.
- **Near the celestial pole,** guiding gets increasingly difficult as the movements of the RA axis get very small next to the poles (cosinus DEC function). For guiding near the pole, as an exception it is sometimes advisable to point the guidescope a little bit away toward the equator. Do not test guiding near the Polestar, choose a star field near the celestial equator!
- **„Focus“ und „Shutter“:** At DSLR exposure Mgen uses the remote control jack of your camera. It uses two signals: "Focus" corresponds to the half pressed release button, usually triggering autofocus at daytime photography. "Shutter" tells the camera to open the shutter.

- **Dithering and Exposure:** Before Mgen triggers a new DSLR exposure, it checks if guiding is stable. There will be no exposure if it's not stable, nor will there be an exposure when dithering is in progress. The waiting time is needed by some DSLRs to save the picture before it is ready again. That's important if there is no dithering going on. Dithering makes use of this time, too. Usually it lasts longer than the wait time, and then the wait time is included.
- **How often to dither?** If you take a lot of exposures, it's sufficient to dither about after 3 pictures. When doing LRLGLB with CCD, I do it after each group. Saves time!
- **Mirror lock:** It is not needed to use mirror lock at long time astro photography. The small tap of the mirror is a problem only at short exposure times, lets say if you take a photo of a distant bird in daytime at 1/250 with a C8. It causes unsharpness due to the movement. At longtime photography, the small short movement could only be seen at the brightest stars, but that is totally covered by the overexposure's blooming.
- **Dither width:** There is no precise rule, but you may go with the relation of the focal lengths of your guidescope to your main scope. If you use a 130mm guidescope and your main scope has 1000mm focal length, this is like 1:8. If the pixelpitch of Mgen (3.75μ) and main cameras are similar, 1 pixel ditherwith on Mgen then means 8 pixels on the main camera. This is already bigger than the usual hotpixel cluster that causes the dreaded walking noise, but if you take the double value its more safe. So, here choose 2 pixel ditherwith at least. But if the camera has a more pronounced darkcurrent pattern, it could be even more. Are you dithering your Samyang 135mm, the relation is 1:1 and you may choose 16 pixel – thats the same ditherwith on the DSLR sensor like in the first example. That way you may estimate the proper ditherwith and save time at long focal lengths.
- **Usage with CCD/CMOS Cameras:** Mgen3 can be used via the **Ascom App** with most camera controlling softwares. Check out <https://mgen.app> Direct implementation via the developer API has been done already with NINA, others like APT are in progress. The migration of the API to Linux is near, and will allow connection to INDI software.

This manual will be extended and updated.

We wish you success and happy tracking with the Mgen-3, and clear skies!
Your Lacerta Team

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