

# DynoStar X3 Version 3.00d

## PowerFlex MTS-3SDI, MTS-3SDI+ Version 3.10b



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### Operating instructions

(for optimal B&W-print set properties/graphic/intensity to bright)

DynoStar X3 and MTS-3SDI are telescope controllers with many special functions like e.g. GOTO. They are suitable universally and optimally for all telescope mounts with usual 2-phase stepper motors, also for powerful and fast stepper motors. Several mounts are stored at the same time and can be selected easily. For mounts that are not already stored, a few one-time adjustments are necessary for immediate starting of operation. Software updates can be loaded through the PC-cable.

Functions and operating of these telescope controllers are largely identical since version 3.00. The particularities of MTS-3SDI (resp. MTS-3SDI+) and DynoStar X3 are marked in the text.

Beginners are asked to read the first chapters in the given sequence. Thereby you are introduced step by step to the operation and basic possibilities. You should try out at once what you have read. The best way is to do this calmly at day. If possible, also set up the mount and connect the motors. You can make eventual necessary adjustments at once and you can convince yourself from the correct functioning. With help of the setting circles you can test the GOTO. After that, the operation under real observation conditions should work at once.

Whenever it was possible, the chapters were arranged in such a way, so that they base on each other in sequence. For a compact operating instructions (without omitting details at the same time), cross relations to subsequent chapters weren't always avoidable. For better readability, often abbreviated expression styles and technical terms were used. If necessary, you should consult the corresponding chapters or the term explanations immediately. The menu items are in English language, because this allows a shorter and more pithy representation on the small display.

There may be future software versions, without immediate available updated operating instructions. Differences may be for example: New features, rearrangements in the menu, changed input fields, changed terms. In this case, please pay attention to what the display shows! The meaning will be mostly self-explaining.

This operating instructions can't perform an introduction into amateur astronomy or the handling of telescopes and mounts. To have more benefit from your equipment, you should use astronomical literature and internet and you should contact people with the same interests.

Some more: Don't scare from this operating instructions's size! The many features had to be described completely how they are. But the operating surface has been so intuitively designed, so that you'll get accustomed to it very quickly and need the operating instructions only very rarely.

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## **1. What is a telescope controller?**

The primary purpose of a telescope controller is to avoid that adjusted celestial objects (shortly called objects) move out of the telescope's view due to the earth's rotation.

This is called an (automatic) tracking.

If you want to observe an object for longer than only a few seconds or with high magnification, you would else have to move the telescope without automatic tracking permanently by hand.

For astrophotography an automatic tracking is even more useful. Otherwise only short focal lengths or very short exposure times would be possible for sharp photographs.

The tracking is possible at the easiest, if one axis of the mount is parallel to the earth's axis. Then only this axis (polar axis or right ascension axis, in the following shortly called RA-axis) has to be rotated with constant velocity, so that objects remain in the telescope's view.

At the RA-axis a second axis (declination axis, in the following shortly called DE-axis) is mounted right-angled, at which in turn the telescope is mounted right-angled.

With that the telescope can be turned to each position at the sky.

Then one speaks also of a parallax (or parallactic) mount.

The RA-axis is usually equipped with a worm gear, which is driven by an electric motor at precise velocity. Usually an additional gearhead is mounted between them in order to adapt rotation velocity and drive power (torque).

A telescope controller should additionally perform the following to allow convenient visual observations and astrophotography:

- Fine movement of the RA-axis by small variations of the tracking velocity
- Fine movement of the DE-axis (additional motor and gearhead at the DE-axis is needed)
- Switching to high speed (usually in the range 8x to 32x)

4 Direction buttons are used to control the motors directly.

More powerful telescope controllers allow more possibilities:

- Variable selection of speeds
- Functions, that reduce alignment errors and inaccuracies of the mount
- Display for easier handling, special functions, displaying informations
- Automatic positioning to celestial objects (in the following called GOTO)
- Integrated catalogue of celestial objects: Stars, Nebulas, Planets, Comets
- Driving more powerful motors for faster GOTO (also for bigger telescopes)
- Connection of further devices: Autoguider, Computer, Encoders

The MTS-3SDI and DynoStar X3 are such powerful telescope controllers.

## **2. Why a MTS-3SDI or DynoStar X3?**

The assortment of products for the amateur astronomy at acceptable costs is larger than ever before.

At the same time there are big differences in quality and functions of optics, mechanical parts and electronics. More independent information and consultation are thus necessary, if a purchase decision is to prove as the correct one at longer-term.

But it has also become easier to exchange experiences with many other amateur astronomers, e.g. in special internet forums. Besides questions about operating and trouble-shooting, you will get not rarely also concrete purchase recommendations, about like this:

"Even if the original telescope controller seems to be sufficient first, with increasing occupation with the amateur astronomy inevitably also the desire for larger and more efficient equipment will arise. If possible, you leave the original telescope controller away and better purchase a telescope controller that performs much more for reasonable extra costs. This should be at least a MTS-3SLP+, which you can let upgrade to the MTS-3SDI+ if needed. Additionally with the LCD, you have an easy operation by menu guidance and with the keycode also a PC-independent GOTO controller. Or you decide directly for a DynoStar X3. A good idea are also better stepper motors for a reasonably fast GOTO. If you desire, the controller comes already suitably adjusted.

You connect the motors and power source (e.g. car battery), check the correct direction of rotation and change it if necessary. That was already everything for the time being."

After the mount is aligned, you can now do the following with it:

1. Adjust objects in the eyepiece. With 4 keys you can drive into each direction.
2. Center objects in the eyepiece, before you increase the magnification.
3. Take a walk at larger objects, e.g. moon, star clusters.
4. Observe objects for a long time. The telescope follows automatically.
5. Shoot astrophotos with short focal length (photo objective) without manual corrections.
6. Shoot astrophotos with long focal length (telescope) with manual corrections.
7. Shoot astrophotos with autoguider assistance. The corrections are done by the autoguider.
8. GOTO via PC and planetarium software. Click the desired object at the screen. The telescope controller moves then the telescope automatically towards it.
9. GOTO alone with the telescope controller. With help of the filter function you quickly find each desired object in the object catalog. Give simply a search criterion, e.g. if you like to observe only globular clusters. Find e.g. problem-free Uranus, Neptun or during the day Venus, Merkur, Jupiter. The DynoStar X3 adjusts even newly discovered comets, whose orbital elements you only need to enter.
10. Also look at the object catalog. Interesting additional information for each object is displayed. Become casually acquainted with names of stars and nebulas with ease.
11. Organize for your friends a sky walk and show them many interesting objects. On the basis of the additional information in the display you also can immediately tell them something. Use the time, which is saved with the help of GOTO, for actual observations.

### **3. Unpacking, connecting, trying out**

After receiving the delivery, you should be in possession of the following parts:

The controller: That is one single hand control box with control elements, indicators (LED for MTS-3SDI, LCD for DynoStar X3) and electric connections.
The LCD, if it was ordered additionally with the MTS-3SDI. Possibly your dealer has already installed it. Otherwise proceed according to the assembly instructions.
The motor cable. It is not automatically included in the delivery. Since there are different motors, you should have ordered the appropriate one or competent persons can assemble it home-made. It always consists of a 15-pin DSUB connector, from which leads one cable to the power source as well as 2 cables to the motors. Also joint cables for motors and power source are possible for some certain mounts. At the DynoStar X3 3.2A (with booster module) the DE-cable has a separate DSUB-15 connector. At the DynoStar X3 1.6A this lower DSUB-15 connector is not occupied.
Possibly further accessory parts, like PC cable, autoguider cable (both combined as Multi-Interfaceable for the DynoStar X3).
Possibly new motors. These needn't be installed already for the first and can be connected for the first attempts how they are. You can install them later, when you have convinced yourselves of the function.

Next a direct current source (DC) is needed. A car battery with 12V is always suitable. Also a 12V portable power pack, a 12V sealed lead-acid battery or a DC power supply unit are suitable, which can deliver at least 1A (better 2A or 2,5A). At the motor cable are banana plugs, which fit directly for some power supply units.

For a car plug socket you would have to install a suitable car plug (it is available in each do-it-yourself store). If necessary use alligator clips provisionally. Or assemble a self-made adaptor cable and/or an extension cord.

The controllers have a wrong-polarity-protection, so that in this regard nothing can happen. With accumulators you should be careful not to short-circuit the poles accidentally, because a very high current flows then, which can damage accumulator, cable and contacts.

A fuse (for instance 4A - 5A) is recommended thus. It is also possible to use 24V, but a change of the motor adjustments at the MTS-3SDI is then necessary before.

With the DynoStar X3 you can immediately use each voltage within the permitted limits (see technical appendix).

Now connect the motor cable to the controller and the motors.

Before you connect the power supply, the ON/OFF-switch of the MTS-3SDI should be OFF. The DynoStar X3 hasn't this switch. Now connect the power supply.

On the display an introduction text with version number and manufacturer information appears.

```
DynoStar X3      by S.Boxdoerfer      http://www.
Version 3.00d    Elektronik 2004      boxdoerfer.de
```

## 4. Short instructions: Switching on and off

MTS-3SDI and DynoStar X3 have no switch in the power supply line. With connecting the supply voltage the controllers prepare themselves immediately for the operation: The microcontroller boots up, accomplishes a self check, initializes the internal and external hardware components, loads the mount parameters and waits then for your inputs. If the speech is about switching on and off, then this means to switch on and off the tracking. For that there are several possibilities, which are described later in detail once more. The simplest possibility after appearance of the introduction text is the following:

At the MTS-3SDI you turn the tracking on and off by the ON/Off-switch.

At the DynoStar X3 you press RIGHT twice to switch the tracking on (the first RIGHT terminates the introduction text and changes into the tracking mode, the second RIGHT starts the tracking). To switch off, hold MODE for at least 3 seconds.

Display in tracking mode (coordinates, stop watch, fast speed):

```
00h09m23s0  12
+29°05'21" X 64
```

Make sure that the tracking is switched off, before you separate the supply voltage. Thus the controller has still the opportunity to switch off the motors properly and to store the position of the RA motor for the PEC function.

## 5. Short instructions: Select the mount

Some parameters must be suitably adjusted for the actual mount (resp. motors), so that the motors function correctly and run with correct speed and direction. In the initial condition or after an update, the controllers are already preset for a certain mount.

MTS-3SDI: EQ4, EQ5, Astro5, Vixen MT1 (all compatible)

DynoStar X3: MillenniumMount1

```
>Loc Berlin
Mt. Millennium!
```

Or your dealer has already made other adjustments suitable for your mount.

Thus if your mount is already adjusted, you actually only need to check the direction of the rotation and change it if necessary (see menu item MOTORS/\*SetGearing).

Otherwise use one of the following possibilities:

1. If available, select the suitable mount/motors from the menu (menu item Mt. "mount"). Alternatively also with dip switches and combination of buttons (only MTS-3SDI).
2. Load the suitable adjustments with the MTSconfi software (only MTS-3SDI).
3. Change the parameters individually suitably. You can do that easily in the menu. Or with a MTS-3SDI without display also with dip switches and a combination of buttons. In the following chapters the relevant parameters are explained exactly and how you can adjust them.

## 6. Operation modes, menu mode, menu system

The menu system permits the quick and clear choice of a huge number of functions (=menu items) from a list (=menu) with only 5 buttons. The menu system resembles the pulldown menu of PC software, with the difference that only a section of 2 menu items is visible at the same time. Located in the upper line of the display is the current (with RIGHT selectable) menu item, the next is below. The direction buttons De+, De-, Ra-, Ra+ and the Mode button are called for the use in the menu mode simply UP, DOWN, LEFT, RIGHT and MODE.

These abbreviating phrases are also used in the text:

„by LEFT“ = pressing shortly the LEFT button.

„by LEFT+RIGHT“ = pressing shortly and simultaneously the LEFT and RIGHT button.

„hold MODE“ = holding the MODE-button for a longer time.

Sometimes it depends also on an exact sequence, how the buttons are to be pressed and released. Then it e.g. means: hold MODE, then RIGHT.

Afterwards you can release the pressed button. For the other buttons the meaning is accordingly.

First you should know that there are in principle 4 operating modes:

- Tracking mode
- Menu mode
- Functionmode
- GOTO mode

Depending on the operating mode the buttons have a certain meaning and/or function.

For the operation it is thus important to know, what operating mode is active at the moment.

You recognize this normally immediately by the different display.

After the introduction text appears, you can change by MODE into the menu mode.

The menu mode is recognizable by the symbol > in the upper left corner in the display.

By MODE you can switch back and forth between menu mode and tracking mode.

You will experience details of the tracking mode in the next chapter. First to the menu mode:

```
>SelectSpeed    >LX200          >Loc Berlin    >SetTime&Date  >Servicecode
LX200           GOTO-CATALOG    Mt. Millennium1 INFO
```

In menu mode the main menu appears and begins with the top menu item (SelectXSpeed) in the upper line. By DOWN the further menu items are displayed in sequence. If the last menu item is reached, the lower line remains empty. By UP, you come each time again one menu item upwards. Longer UP or DOWN causes a quicker pass of the menu items. In the main menu you always come by LEFT immediately to the top menu item. By RIGHT you can select the menu item, that comes after > in the upper line. By RIGHT you can also open SUBMENUs. SUBMENUs thematically summarize menu items, thus they serve for better clarity and permit quicker access to menu items.

```
>GOTO-CATALOG
TRACKING Sidoff
```

You can recognize a SUBMENU by its continuous capitalization. SUBMENUs may in turn contain other SUBMENUs.

You get by LEFT at any time from a SUBMENU into the higher MENU.

Several times LEFT thus leads automatically back to the top menu item of the main menu.

(Hint: That is very helpful, if you got lost in the menu. Useful is also: LEFT and then RIGHT automatically leads to the top menu item of the current SUBMENU.)

Switching to tracking mode by MODE is possible from each menu item.

After the change back to the menu mode, this menu item appears immediately again.

You can differentiate menu items roughly into the following categories:

- SUBMENU
- Starting a certain action or function
- Input of parameters and adjustments
- Selection of options or objects
- Display of information

The individual menu items and the input possibilities are described separately.

## **7. Tracking mode: Switching on and off the tracking**

As previously mentioned, there are several ways how to switch the tracking on and off.

### **DynoStar X3 and MTS-3SDI:**

After you have switched into the tracking mode (twice MODE after the introduction text), you can immediately start the tracking in tracking mode by RIGHT or LEFT.

Now you can control the motors directly by the 4 direction buttons.

The speed is switchable by SLOW/FAST.

If you hold MODE for at least 3 seconds, the tracking is switched off. Otherwise MODE only switches back and forth between tracking mode and menu mode. As verification the 3 seconds on the display are counted down.

(Small hint: If it occurs to you after the 3 seconds that you didn't want to switch off the tracking, you should additionally press UP or DOWN before you release MODE. Then this only changes the FAST-speed by one level and doesn't switch off the tracking.)

An alternative possibility exists in the menu mode in the submenu TRACKING. There you can switch the tracking on and off immediately by selecting menu items. Also the option between solar, lunar and sidereal speed (sun, moon, stars) exists.

**Only DynoStar X3:**

From the introduction text you also come directly with one of the direction buttons into the tracking mode, without detour over the menu mode. Twice RIGHT will thus start the tracking immediately. That is useful if you want to start the tracking immediately while you have no view on the display.

**Only MTS-3SDI:**

Apart from the new operating mode with the mode button, the operating mode of the old version 2.xx is alternatively still supported, so that the MTS-3SDI can be used if necessary also without display. The tracking can also be started by placing the ON/OFF switch to ON. As long as the ON/OFF switch is ON, you cannot switch by MODE into the menu mode. This prevents inadvertent adjustments and selection of menu functions.

**Conclusion:**

If you have a MTS-3SDI with display and want to use the menu functions, always leave the ON/OFF-switch OFF.

However if you have no display or if you only need the tracking mode, you should use the ON/OFF-switch.

Small hint: Nobody can prevent you to place the ON/OFF-switch ON after you have already switched by MODE in menu mode and tracking mode and have started the tracking then. In this case the MTS-3SDI will switch into the old operating mode of the version 2.xx. If you switch then to OFF, the tracking is switched off. However a small bug in the software prevents only here, that also the PEC information is stored. If you need the PEC function stored, you should not make use of this possibility. Afterwards you are free, how you start the tracking again.

In the old operating mode of the version 2.xx the activation of various functions (e.g. PEC function) and adjustments is done by holding a certain combination of buttons, while you switch ON. When the ON/OFF-switch is OFF, only the current adjustments are shown on the display by the same combinations of buttons.

The description of the adjustment possibilities of the version 2.xx is, besides a few exceptions, is not the subject of these operating instructions. All necessary adjustments can also be done by the MTScnfi software via PC, so the older operation instructions are not absolutely necessary. (On my website: MTS-3 , MTS-3LP , MTS-3SLP , MTS-3SDI , SINUS II Manual).

## **8. Tracking-mode: How to switch speeds**

The correct tracking speed RA-Slow should already be adjusted in MOTORS/\*SetGearing and the rotation direction in MOTORS/\*Frequency.

The correction speed for RA is specified by UTILITIES/Corr-FactorRA.

The correction speed for DE is specified by DE-Slow MOTORS/\*Frequency.

For fine positioning and for tracking for astrophotography, you have to switch to SLOW.

For fast positioning you have to switch to FAST.

When pressing a direction button, the corresponding motor runs then with the speed level "manu" that is selected in SelectXSpeed.

If you press additionally the opposite direction button, the motor runs then with the speed level "goto" that is selected in SelectXSpeed.

The direction is specified by the direction button, which was pressed first.

Thus you have at any time 2 fast speeds available, without having to switch.

You can change the speed level "manu" also directly in tracking mode:

Holding MODE, then UP increases the speed level.

Holding MODE, then DOWN decreases the speed level.

The changed speed level is only valid for the moment. However it is durably stored with SelectXSpeed.

Depending on purpose you select an appropriate speed:

- SLOW for the fine centering in the eyepiece
- FAST (~ 4x) for the coarse centering
- FAST (~ 16x) for taking a walk
- FAST (~ 64x-250x) for manual positioning over a medium distance
- FAST (>250x) for automatic positioning (GOTO)

Right ascension and declination are shown in the display for your information. You can also specify other information to be displayed in tracking mode (see SHOW/ShowWhileTrack).

```
00h09m23s0 12
+29° 05' 21" X 64
```

In the lower line to the right of the "X" is the current FAST speed.

In the upper line to the right the stop watch is displayed, which can be reset and started by switching to SLOW and stopped by switching to FAST. That is e.g. useful to supervise exposure times.

## 9. Tracking mode: Spiral mode and loop mode

It may happen after a larger GOTO distance, depending on the accuracy of the polar adjustment of the mount, that the target object is not within the eyepiece, but somewhat outside.

You may then use the loop mode or spiral mode during the tracking mode to find the target object quicker.

The **spiral mode** starts by holding MODE, then RIGHT, then releasing MODE. Starting from the momentary position, the telescope then drives in an angular spiral course outwardly, with the FAST speed „manu“. Thereto the switch must be on FAST. For the duration of the spiral mode the motors are not directly controllable by the direction buttons.

Terminate the spiral mode by MODE, if the object appears in the eyepiece.

As long as the spiral mode is active, also the following is possible:

By LEFT you can return on the same spiral to the starting point and by RIGHT you can invert the direction again.

Switching to SLOW stops the spiral travel momentarily, switching to FAST continues it.

By UP the speed can be increased, by DOWN it can be decreased.

By LEFT+RIGHT the travel returns on direct way to the starting point. However both motors only run sequentially, not concurrently.

When it arrives at the starting point, the spiral mode ends automatically.

The **loop mode** functions similarly. The difference is only, that the telescope doesn't describe an open spiral, but a closed rectangular course around the starting position.

The loop mode starts by holding MODE, then LEFT, then releasing MODE.

The distance of the spirals can be changed in UTILITIES/Spiral (preadjustment 0,5°). A value of zero disables loop and spiral mode. A negative value inverts the spiral direction.

In dependence of the declination the distances in RA are increased automatically in such a way that the apparent distances from DE and RA are about the same in the eyepiece.

## 10. FAST speed levels

### **Selecting predefined speed levels**

You can select out of 17 fast speeds (0 - 16).

The manual speed level (manu) and the GOTO speed level (goto) may be different.

You do the selection in the menu item SelectXSpeed.

```
manu#0 RA 0064 manu#04 RA 1000
goto#11 De 0064 goto#1 De 1000
```

The speed levels 0 - 15 are displayed as multiple of the tracking speed (x-multipliers).

A meaningful gradation is already predefined:

4x,8x,16x,32x,64x,125x,175x,250x,375x,500x,700x,1000x,1400x,2000x,2800x,3600x

For comparison the conversion in degrees per second: 1x corresponds to  $360^\circ/86164s = 0,004178^\circ/s$ .

Thus corresponds for example 64x =  $0,2674^\circ/s$  or 1000x =  $4,178^\circ/s$ .

The speed level 16 is also selectable and is displayed as "freq".

It corresponds to the maximum speed, which is programmed in MOTORS/\*Frequency directly as frequency in half steps per second.

All other speed levels are limited automatically to the maximum speed. In the case of limitation the effective X-multiplier is displayed.

## Assigning X-multipliers individually to the speed levels

In ProgXSpeed you can change these predefined X-multipliers if necessary. The X-multiplier of each speed level may be even different for RA and DE. However, only the X-multiplier for RA is displayed in the tracking mode.

A meaningful reason for an individual change would be for example a closer gradation of the X-multipliers. You don't need the highest X-multipliers, if the motors would not manage these high speeds anyway.

It is recommendable to arrange X-multipliers according to rising values, although this is not mandatory. The selection in SelectXSpeed is so more logical.

## Hints for maximum speed

The pre-adjustment for the manual speed (manu) and the GOTO speed (goto) is the speed 16, the maximum speed.

With the MTSconfi software you can change the maximum speeds of a MTS-3SDI only (they are called there RAfast and DEfast).

This pre-adjustment ensures that each change of the maximum speeds by MTSconfi, directly also changes the speeds for manu and goto.

It functions thereby as with version 2.xx, which knew no speed levels yet.

Normally you have no access on the menu and SelectXSpeed with a MTS-3SDI without LCD, in order to select speed levels differently (except inadvertently, blindly or by display-redirection). However, the speed level for "manu" is selectable from the tracking mode (however it is not stored).

## 11. Input fields and cursor

After you have opened one menu item by RIGHT, in which adjustments can be changed, there appear one or more input fields with the current values. In addition a flashing rectangle (cursor) can be seen.

```
>SetTime&Date 18h38m01s0 UT 18h38m01s0 UT >Loc Berlin 0 52N500 013E400
INFO          Tu 22Aug 2006 Tu 22Aug 2006 Mt. Millennium1 +01h Berlin
```

Input fields can contain different things dependent on the context:

Numbers, a list of alternatives or alterable text.

With numbers there can be additional signs, decimal points, degrees, minutes, seconds or other special separators.

Each input field has individual minimum and maximum values, which cannot be exceeded by your input.

The place with the flashing cursor can be changed by UP or by DOWN.

With numbers an add carry happens automatically on the higher digit.

Some input fields are cyclic. Those are e.g. angular data, time data or lists.

The cursor can be moved by LEFT or by RIGHT to the other places of the input fields.

Longer pressing moves the cursor faster.

All input fields can be accessed cyclically in this way forward or backwards.

By LEFT+RIGHT, you can immediately move the cursor forward for one whole input field. With numbers UP+DOWN sets the cursor and all places right of it to zero respectively the value to the minimum value. With lists the first alternative is selected.

With alterable text:

LEFT+DOWN changes the cursor successively to a blank (" "), 0, A and a.

UP+DOWN changes additionally all characters right of it in this way.

LEFT+UP changes the cursor from upper-case to lower-case character and vice versa.

RIGHT+DOWN decreases the ASCII code of the cursor by 4.

RIGHT+UP increases the ASCII code of the cursor by 4.

Note: All ASCII codes 32 (blanks) to 127 can be input, with exception of a few special characters, which are deviating in the character set of the LCD.

By MODE you can terminate the input.

Afterwards you are usually also asked, what should happen with the input:

Use : use only now, do not store

Cancel : do not use and also do not store

Save: use and store now

```
How handle data? How handle data? How handle data?
Use [0][0][0][0] Save Use [0][0] Cancel Save Use Cancel [0][0][0]
```

Move the cursor by LEFT or RIGHT to the desired action, which is then executed by MODE. Now you are again in the menu mode.

In some menu items the cursor is still at the same place, when you select it subsequently anew.

## 12. Menu items

The menu items are described in the sequence, how they are also arranged in the menu of the controller. Indented menu items belong to a submenu.

### **SelectXSpeed**

Selection of the FAST speed levels "manu" (for manual) and "goto" (for GOTO).

The X-multiplier (= the multiple of the tracking speed) which is associated with the current speed level is displayed on the right side. The highest speed level "freq" is exactly the speed in MOTORS/\*Frequency. No speed level can be faster than "freq", even if it is adjusted as the a higher X-multiplier in ProgXSpeed.

By MODE the values are stored durably and without further query.

### **LX200**

In this menu item the main program of the controller almost exclusively takes care of the LX200 commands and can react therefore fastest. Select LX200, if that is important to you. Otherwise you leave the controller simply in the tracking mode.

In the menu and most menu functions the controller responds likewise to the LX200 commands.

However a GOTO instruction is only then executed when the LX200 menu item or the tracking mode is selected.

The direction control commands :Mw# :Mn# :Me# :Ms# :Qw# :Qn# :Qe# :Qs# :Q# have a very fast response time in each mode. However, you shouldn't select the command rate too high for autoguiding, otherwise the receive buffer couldn't be emptied fast enough under all circumstances. And occasionally individual direction control commands couldn't be recognized. The version coming soon has this restriction no longer.

## **GOTO-CATALOG**

### **GotoCoordinates**

GOTO or alignment with any desired numeric coordinates.

For a stationary mount: If you take over the coordinates with the first Align1\* unchanged, then you avoid having to adjust a reference star. A condition is that the axes of the mount weren't moved manually after switching off, and that the date, time and local coordinates are correct.

### **Catalog&Filter**

Object catalog:

Stars assorted according to constellations and number, in sequence NGC and IC nebula objects.

MTS-3SDI:290 stars up to 3,5mag,1962 nebula objects up to 12mag (incl. all Messier objects).

DynoStar X3: 2152 stars up to 5,0mag, all 13226 NGC and IC nebula objects.

With the filter function, an object selection can be narrowed (see filter function).

### **BrightStars**

Quick selection of stars up to 2,6mag. The filter parameters are temporarily suitably preset for it. They can be further specified for the individual case.

### **Nebula\_by\_No.**

Quick selection of Messier, NGC and IC objects by known numbers.

### **SwitchDec**

Correction of the GOTO direction in DE. For MTS-3SDI as alternative to dip switch 10.

**SyncEncoder**

Is only of importance, if the encoder cable with encoders is attached. Synchronizes the motor coordinates with the encoder coordinates. Useful, after a manual move was done by loosening the clutches while encoders were deactivated. However if the encoders are constantly activated (Encodertolerance<>0), this happens automatically when exceeding the Encodertolerance. In this case SyncEncoder is unnecessary.

**Planets**

Coordinates of sun and planets.

**COMET editable**

List of 16 objects in the solar system, alterable for own objects.

**OWN OBJECTS ed**

List of 4 objects in the solar system, alterable for own objects.

**MINOR1**

20 minor planets from 1 Ceres to 20 Massalia

**MINOR2**

20 minor planets from 21 Lutetia to 80 Sappho

**MINOR3**

20 minor planets from 89 Julia to 419 Aurelia

**MINOR4**

5 minor planets from 433 Eros to 4179 Toutatis

**SetTime&Date**

Input of universal time coordinated (UTC) and date. Necessary for the coordinate computation of objects in the solar system. With the MTS-3SDI this is necessary with each start-up, if planet coordinates are needed or the horizon is to be considered.

With the DynoStar X3 this is not necessary, since the clock continues running thanks to an internal lithium battery. In longer intervals you should check and if necessary readjust the clock. GOTO for stars and nebula objects will function also without correct time/date.

**Set\_De0\_Position**

Is necessary before an adjustment with 2 stars (Align2\*\*). The telescope should be aligned right-angled to the RA axis as exactly as possible. If the declination setting circle is exactly adjusted, that is identical with 0 degrees on the declination setting circle.

**PolarRoute**

3 settings are possible:

-Auto (preset): GOTO goes automatically over the pole, if this is the fastest way.

-Ask: Like auto with confirmation.

-Never: GOTO never goes over the pole.

**Tracking****On**

Starts the tracking with the speed that was selected last. Same effect as RA direction button in the tracking mode when tracking was off.

**Off**

Stops the tracking. Same effect as MODE button for at least 3 seconds in the tracking mode or menu mode.

**AltAz**

GOTO with azimuthal mount. An accurate azimuthal adjustment is assumed. Necessary are also time/date and location coordinates. Then only Align1\* is necessary.

After a GOTO, the tracking starts with constant speed in both axes and first tracks the object accurately. When the object moves after some time slowly out of the eyepiece view, the GOTO should be repeated.

**Sidereal**

Tracking with sidereal speed (stars)

**Solar**

Tracking with solar speed (sun)

**Lunar**

Tracking with lunar speed (moon)

## UTILITIES

### Spiral

Distance of the spirals in the spiral/loop mode. A value of 0 disables spiral/loop mode. Negative values invert the direction of rotation.

### RAmanu(DE)

If set, the manual FAST speed for RA increases automatically with increasing declination. Thus the apparent movement for DE and RA remains equal in the eyepiece. Isn't stored.

### ExchangeRA

Exchanges the function of the RA direction buttons. The autoguider input and the LX200 direction commands are also concerned. Isn't stored.

Since version 3.10b: In the tracking mode MODE+RIGHT+DOWN has the same effect. The meaning of the buttons for menu and menu functions does not change thereby.

### ExchangeDE

Like ExchangeRA, only for declination.

Since version 3.10b: In the tracking mode MODE+LEFT+UP has the same effect.

### PowerOffDE

Select whether the DE motor current, when it stops, should be switched off or not. The preset value is off. Isn't stored.

### DE-Play

Specifies the gear backlash compensation for DE

### RA-Play

Specifies the gear backlash compensation for RA

### CorrFactorRA

RA correction speed. Examples: 2,0 is double speed or zero speed (stop). 1,25 is 25% more or less speed.

### Refrac

Refraction correction. Only meaningfully with time/date and location coordinates.

## PEC

### EnablePEC

Activate PEC function

### DisablePEC

Deactivate PEC function

### RecordPEC

PEC recording starts when you switch to SLOW in tracking mode.

### RA-Motor\*Gear

Half steps \* gear reduction. Is absolutely necessary for PEC.

## ProgXSpeed

Individual programming of the X-multipliers. May be different for RA and DE.

## Loc

Observation locations with names, coordinates and time difference of the time zone with respect to UTC.

(MTS-3SDI: 4 observation locations, DynoStar X3: 10 observation locations).

The correct observation location coordinates are only necessary for the computation of the horizon situation, if you want to use the following features:

- Filter parameter: elevation above horizon
- Refraction correction
- Display of Sidereal Time
- Display of azimuthal coordinates
- Polaris (alfa UMi) hour angle for alignment assistance
- AltAz operation (azimuthal mount)

## Mt. „Mount“

Selection of one of the stored mounts. The name of the current mount is displayed in the menu. You may also change the name. A meaningful name is recommended. If you have a MTS-3SDI without display, the mounts are selectable also by combination of buttons with the old 2.xx operating mode.

Note: The list for the DynoStar X3 looks differently. You will recognize this then in the LCD.

**\*CopyMount**

Copying of complete mount data records. Thus you can quickly create different parameter variants for a mount or backup copies.

**SHOW****ShowWhileTrack**

Selection, which should be displayed in tracking mode. Normally Coordinates is selected. With the MTS-3SDI not each of these items are possible.

**LocalT**

Local Time

**ZoneT**

Zone Time

**UnivT**

Universal Time Coordinated in Greenwich (UTC)

**SidT**

Sidereal Time

**Show\_RA+De**

Display of RA and DE coordinates

**Show\_Azimuth**

Display of azimuthal coordinates

**ENCODER****SetEncoder**

Number of encoder increments for one total revolution (4 \* number of lines \* reduction). For a correct function the respective sign must be changed if necessary.

**EncoderTolerance**

Even if your mount is equipped with encoders, the coordinates are computed under normal conditions from the motor positions, since this is most exact.

With EncoderTolerance you specify, how much the deviation of the motor positions from the Encoderpositionen may be, before the coordinates are computed from the encoder positions.

When starting a GOTO the motor positions are initialized by the encoder positions.

A value of 0 disables this function. If the GOTO is to be interrupted immediately, when EncoderTolerance is exceeded, then set EncoderTolerance negative.

**ShowEncoder**

Displays the coordinates, which are computed from the encoder positions.

**MOTORS****MotorCurrent**

Only DynoStar X3. Both motors, SLOW and FAST can be adjusted separately.

**\*PWM,limit**

Only MTS-3SDI. Both motors can be adjusted separately.

Adjustment of PWM values in % and 100%-limit frequency in Hz. Only certain values are possible, therefore the adjustment is not made in a numeric input field.

**\*SetGearing**

Total reductions for RA and DE axes in 1/64-micro steps. The sign of RA specifies also the direction of the tracking (operation on Northern or Southern Hemisphere). The correct sign has to be tried out. With a MTS-3SDI this can also be done with dip switch no. 9.

Note: The direction of the tracking changes not immediately, but only after a restart.

**\*Frequency**

Depending upon SLOW/FAST switch position, you can adjust the respective frequency.

The FAST frequencies specify the permitted maximum speeds.

**Acceleration**

Acceleration values 0 to 5

**\*C-Symmetry**

Only DynoStar X3. Calibration of motor driver electronics.

**Microstep**

Micro step adjustment. 1/64 is usually recommended.

**Set\_Time&Date**

Input of Universal Time Coordinated UTC and date (identical with GOTO-CATALOG/Set\_Time&Date).

## INFO

### Version

Version number of the software

### Serial#

Serial number of the controller

### Keycode

Only MTS-3SDI:

Input of serial number dependent code, in order to enable the full functionality of the GOTO from the internal object catalog.

Otherwise a GOTO/Alignment is limited to  $\pm 30$  degrees of declination.

The restriction does not concern the GOTO by the LX200 commands.

## Polaris

Hour angle of Polaris (alfa UMi) for alignment assistance. Date/time and location coordinates are necessary.

## BrightContrast

Brightness and contrast adjustment for DynoStar X3. Possibly the contrast is not optimal after loading an update. The LCD of the MTS-3SDI has for it discrete buttons and operation instructions.

## Baudrate

The setting of the baud rate must be identical to your planetarium software.

The presetting is 9600 baud.

Low baud rates are recommended for large cable lengths.

The value 0 disables any reception.

Only MTS-3SDI: Adjust 9600 Baud for MTSconfi.

## Servicecode

Without the input of the service code 1589, some critical functions which begin with \*, are hidden in the menu. The servicecode is stored, so it doesn't need to be entered each time again. The input of a wrong servicecode hides these functions again.

## 13. GOTO out of the internal object catalog

Objects can be selected in several ways:

- Nebula objects directly by indication of a well-known number
- All stars and nebula objects with the help of the filter function
- Bright stars for quick initialization (filter parameters are already preset)
- Objects in the solar system directly from the menu
- For not stored objects directly by input of coordinates

### The initialization (alignment) before the first GOTO, Align1\*

Before the first GOTO is possible, the controller first needs an initialization.

For that adjust a well-known object in the telescope and select it at the controller.

By MODE you induce then the initialization.

The safety query Cancel Align1\* appears. Select Align1\*.

Thus the initialization (also called alignment) is completed.

>Catalog&Filter	alf & And 2m1F	21 & And 2m1F	now? 000000	now? Cancel
BrightStars	Sirrah	000023 * +290521	Align1*	000000

### Check of the correct DE-direction after the first Align1\*

Next you check with FAST speed in the tracking mode whether the actual movement of the telescope in DE corresponds with the change of the DE-coordinate on the display. Otherwise, a correction is necessary: Select in the menu GOTO-CATALOG/SwitchDec once. Alternatively you could also change the sign of DE in MOTORS/SetGearing or the dip switch 10 (with MTS-3SDI). If you do not make this check, the first GOTO can go into the wrong DE-direction. If that is so, do the correction now. All further GOTO and Align1\* are then correct.

### Start the GOTO

Select now another object at the controller, which you would like to observe.

By MODE then the safety query Cancel Goto Align1\* Align2\*\* appears.

alf & A#1 0m8F	53 & A#1 0m8F	now? 000000	Goto	now? Cancel
Altair	195047 * +085157	Align1* Align2**	Align1* Align2**	

Select Goto. Now both motors start with ,goto' speed and move the telescope to the object. After the last motor has stopped, the object should be visible in the telescope. The tracking starts automatically.

There are also possibilities to intervene in the GOTO:

- Steering against by the direction buttons
- Breaking by MODE
- Breaking by stop command via PC

That is necessary when you notice that the telescope would push otherwise against something (tripod, pedestal, wall, etc.). Danger exists also for mounts with limited slew range (e.g. because of projecting DE motor). If it is not obvious that this case cannot happen, thus you should always supervise the GOTO.

GOTO selects automatically the quickest possible route. In GOTO CATALOG/PolarRoute you can adjust whether this may also lead across the pole. Normally the route leads in broken line to the target object, since both motors usually have to run different long routes and thus one of the motors stops earlier. It can therefore also occur that the telescope moves slightly below the horizon. If you steer against with the direction buttons, the fastest way is permanently computed again. From a certain point, the GOTO then will continue to go on with your wished route. In order to check this, you release occasionally the button briefly. If the motor does not become slower then respectively does not change the direction, you need not to steer against further.

## Hints to Align1\* and GOTO

Take for Align1\* if possible an object, which is far distant from the pole and horizon. If only an inaccurate polar alignment of the mount is possible, divide larger GOTO distances into smaller ones by going to objects between them, center these and use them for a new Align1\*.

If you have only slow motors, in order to save time it can be more useful for larger distances to slew the telescope by hand and do a new Align1\* at a bright star in the neighbourhood of the target object. Also you can better move the telescope manually with FAST-speed away from an unfavorable position, instead of having to steer much against the GOTO then.

If the selected object (according to opinion of the controller) is below the horizon, a safety inquiry with NO and YES appears again after selecting Align1\* or Goto. That can e.g. occur, if date, time or the coordinates of the observation place were quite wrongly entered or you were wrong with the object. Check then this again.

This safety inquiry does not appear at the MTS-3SDI, if you did not enter time and date. Functions, which consider the horizon, can't be used meaningfully in this case. Nevertheless GOTO will work correctly. You are then responsible to select no objects below the horizon.

## Align2\*\*

The controllers also allow GOTO with completely wrong aligned or anyhow set up mounts. Therefore a zero-position of the DE-axis and a second object are necessary. Use this function only, if you do not have a possibility to align your mount. This function is generally afflicted with some inaccuracies. In a future version there will be also some optimizations, but even then a moderately good polar alignment might give the better results with Align1\* only.

Slew the telescope in such a way that it is oriented accurately right-angled to the RA axis. If the DE setting circle is correctly adjusted, this matches with 0° on the DE setting circle. Select then GOTO-CATALOG/Set\_DE0-Position. Slew then the telescope to the first object and select Align1\*. This sequence may also be vice versa.

After Align1\* and Set\_De0-Position were made, slew to the second object and select Align2\*\*.

For accuracy both objects should be far away from the horizon, have a distance of about 45° to 90" in each axis and located on the same side of the pole of mount (don't slew over the pole).

In each case pay also attention to a good centering in the eyepiece. After you have accomplished the Align2\*\* correctly, you can subsequently slew to all objects by GOTO. If you select in sequence an Align1\*, the initialization with Align2 would be deleted\*\* again.

Since the tracking still is done only in the RA axis with the normal speed, it is nevertheless meaningful to align the mount approximately to the pole. Thus the objects remain longer in the visual field. In any case you can bring back the same object immediately into the visual field by a repeated GOTO.

## **14. GOTO by PC with planetarium software**

### **Preconditions**

Install a planetarium software (e.g. TheSky, Guide, Cartes du Ciel).

Select in the planetarium software the same baud rate, which is also adjusted at the controller. The presetting is 9600 baud. Select in the planetarium software LX200. Deviating notations like LX200 generic, LX200 classic, Meade or similar are also correct. Some planetarium software need therefore an extra installation.

- Connect PC and controller through the PC-cable or Multi-Interfacecable.
- The mount should be aligned correctly.
- Start the tracking in tracking mode.
- Select in the planetarium software "Establish link to the telescope" or similar.

After successful connection mostly the momentary coordinates are read from the controller and displayed, maybe also a control window with direction buttons, abort button, speed selection and other options. If not, you can select it from the menu.

If the initialization wasn't made yet, these coordinates still contain random values. You can now check whether this coordinates display conforms with that of the controller or if the coordinates change in the same sense by the operation of the direction keys of the controller.

### **The initialization**

Adjust a well-known object in the telescope and select it in the planetarium software for the initialization (corresponds to Align1\* from the previous chapter). Normally this is done by a mouse click at the screen. The operation of different planetarium software is not always uniform, so consult also their manuals.

### **Checking the correct DE-direction after the first Align1\***

See previous chapter.

### **Initiate the GOTO**

Select now the desired target object for GOTO. Now both motors start with "goto" speed and slew the telescope towards the object. After the last motor has stopped, the object should be visible in the telescope. The tracking starts automatically. You can also break the GOTO before. Thereafter you can select the next target object.

### **Hints to GOTO by PC**

After the GOTO has started, you have at the controller the same intervention possibilities as with the GOTO from the controller's internal object catalog (see previous chapter). Both variants of GOTO and initialization can be used at the same time without problems.

GOTO commands can only be executed, if the controller is in tracking mode or the LX200 menu item is selected (see menu items). In the other operating modes GOTO commands are correctly registered, but are executed only when you change to tracking mode or select the LX200 menu item.

If your planetarium software (e.g. TheSky Version5) does not have an initialization command, you have to perform the initialization directly at the controller, since without previous initialization otherwise no GOTO command can be executed.

In order to make then an initialization possible also with a MTS-3SDI without LCD, there is a special solution in tracking mode: Hold MODE, then press LEFT+RIGHT, then release MODE. With that you tell the MTS-3SDI, that exceptionally the next GOTO command from the PC is to be interpreted as initialization. Adjust then the object in the telescope for initialization and select it for GOTO. Therewith the initialization is completed.

## **15. Filter function, object search**

From GOTO CATALOG/Catalog&Filter or GOTO CATALOG/BrightStars you get by RIGHT into the adjustment of the filter parameters. By MODE you get back.

```
>Catalog&Filter  alf α And  2m1P  _ any * <+19m1
BrightStars     Sirrah  400° e+00° >000'0
```

You can then start the search in the object catalog forward by UP or backwards by DOWN. The search direction is indicated by an arrow and can be reversed during the search at any time. If the search takes too long for you, you can also break it by LEFT, then the right now examined object appears. By LEFT you can also switch from coordinate to distance display. Or you wait, until the arrow disappears and an object is displayed. Thereafter you can use the object for GOTO or Alignment by MODE, you can resume the search by UP or DOWN, you can change the filter parameters by RIGHT or you can leave the object catalog by twice MODE. If the search delivers quickly many objects (e.g. if the filter parameters are generously selected or the filter function is switched off), you can go through the object catalog faster by longer pressing UP or DOWN (after some seconds objects are skipped).

All filter parameters can be combined. However some combinations or extreme adjustments are not meaningful, since then possibly no objects are found. Therefore you should first try out each filter parameter separately and add further ones step-by-step if necessary. The filter parameters are not stored durably.

M Tri 00 <+19m1 400° e+00°>000'0	M 33 Tri 62° TriangulumGalaxy
M C99 00 <+19m1 400° e+00°>050'0	n6960 C99 70° FilamentaryNebul
M C99 01 <+19m1 400° e+00°>000'0	n6826 C99 2°3 Blinkin9Planetar

### Global filter switch (1 graphic character)

Select Fil or Abc to switch the filter function on, because it is switched off as default (Off).

#### Off

All objects can be displayed one after the other independent of their attributes.

#### Filt

Only these objects are found and displayed, which fit to the filter parameters.

#### Abc

Only these objects are found and displayed, which fit to the filter parameters and have at the same time a well-known name (trivial name).

### Type of object (1 character)

- \_ find stars or nebulas
- NIC find only NGC or IC nebulas (also all Messier nebulas have a NGC-number)
- \* find only stars
- M find only Messier nebulas

### Constellation (3 characters)

- any find objects in each constellation
- And ... Vul find only objects in this constellation

### Type of nebula (3 characters)

Find only special nebulas (corresponds accurately to the notations in the NGC2000 catalog). At the same time you should select NIC or M as type of object, since otherwise also stars are displayed.

- \* find each nebula
- Gx only galaxies
- OC only open clusters
- Gb only globular clusters
- Nb only bright reflection or emission nebulas
- PI only planetary nebulas
- C+N only star clusters together with nebula
- Ast only asterisms
- Kt only single knots in a galaxy

The other options are not interesting, because they concern only very few and doubtful objects.

### Object brightness (6 characters)

Find only objects that are brighter or fainter than this magnitude.

The default is <19.1mag, so each object is found.

### Distance from the momentary position (4 characters)

Find only objects within this distance in degrees from the current position.

With zero degrees all objects are found.

### **Elevation above horizon (4 characters)**

Find only objects at a minimum elevation in degrees above the horizon. In addition date/time of day and local coordinates are necessary. A negative value finds additionally objects at a maximum depth below the horizon. A value of zero finds all objects.

### **Object size (6 characters)**

Find only nebulas that are larger/smaller than this value in arc minutes. The value of zero finds all objects. At the same time you should select the object type NIC or M, as else stars would also be found and displayed,

## **16. Objects in the solar system, orbital elements**

You can select sun and planets directly as menu items (with DynoStar X3 also minor planets and comets). The current coordinates as well as sun distance and earth distance in astronomical units (AU) are then displayed.

```
>2060 Chiron      20h24m53s5r14.27
20000 Uaruna     -11°43'09"413.35
```

For the correct computation also the correct date/time adjustment is necessary. By LEFT you get immediately back into the menu mode. By MODE you can use the coordinates for Alignment or GOTO.

Only DynoStar X3:

By UP or by DOWN you get to the display of the orbital elements.

When the cursor flashes in the upper left edge of the display, you can go through the orbital elements one after the other by DOWN and by UP.

Below the cursor appears the symbol, right of it the value of the orbital element and at the very right its meaning in words.

After you have moved the cursor by RIGHT or LEFT to the input field, you can change the data in this input field.

For the selection of other orbital elements you move the cursor then again to the very left on the symbol.

```
|| 2060 Chiron      || 2004Jul14.0000 || 0.381860 Eccen || 0°0195344Daily || 209°25558 Node
E 0000__01.0000  a +013.654289 AU || 060°04533 Anom || +006°93493Incl || 339°42540 Peri
```

By MODE the input is terminated and you are asked whether it is to be stored. So you can enter orbital elements of other objects by changing already existing ones. However only those ones in the submenus "COMET editable" and "OWN OBJECTS ed" are actually stored. The orbital elements of the other objects are protected against overwriting.

## **17. Backlash compensation for RA and DE**

In the drive components of a mount (worm gear, gear wheels) a certain backlash usually is unavoidable. When a direction reversal is done, hence the motor first has to bridge this backlash before the telescope reacts. At slow speed that can take several seconds. In order to shorten this time significantly, you can use the automatic backlash compensation.

In UTILITIES/RA-Play and UTILITIES/DE-Play it is adjustable that the stepper motors run after a direction reversal for a number of steps at higher speed.

### **Hints for the backlash compensation**

The necessary number of steps has to be determined by trying out.

For astrophotography adjust the backlash compensation better with some less than too many steps.

In RA the backlash is no problem for tracking, since the RA motor therefore runs always in the same direction. However in DE corrections can be necessary for both directions.

The backlash compensation runs at the selected speed for "goto". Up to which speed the motor actually accelerates, depends however also on the selected acceleration (MOTORS/Acceleration).

For MTS-3SDI only:

If the dip switches 1-8 are all OFF, exclusively the value in UTILITIES/DE-Play is used.

If the dip switches 1-8 are not all OFF, exclusively the value of the dip switches 1-8 is used.

Each dip switch 1-8, which is set ON, contributes additively to the total value:

4, 8, 16, 32, 64, 128, 256, 512

## **18. PEC, Periodic error correction RA**

Mechanical inaccuracies in the drive of the RA axis are often the main cause for an uneven tracking, i.e. the object remains not accurately in the same place in the image field, but moves in the image field slowly back and forth.

Since this movement happens essentially periodically with each worm revolution, this is called the periodic worm error.

For big and qualitatively good mounts this is a few arc seconds. Other mounts can however show a substantial periodic worm error.

The controller has a function for the (to a large extent) correction of this error: periodical error correction, in the following abbreviated as PEC.

The PEC function first records your manual corrections during a worm revolution. Afterwards the PEC function compensates the periodic worm error by predicted variations of the tracking speed.

### **PEC-preconditions**

The parameter RA-Motor\*Gear (RAMG) must be adjusted correctly (see menu items).

In the PEC submenu you can find all necessary menu items for handling the PEC.

With a MTS-3SDI without LCD you can do it by the LEFT button and ON/OFF switch.

### **PEC-strategy**

Adjust a star in the crosshair eyepiece, start the PEC recording and hold the star in the tracking mode in the center of the crosshair. You can also use an autoguider for that.

First select the PEC recording in the menu, then change into tracking mode and switch to SLOW to start it. While a PEC recording is still in progress, you can restart it at any time by switching from FAST to SLOW.

The PEC recording finishes after one worm revolution automatically.

The PEC function is activated then and takes over the corrections immediately.

The PEC function remains activated and stored also after switching off.

The PEC function can also be deactivated, but it still remains stored.

Then the PEC function can be activated again at any time without new PEC recording.

### **PEC hints**

You can break, restart or repeat a PEC recording at any time.

The process of the PEC recording is displayed (MTS-3SDI: 0-63, DynoStar X3: 0-127).

The status of the PEC function is displayed in the menu right of the submenu PEC.

With a MTS-3SDI both is indicated via the color of the LED (the LED temporarily also may show another color in other operations modes for other purposes):

1. green: PEC function invalid
2. yellow: PEC function deactivated
3. red: PEC function activated
4. alternating yellow-dark: PEC recording is in progress

The PEC function becomes invalid in these cases, i.e. deactivated and deleted:

1. If the current supply is separated, before the tracking was switched off.
2. If a PEC recording was started and cancelled prematurely.

You should deactivate the PEC function or start a PEC recording:

1. If the worm was turned without controller.
2. If the tracking was started while the RA motor wasn't correctly connected.
3. If the RA motor stopped irregularly (overload, blocking, too high speed).

## **19. Autoguiding**

For autoguiding the parallel autoguider interface (with separate signal lines for each direction) or the serial PC interface (with LX200 direction commands) can be used.

Most special autoguiders have a parallel autoguider interface (SBIG ST-x, MEADE Pictor, Starlight XPress, etc.). Autoguider and controller are simply connected through the appropriate autoguider cable respectively the Multi-Interfacecable. For autoguiders with RJ11-connector the Pictorcable is necessary for the adaption. There are no special adjustments necessary at the controller.

The controller reacts to the control signals of the autoguider in the same way as to the manual operation of the direction buttons. Thus the same correction speeds are used and the switch should be in SLOW position.

Normally you will select the tracking mode for the autoguiding. You can then also intervene manually at any time.

The controller reacts also to the control signals in every other mode. Only with the MTS-3SDI the control signals are ignored for the moment, when a direction key is pressed.

For the autoguiding function with a webcam a PC with special software is needed. Controller and PC are then connected by the serial interface with the PC cable respectively the Multi-Interfacecable. Some autoguiders are connected in identical way, others possibly also directly with the controller. Consult also the manual of the autoguider.

The specific features of the serial autoguiding are:

The baud rates of both devices must be selected identically.

If you intervene manually in tracking mode, the current autoguider command is cancelled.

You should select a low command rate in the autoguiding software, about 2 commands per second.

At much higher command rates otherwise sometimes single commands could not be recognized.

If a higher command rate should be necessary nevertheless, better select the menu item LX200, because the controller is there less busy with other tasks.

If you have connected the autoguider, first the calibration of the autoguiders is necessary.

The autoguider examines thereby the reaction of the controller to the individual control signals, in order to determine directions and speeds of the correction movements of both axes.

After that the autoguiding can begin. The correction speeds of the controller and the correction parameters of the autoguider should be co-ordinated with the photograph focal length, in order to obtain the optimum results. Trying out step-by-step is advisable.

You should use separate current supplies for controller and autoguider.

Thus you avoid a ground loop through the autoguider cable, which could falsify the signals. In addition so no current glitches from the stepper motors get through the current supply at sensitive camera electronics, which could cause image interferences.

## **20. LX200 command set**

### **Data formats**

The short and the long data formats are accepted automatically (commands :Sr# and :Sd#), likewise an extended data format for RA (with tenth of a second).

Missing leading zeros in the data format of some astro software are also no problem.

As preset, the controller sends the short data format, since not each astro software does accept the long data format automatically.

With the command :U# you can switch between short and long data format. The controller sends then the appropriate data format as reply to the commands :GD# :GR# :Gd# :Gr#. As soon as the controller has received once an extended data format, it sends the extended data format in place of the long data format.

### **Supported LX200 commands**

ACK (ASCII 6)	Acknowledge returns 'G' (German Mount)	Bestätigung gibt 'G' zurück (Deutsche Montierung)
:GR#	reads RA coordinate	liest RA Koordinate
:GD#	reads DE coordinate	liest DE Koordinate
:Mn#	move north	Nord
:Ms#	move south	Süd
:Me#	move east	Ost
:Mw#	move west	West
:MS#	starts the GOTO	Startet das GOTO
:Qn#	stop north	Stoppt Nord

:Qs#	stop south	Stoppt Süd
:Qe#	stop east	Stoppt Ost
:Qw#	stop west	Stoppt West
:Q#	stops GOTO or any move	Stoppt GOTO oder jede Bewegung
:RG#	Guide speed (SLOW))	Nachführgeschwindigkeit (SLOW)
:RC#	Center speed (SelectXSpeed manu 0)	Zentriergeschwindigkeit (SelectXSpeed manu 0)
:RM#	Find speed (SelectXSpeed manu 3)	Suchgeschwindigkeit (SelectXSpeed manu 3)
:RS#	Slew speed (SelectXSpeed goto)	GOTO-Geschwindigkeit (SelectXSpeed goto)
:Gr#	reads back RA-buffer	Liest RA-Puffer zurück
:Gd#	reads back DE-buffer	Liest DE-Puffer zurück
:Sr ...#	loads RA-buffer	Lädt RA-Puffer
:Sd ...#	loads DE-buffer	Lädt DE-Puffer
:CM#	alignment, initialize coordinates with RA,DE-buffer	Initialisierung der Koordinaten mit RA-Puffer und DE-Puffer
:U#	toggle short/long format, short format is default	Wechselt kurzes/langes Format, kurzes Format ist voreingestellt

## **21. Loading an update**

Connect controller and PC. Activate the update mode by holding all 5 buttons, while you attach the supply voltage. Start then the update program and follow the instructions.

First the program memory is loaded, afterwards the data memory is loaded optionally and verified again. The data memory actually must always be loaded, so that program and data structure are compatible and everything works correctly.

The exception is permitted only if it involves "a small" update, which repairs only a bug but has still the same data structure. The advantage is that your own adjustments remain stored and the update is loaded faster.

However you should have always noted your own adjustments in any case, since you could have to enter them after a "big" update again or in the event of an error.

Sometimes it can occur that the verify of the data memory proceeds very slowly and with endless error messages. Then probably only a harmless synchronization problem is present. The data memory was correctly loaded with highest probability. Break the verify then by CONTROL-BREAK.

In rare cases the program memory cannot be completely loaded immediately, because the program breaks prematurely. Simply try it again. After connection of the supply voltage a controller with incomplete program always starts in the update mode.

It does the same, if loading the program memory was interrupted from any other reasons. If loading the data memory was interrupted, you have to set the controller into the update mode and load the update again.

If it should not have worked after a few times yet, there is obviously a small problem with the timing when the Flash ROM is written. This occurs only with some few microcontrollers. If you are affected by this, contact the manufacturer with the serial number for support.

## **22. MTS-3SDI: compatibility to version 2.xx**

Software that bases on the old 2.xx command set (e.g. MTSca, MTScontrol, ASCOM driver) can't be used any longer. MTSconfi is still supported for adjusting the parameters. Likewise the LCD redirection to the RS-232 interface can still be used.

The version MTS-3SDI 3.xx uses another storage area for the data code than the older MTS-3SDI versions 2.xx. For this reason it is also possible to load the version 3.xx and an older version alternately without having to load the data code again and so own adjustments needn't be overwritten. In this case you need not to accomplish the download of the data code, but break the update program by the escape key. With the older versions a download of a data code is not foreseen anyway, the re-initializing of the data code happens here only through the RESET.

## **23. MTS-3SDI: MTSconfi, mount parameters**

If your mount is not listed among the stored mounts, you can use the program MTSconfi in order to adjust the MTS-3SDI properly.

Therefore load MTSconfi.zip from our website. In addition to the actual program MTSconfi.exe there are files included for several mounts with various motor equipments, for 12V and for 24V. Select the suitable file or change the parameters in a file suitably for your mount, if your mount is not included.

Now connect PC and the MTS-3SDI through the PC cable. Both switches must be OFF and SLOW. Attach the supply voltage. No button must be pressed.

Start MTSconfi, follow the instructions and enter the suitable file name.

If you like to change only individual parameters of the MTS-3SDI, store first the read parameters in a file. Change then this file by an editor and load this file then back into the MTS-3SDI.

If you like to use the MTS-3SDI without LCD for GOTO, DEslow may not be adjusted freely with MTSconfi, but must be calculated like RASlow.

The MTS-3SDI computes from DEslow the total reduction for DE, which is stored in SetGearing. A wrong value otherwise would falsify the GOTO in DE.

## **24. Operate MTS-3SDI by ON/OFF-switch**

You can start the basic functions of a MTS-3SDI also with ON/OFF switch and a combination of keys. Without LCD you have normally only this possibility.

There are still further such functions, which serve for the adjustment of motor parameters. These are described in the manual of version 2.00 and MTS-3SDI additional manual..

However it is expected that these old 2.00-compatible functions will not be included in future versions any more in favor of new features. For adjustments you should thus better use the MTSconfi software or the LCD.

### **Start sidereal tracking (speed for stars)**

Switch to ON.

### **Start solar tracking (speed for sun)**

Hold UP, switch to ON, release UP.

### **Start lunar tracking (speed for moon)**

Hold DOWN, switch to ON, release DOWN.

### **Stop tracking**

Switch to OFF.

### **Start tracking and record PEC**

Hold LEFT, switch to ON, release LEFT.

By switching from FAST to SLOW the recording starts, if necessary repeated.

### **Activate/deactivate PEC**

Hold LEFT, switch to ON, release LEFT, switch to OFF.

The status of the PEC function is switched. Notice the LED color!

### **Select pre-adjusted mount**

For a certain mount, set the specified dip switches 1-3 to ON and the others to OFF. The dip switches 4-10 are indifferent.

Hold UP+RIGHT+DOWN, switch to ON, release all, switch to OFF.

Mount0	Mount1	Mount2	Mount3	Mount4	Mount5	Mount6	Mount7
<b>Vixen MT1, Astro5, EQ4,EQ5 12V</b>	EQ6, HEQ5 12V	Vixen Escap P530-004 12V	EQ6 / CI700 Escap P530-004 12V	Vixen Astro- meccanica Motorset 12V	EQ6 Astro- meccanica Motorset 12V	OTE 150 12V	EQ6 McLennan Motorset 12V
- - -	1 - -	- 2 -	1 2 -	- - 3	1 - 3	- 2 3	1 2 3

The mount7 has a special role. It serves as backup copy, which can be copied back if necessary at any time. It is also not changed by a RESET. If you adjust mount7 by dip switches, it is not selected but overwrites the currently selected mount.

### **Create backup copy**

The current mount is copied to mount7.

Hold UP+LEFT+DOWN, switch to ON, release all, switch to OFF.

### **RESET**

Hold LEFT+UP+RIGHT+DOWN, switch to ON, release all, switch to OFF.

Mount0 to mount6 are reset to the original values, mount0 is selected. Mount7 remains unchanged.

The baud rate is set to 9600.

**Select baud rate**

For a certain baud rate set the specified dip switches 1-4 to ON and the others to OFF.

The dip switches 5-10 are indifferent.

0	300	600	1200	2400	4800	<b>9600</b>	14400	19200	28800	57600
- - - -	1 - - -	- 2 - -	1 2 - -	- - 3 -	1 - 3 -	- 2 3 -	1 2 3 -	- - - 4	1 - - 4	- 2 - 4

**25. Configure the mount and motor parameters**

If your mount is not included in the list or for the MTS-3SDI no suitable MTSconfi file is available, you have to adjust the suitable parameters yourself. First get the reduction data and motor data of your mount. Here is explained, how you calculate or find out these parameters and for the exact understanding their meaning is specified.

**Relevant parameters for DynoStar X3 and MTS-3SDI****Slow- and Fast-frequencies MOTORS/\*Frequency**

$RA_{slow} = \text{worm wheel} * \text{gearhead} * \text{motor full steps} * 2 / 86164$

For 1x choose  $DE_{slow}$  like  $RA_{slow}$ . Otherwise  $DE_{slow}$  is chosen as required.

Choose  $RA_{fast}$  and  $DE_{fast}$  as high as the motors can still manage it reliably.

**Total reduction MOTORS/\*SetGearing**

$RA$  and  $DE = \text{worm wheel} * \text{gearhead} * \text{motor full steps} * 64$

Mostly  $RA$  and  $DE$  are identical. The sign of  $RA$  determines also the rotation direction of the tracking (see menu item MOTORS/\*SetGearing).

If SetGearing is not correctly selected, the GOTO distances are not correct. Check that during tracking (without corrections) the  $RA$  coordinate does not run away.

**Acceleration MOTORS/Acceleration**

Small values cause a low acceleration, which is in particular necessary for heavy telescopes with long lever due to their mass inertia. Otherwise you should try out, how much you can select the value, without the motors stop during acceleration.

**Micro step resolution MOTORS/Microstep**

Normally you let the finest value 1/64. Coarser values can be necessary for some mounts, if the total reduction is rather high. Otherwise the Slow speed was limited by the maximally permitted micro step rate of 2000Hz.

(Example: Slow frequency 20Hz half step rate, micro step 1/64 results in 640Hz micro step rate).

**Relevant parameters for DynoStar X3****Motor current, MOTORS/\*MotorCurrent**

Do not select more than the rated current of the stepper motor. If the torque is sufficient, lower adjustments are always permitted e.g. to minimize the current consumption for operation with battery. You should note however that a lower current can worsen the resolution of micro step dependent on the necessary torque.

If the rated current is not specified, then  $\text{rated current} = \text{rated voltage} / \text{winding resistance}$ .

For bipolar stepper motors with 8 leads it is twice as high for parallel interconnection as for serial interconnection. Usually this is extra specified. For unipolar stepper motors the specified rated current is valid when using half windings. When using the whole windings then 70% of the rated current is valid.

**Calibration function, MOTORS/\*CurrentSymmetry**

The DynoStar X3 can regulate the motor currents very accurately over a large range and thereby allows also very precise micro steps.

In order that the accuracy is not reduced by manufacture tolerances of drive electronics, the DynoStar X3 has a calibration function, in order to determine and compensate the tolerances.

This function is normally only necessary once after you have loaded an update (the update resets the calibration to average values).

Therefore both motors must be connected and you should use a low voltage (usually about 12V) for a maximum accuracy.

Otherwise without calibration, weak stepper motors with little winding current could not run steadily or not at all and powerful stepper motors with the maximum winding current would also unnecessarily stress the DynoStar X3. If you operate several mounts alternately, accomplish the calibration with the weakest motors. With completely wrong calibration, e.g. if no motors were connected during the calibration, the motors will not function correctly. You recognize a good calibration also by the fact that the current consumption of the DynoStar X3 varies only little at low motor speed.

## Relevant parameters for MTS-3SDI

### Motor current, MOTORS/\*PWM,limit

For the maximum current the same is valid as with the DynoStar X3.

But here the determination of the parameters is somewhat more complicated, since the current control system of the MTS-3SDI has to manage it without current sensing resistors.

The motor current can therefore not be adjusted with absolute values, but depends on the supply voltage and the total resistance. The total resistance is the sum of winding resistance, cable resistance and internal resistance of the motor electronics.

Cable resistance + internal resistance are for a MTS-3SDI for instance  $0,5\text{Ohm}+2,4\text{Ohm}=2,9\text{ ohm}$ , for a MTS-3SDI+ for instance  $0,5\text{Ohm}+0,7\text{Ohm}=1,2\text{Ohm}$ .

The parameter PWM serves to be able to adjust the motors current proportionally smaller than this would be the case solely after Ohm's law ( $I=U/R$ ).

Motor current = PWM \* supply voltage/total resistance.

The equation can be transformed, in order to compute the necessary PWM value:

$\text{PWM} = \text{motor current} * \text{total resistance}/\text{supply voltage}$ .

If necessary you have to limit the motor current to the maximally permitted output current of 0,5A (MTS-3SDI) or 1,0A (MTS-3SDI+).

Example MTS-3SDI+: Motor current=0,7A Winding resistance=6Ohm

Supply voltage=12V:  $\text{PWM} = 0,7\text{A} * (6\text{Ohm}+1,2\text{Ohm}) / 12\text{V} = 42\%$

Supply voltage=24V:  $\text{PWM} = 0,7\text{A} * (6\text{Ohm}+1,2\text{Ohm}) / 24\text{V} = 21\%$

It is sufficient, if the PWM value is only approximately adjusted. Thus the motor current is controlled quite exactly at slow speeds.

### Critical frequency, MOTORS/\*PWM,limit

Besides the limit values have to be adjusted in such a way, that the motor current is still controlled exactly enough at higher speeds.

For the exact understanding, here is a small excursion to the operational principle of stepper motors: In order that the rotor of a stepper motor rotates, the currents in the two windings must be controlled according to a certain sequence alternating in one and the other direction. Briefly said, in both windings flow (90° phase shifted) alternating currents, depending on the desired speed at a certain frequency.

The motor current, from which up to now was the speech, here actually means the desired maximum value (amplitude). So the current in each winding changes periodically between zero, positive maximum value, zero, negative maximum value, zero, etc.. But the current cannot rise and fall any fast because of physical reasons (inductance, counter-emf), which causes from a certain frequency up (in the following called critical frequency) that the peak value does not reach any more the desired maximum value. With each further frequency increase the peak value of the current continues to decrease. In consequence the torque becomes lower and lower, until the stepper motor finally stalls.

The DynoStar X3 has a current regulation in hardware, that will increase the PWM automatically and steplessly to 100% up to the critical frequency, so that the desired maximum value is actually reached. The microcontroller does not need to worry about it. Beyond the critical frequency the torque decreases then continuously.

The MTS-3SDI unfortunately has no hardware, which would increase the PWM automatically with increasing frequency. The microcontroller must take over this task. Therefore it is necessary to adjust suitable limit values for the critical frequency. The critical frequency depends on supply voltage and the type of the stepper motor. Unfortunately there is no accurate formula to compute it. Therefore the best way is to determine suitable limit values experimentally.

However there are these simple rules:

1. First adjust the PWM values.
2. As reference point, limit values in MTSconfi files of similar stepper motors are recommended.
3. The limit value must be the higher the lower the winding resistance or the higher supply voltage is.
4. Adjust for testing the lowest acceleration and use preferably an analog amperemeter, in order to observe the current consumption of the MTS-3SDI.

5. If the current consumption rises much during acceleration or the electronic overcurrent protection responds, a higher limit value should be selected.

6. If the current consumption drops much during acceleration and the torque becomes too small, a lower limit should be selected.

7. If strong resonances arise during acceleration, then select a slightly higher limit value.

In principle the adjustment of the limit values for weak stepper motors or low maximum speeds is rather uncritical.

The adjustment of the limit values for powerful stepper motors must be done the more exactly, the higher the motor current, speed and supply voltage are. For very low winding resistances the principle works too inaccurately and the DynoStar X3 is strongly recommended then.

## **26. Trouble-shooting, reasons and solutions**

Problem	Reason, problem solution
Direction of rotation is not correct	Change signs of RA in SetGearing (or for MTS-3SDI change dip switch 9), then restart
Motor does not run correctly, controller or motor becomes very hot	DynoStar X3: CurrentSymmetry MTS-3SDI: PWM and limit adjustments
Motor becomes very hot	DynoStar X3: reduce MotorCurrent MTS-3SDI: reduce PWM
Motors are switched off	DynoStar X3: MOTOR SHUTDOWN, too weak power supply, possibly reduce MotorCurrent
Motor omits steps	DynoStar X3: increase MotorCurrent MTS-3SDI: decrease limit value
Motor stops at high speed and hums	Decrease speed
Direction of rotation of the motor is undefined	A winding connection is interrupted. Measure connector, cable, motor, conductance.
LED, LCD backlight flashes slowly	Low-Voltage warning
LED, LCD backlight flashes quickly after connecting the supply voltage	Memory error, load update again, contact manufacturer
GOTO leads to wrong DE-direction	Select SwitchDec once or change dip switch10
GOTO leads to wrong position	SetGearing is not correct
GOTO is inaccurate, drift in declination	Alignment of the mount
GOTO breaks suddenly	Negative Encodertolerance. Set it either more negative or positive. Set it to zero when encoders are not used
Planet coordinates are not correct	Date/time-adjustment
Display does not show coordinates	Adjust coordinates in SHOW/ShowWhileTrack
Tracking is too slow although the Slow frequency is correct, right and left corrections are not symmetrical	Select coarser micro step
Tracking is inaccurate	Check clutch, gear wheels, set-screw. Switch PEC off and record it again.
Loading an update does not work	See chapter
Disturbance of the autoguider signals	No potential separation, use separate current supplies

## 27. Term explanations

stepper motor	A special electric motor, which performs a defined rotation motion (steps) which is exactly controlled by electronics. Very slow and high speeds and an accurate positioning without expensive regulation electronics (e.g. like servo actuators). The change of the current flow in several windings in a certain sequence generates the rotation motion. At constant current flow the stepper motor stands still and produces a holding torque.
2-phase stepper motor	Commonly used design of stepper motors with 2 windings. Apart from performance data and the number of connections, there are different manufacture technologies and qualities: Permanent magnet stepper motor (cheap, low power), hybrid stepper motor (industry standard), disk magnet stepper motor (expensive, max. power)
bipolar 2-phase stepper motor	4 or 8 connections. The type with partial windings and 8 connections makes it possible to interconnect the partial windings externally either in parallel, serial or unipolar. The bipolar operation requires that the controller can control the current of both windings in both directions. With the bipolar operation the complete winding volume is used at the same time, which increases the efficiency.
unipolar 2-phase stepper motor	5 or 6 connections. In order to save connections, the partial windings can be already internally connected in series. There are then 2 windings with additional center connections, altogether 6 connections. Such a stepper motor is designed for unipolar operation, but it can also be used for bipolar operation. Stepper motors with 5 connections can only be operated unipolar. The unipolar operation permits that the controller only needs to control the current in each partial winding in one direction. That makes electronics less complex and cheaper. Only the half winding volume is used at the same time, which reduces the power efficiency.
Frequency <a href="http://en.wikipedia.org/wiki/Frequency">http://en.wikipedia.org/wiki/Frequency</a>	Generally events per second. Frequency values refer here to half steps per second.
full step mode	In both windings flows the full current. The commutation of the current flow in the windings in a certain sequence always turns the rotor suddenly one full step.
half step mode	Before the current flow in a winding is commutated, the current in the winding first is switched off completely in an intermediate phase. Thus the steps are only half as large and the stepper motor runs more calmly.
micro Step mode	The current flow in both windings is controlled in smaller steps in shape of approximate sine and cosine curves. Thus the steps are even smaller and the stepper motor is running even more calmly.
LED <a href="http://en.wikipedia.org/wiki/Light-emitting_diode">http://en.wikipedia.org/wiki/Light-emitting_diode</a>	Light Emitting Diode The small lamp of the MTS-3SDI.
LCD	Liquid Crystal Display. For the controllers it is an alphanumeric display.
RA <a href="http://en.wikipedia.org/wiki/Right_ascension">http://en.wikipedia.org/wiki/Right_ascension</a>	Right ascension or right ascension axis
DE <a href="http://en.wikipedia.org/wiki/Declination">http://en.wikipedia.org/wiki/Declination</a>	Declination or declination axis
Autoguider, autoguiding	A system, which notices the deviations of the guidance star through an electronic image sensor in the focus of the guidance telescope, computes necessary corrections and passes the correction signals to the telescope controller. Is very helpful for long focal length astrophotography.

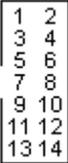
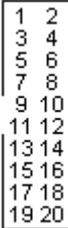
Incremental encoder, rotation transducer <a href="http://en.wikipedia.org/wiki/Rotary_encoder">http://en.wikipedia.org/wiki/Rotary_encoder</a>	Sensor, which transforms rotating motions through an optical disk with line pattern into electrical signals. Two 90° phase shifted digital square signals allow then the logging of speed and relative rotation angle. With incremental encoders at both axes of a mount the absolute coordinates RA and DE can be determined after an initialization.
GOTO	Automatic positioning to celestial objects
Microcontroller <a href="http://en.wikipedia.org/wiki/Microcontroller">http://en.wikipedia.org/wiki/Microcontroller</a>	The small single-chip-computer of the controller
Software resp. firmware <a href="http://en.wikipedia.org/wiki/Firmware">http://en.wikipedia.org/wiki/Firmware</a>	The program in the microcontroller of the controller.
Menu, menu system, menu items	User interface with display
Features	Characteristics and functions
Alignment, Initialization	Tells the coordinates to the controller
Motor current	Maximum current which is controlled in the windings of the stepper motors.
LX200, LX200 command set <a href="http://en.wikipedia.org/wiki/Meade">http://en.wikipedia.org/wiki/Meade</a>	Telescope and telescope controller with serial PC interface of the US company Meade. As a result of the high spreading of the LX200 and their support by many PC software, for compatibility reasons the LX200 command set was used by other manufacturers for their own telescope controllers, mostly in reduced complexity only with the commands, which are necessary for GOTO and autoguiding.
Tracking <a href="http://en.wikipedia.org/wiki/Telescope_mount">http://en.wikipedia.org/wiki/Telescope_mount</a>	Tracking of the adjusted celestial object, compensation of the earth rotation by rotating the RA axis.
DSUB connector <a href="http://en.wikipedia.org/wiki/D-subminiature">http://en.wikipedia.org/wiki/D-subminiature</a>	A wide-spread design of a connector system for data links.
Cursor <a href="http://en.wikipedia.org/wiki/Cursor_%28computers%29">http://en.wikipedia.org/wiki/Cursor_%28computers%29</a>	The small flashing rectangle in the display, at whose position inputs can be done.
Dip switches (dual in print switches) <a href="http://en.wikipedia.org/wiki/DIP_switch">http://en.wikipedia.org/wiki/DIP_switch</a>	The small 10 switches of the MTS-3SDI, also jokeful called mouse piano.
PEC	Periodical error correction

## 28. Technical data

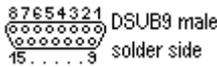
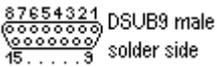
### Controllers

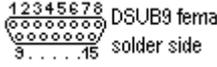
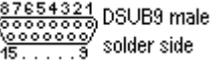
	MTS-3SDI, MTS-3SDI+	DynoStar X3 1.6A
Supply voltage	10V – 28V DC (stabilized DC voltage)	10V – 39V DC (stabilized DC voltage)
Current consumption, motors switched off	~20mA (without LCD) ~46mA (LCD max. bright)	~24-30mA (LCD-Backlight off) ~29-43mA (LCD max. bright)
Typ. current consumption at 12V with Escap P530-004	~0,25A (only RA motor)	~0,35A (only RA motor)
MOSFET-polarity protection	0R085	0R024
TRANSIL-protection diode	30V	39V
Warning Low Voltage	9,6V LED flashes	variable 10-34V backlight flashes
Internal 5V voltage	Linear voltage regulator 100mA	Switching reg., 500mA 260kHz
Melting fuse	2A super fast	4A super fast
Elektr. overcurrent protection	~2A total	~2A each winding separately
Stepper motor winding current maximum	MTS-3SDI: ~500mA MTS-3SDI+: ~1000mA	DynoStar X3 1.6A: 1600mA DynoStar X3 3.2A: 3200mA
PWM switching frequency	21,6kHz fixed	~25kHz fixed
PWM principle	controlled, no sense-resistors	regulated, 0R22 sense resistors
Micro step	1/64	1/64
Stepper motor control frequency Slow (calculated in half steps)	1Hz-1000Hz	1Hz-1000Hz
Stepper motor control frequency Fast (calculated in half Steps)	14Hz – 5000Hz	14Hz-14400Hz
Fast micro step changeover	-450Hz:1/8,-900Hz:1/4, >900Hz:1/2	-450Hz:1/8,-900Hz:1/4, >900Hz:1/2

### Interface connector

MTS-3SDI, MTS-3SDI+			DynoStar X3		
	1: LCD data/rs 3: RA+ 5: RA- 7: DE- 9: DE+ 11: RS232-RXD 13: ON/OFF	2: LCD clock 4: Ground 0V 6: 5V 30mA 8: SLOW/FAST 10: RS232-TXD 12: LCD enable 14: Encoder data		1: LCD clock 3: Ground 0V 5: 4,75V 100mA 7: Ground 0V 9: DE- 11: Ground 0V 13: Encoder data 15: RA- 17: Ground 0V 19: SLOW/FAST	2: LCD enable 4: LCD data/rs 6: RS232-RXD 8: RS232-TXD 10: reserved 12: DE+ 14: Ground 0V 16: MODE 18: RA+ 20: Ground 0V

### Motor/Current supply connector

MTS-3SDI, MTS-3SDI+			DynoStar X3 1.6A		
	1: RA-phase1 2: RA-phase2 3: RA-phase3 4: RA-phase4 5: DE-phase4 6: DE-phase3 7: DE-phase2 8: DE-phase1	9: Supply+ 10: Supply+ 11: no connect 12: no connect 13: no connect 14: Supply- 15: Supply-		1: RA-phase1 2: RA-phase2 3: RA-phase3 4: RA-phase4 5: DE-phase4 6: DE-phase3 7: DE-phase2 8: DE-phase1	9: Supply+ 10: Supply+ 11: 4,75V 100mA 12: Encoder data 13: Ground 0V 14: Supply- 15: Supply-

DynoStar X3 3.2A DE			DynoStar X3 3.2A RA		
	1: DE-phase1A 2: DE-phase2A 3: DE-phase3A 4: DE-phase4A 5: DE-phase1B 6: DE-phase2B 7: DE-phase3B 8: DE-phase4B	9: Shield 10: no nonnect 11: no connect 12: no connect 13: no connect 14: no connect 15: no connect		1: RA-phase1A 2: RA-phase2A 3: RA-phase3A 4: RA-phase4A 5: RA-phase1B 6: RA-phase2B 7: RA-phase3B 8: RA-phase4B	9: Supply+ 10: Supply+ 11: 4,75V 100mA 12: Encoder data 13: Ground 0V 14: Supply- 15: Supply-

## 29. Cables, accessories, extensions

Accessories and cables are not components of the controller and are offered separately. Depending on the mount, motors and targeted application you will need the one or the other of it.

### ArcticFlex Motorcable 2x(8x0,14mm<sup>2</sup>) for DynoStar X3 3.2A with booster module

ArcticFlex Motorcable (8x0,14mm <sup>2</sup> ) for booster module	1	phase1A	white	1	Kabel	yellow	Escap P530	
	2	phase2A	brown	7	 DSUB9 female solder side	yellow-white	Motor	
	3	phase3A	green	9		54321	DSUB9 male	
	4	phase4A	yellow	4		6783	solder side	
RA	5	phase1B	grey	2			red	
	6	phase2B	pink	6			red-white	
	7	phase3B	blue	8			orange-white	
	8	phase4B	red	5			orange	
DE								

### ArcticFlex Motorcable (8x0,14mm<sup>2</sup>)

HEQ5 (for original HEQ5-motors additionally adapter cable necessary)	RA-phase1	white	2	 DSUB9 female solder side
	RA-phase2	brown	7	
	RA-phase3	green	8	
	RA-phase4	yellow	4	
	DE-phase4	grey	5	
	DE-phase3	pink	9	
	DE-phase2	blue	6	
	DE-phase1	red	1	

### ArcticFlex Motorcable (4x0,25mm<sup>2</sup>)

Escap P530 serial, EQ6 (for original EQ6-motors additionally adapter cable necessary)	phase1	white	2	 DSUB9 female solder side	Half windings connected by solder bridges in series: 1+6 connected together 5+9 connected together
	phase2	brown	7		
	phase3	green	8		
	phase4	yellow	4		
Escap P530 parallel, EQ6 (for original EQ6-motors additionally adapter cable necessary)	phase1	white	2+1	 DSUB9 female solder side	
	phase2	brown	7+6		
	phase3	green	8+9		
	phase4	yellow	4+5		
AstroMeccanica AM-V	phase1	white	1	DE :	RA:
	phase2	brown	2	 DSUB9 female solder side	 DSUB9 male solder side
	phase3	green	4		
	phase4	yellow	5		
Vixen MT1	phase1	white	5		
	phase2	brown	2		
	phase3	green	4		
	phase4	yellow	1		
EQ4, EQ5	phase1	white	2	 RJ11 6-4	
	phase4	yellow	3		
	phase3	green	4		
	phase2	brown	5		
G11, GM8, CI700	phase1	white	2	 RJ11 6-4	
	phase4	yellow	3		
	phase2	brown	4		
	phase3	green	5		

### Encodercable NGCMAX-compatible

DynoStar X3 connector	Encoder module in Encoder connector	Y-cable RA DE 1m	Ch-B	6	yellow	 RJ11 6-4
 DSUB9 female solder side 2-wires with shield 2m 11: 4,75V 100mA white 12: Encoder data brown 13: Ground 0V shield	 DSUB9 male solder side Program-Interface: 1: RESET 2: +5V 3: Ground 6: SCK 7: MISO 8: MOSI	 DSUB9 female solder side	+5V	2	green	
			Ch-A	7	red	
			Ground	3	black	
			Ch-B	8	yellow	 RJ11 6-4
			+5V	4	green	
			Ch-A	9	red	
			Ground	5	black	DE

### PC-cable for MTS-3SDI

MTS-3SDI ribbon conn. 14 pole	ribbon cable 10-pole	PC COM-Port, DSUB9 female
11 RS232-RXD	red	3 RS232-TXD
4 Ground	white	5 Ground
10 RS232-TXD	orange	2 RS232-RXD

### ST4-cable , ST7-cable for MTS-3SDI

MTS-3SDI ribbon conn. 14 pole	ribbon cable 10-pole	SBIG ST7 DSUB9 male	SBIG ST4 DSUB15 female
3 RA+	black	3	10
4 Ground	white	5	5,8,11,14
5 RA-	grey	6	4
7 DE-	blue	7	7
9 DE+	yellow	4	13

### Multi-Interfacecable4 , Multi-Interfacecable7 for DynoStar X3

DynoStar X3, ribbon conn. 20 pole	Ribbon cable 16-pole		
5 6 RS232-RXD 7 Ground 8 RS232-TXD	4 pole blue green yellow orange	PC COM-Port, DSUB9 female - 3 RS232-TXD 5 Ground 2 RS232-RXD	
9 DE- 10 11 Ground 12 DE+ 13 14 Ground 15 RA- 16 17 Ground 18 RA+ 19 20 Ground	12 pole red brown black white grey violet blue green yellow orange red brown	SBIG ST7 DSUB9 male 7 - 5 4 - - 6 - - 3 - -	SBIG ST4 DSUB15 female 7 - 8 13 - 14 4 - 5 10 - 11

### Pictorcable4 , Pictorcable7

Pictorcable4 DSUB15 male	Pictorcable7 DSUB9 female	Modular cable 6 wire		
-	-	white	1 +5V	
5	5	black	2 Ground	
4	6	red	3 RA-	
7	7	green	4 DE-	
13	4	yellow	5 DE+	
10	3	blue	6 RA+	

### Cable for SBIG color filter wheel (CFW8A) adapter (ST7,ST8,ST10)

The adapter for the SBIG CFW8A occupies the DSUB9 connector. The signals for the telescope controller are looped through to a RJ-11 connector, however their pin assignment is mirror-inverted to the Pictorcable. If the filter wheel is used, thus such an additional adapter cable is necessary.

### Upgrade of MTS-3SLP+ to MTS-3SDI+ (resp. MTS-3SLP to MTS-3SDI)

MTS-3SLP and MTS-3SDI of the same production series exactly share the same hardware.

The difference is the software. The MTS-3SLP does not support micro step, is only delivered with version 2.14 and does not support updates via the PC cable.

With the Upgrade, which is only possible by returning it to the manufacturer, a MTS-3SLP becomes a full-value MTS-3SDI. Then the latest version can be loaded at any time via the PC cable.

### LC-Display for MTS-3SDI

In the basic configuration the MTS-3SDI has no LC-display. The upgrade with the LC-display brings the following advantages:

- easier operation thanks menu system
- faster and easier programming/adjusting
- more functions are usable
- GOTO from internal object catalog (for free trial).

By the way, the LC-display is also usable for the MTS-3SLP, however without menu system.

### Keycode for MTS-3SDI

Without key code the GOTO from the internal object catalog is limited to declinations between  $\pm 30^\circ$ . The keycode cancels this restriction. Of course the keycode is useful only in combination with a LC-display. You can order the keycode at any time. As soon as you have paid, the 9 digit number is immediately communicated to you. You enter it then once in the menu item INFO/Keycode.

### Boostermodule for DynoStar X3

The booster module is a component of the DynoStar X3 3.2A, but also a DynoStar X3 1.6A can be upgraded with it later. The booster module is useful only in combination with stepper motors, which have separate and not magnetically coupled half windings (not wrapped one on the other), like e.g. the Escap P530-004 or P530-0.7. An Escap P530-0.7 can then be operated effectively with 3.2A winding current and allows thus a very high speed (7000Hz) already at a low supply voltage like 12V. With higher voltage, you can even use the maximum possible speed which is supported by the software (14400Hz).

## **30. Security advices**

### **Never connect the mains power (AC) to the controller!**

**The controller probably would be destroyed and for you or other present persons there would exist danger of life by a possible electric shock! Also keep the controller away from unauthorized persons and little children by all means.**

Use only a suitable power supply with stable DC voltage within the permitted range. Too weak electric power-cube transformers or battery chargers are e.g. not suitable!

Coarsely wrong adjusted motor parameters (DynoStar X3: MotorCurrent, MTS-3SDI: PWM and limits) can cause too high winding currents and especially small stepper motors could suffer damages by overheating. After changing of motor parameters or supply voltage, make sure that the stepper motor does not get too hot.

Avoid to unplug the motor connector, while the stepper motor is still supplied with current. Otherwise the fast breaking down magnetic field in the stepper motor's windings induces an uncontrolled high voltage, which can damage the electronics. Also any accidental interruption of one of the motor connections would have the same effect, e.g. by a bad contact or a cable break. Quality cables and safe connectors are therefore no luxury and are strongly recommended.

It is recommended to separate the controller from the cables if it is not used for a longer period. During a thunderstorm otherwise overvoltages could get into the controller and damage the electronics.

Further danger exists by electrostatic charges, if you move on synthetic material floor, carpet or dry underground when the air humidity is low. Isolating rubber soles further increase this danger and the electrostatic voltage. When touching the controller there can occur then a severe discharge, which can possibly damage it, in particular if this is repeated frequently. If you cannot avoid these conditions, you should discharge yourself at a grounded object, before you touch the controller or mount.

Do not expose the controller to higher temperatures than 50°C. Even at lower temperatures the display should not be exposed for a longer period to the bright sunlight. Below the glass otherwise easily higher temperatures can develop, which damage the liquid crystals of the LCD. You recognize an intense increase of the temperature also by the fact that characters and background on the LCD get darker.

Avoid that the controller drops on the floor. An impact on hard underground can not only affect the housing, but could also let break the LCD glass or the oscillating quartz crystal.

Avoid also that the controller is exposed unnecessarily to dust and dirt.

Keep away also all liquids. For the cleaning you can use a cloth dampened with little alcohol.

If a liquid should have get into the controller nevertheless, separate it immediately from the power supply and do not connect the power supply again.

Even if the controller has been dried to a large extent, there can still remain residuals which can cause malfunctions or damages due to their conductivity or attract further dirt due to their adhesiveness. As soon as as possible look for assistance from an expert, who cleans it with distilled water.

Normal dew, which can condense during the night on the controller, is normally unproblematic, if the controller is allowed to dry again, before it is kept in closed custody.

If you use powerful motors, which cause a sufficient self-heating of the controller, no dew is expected inside the controller also at very low ambient temperature. Otherwise you can warm up the controller in the jacket pocket.

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