Telescope Drive Unit
Instruction Manual

FS2

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This manual was written for software version 1.18

1.1 Introduction

Don´t worry, you don´t have to read the whole instruction manual immediately. To begin with you only have to read chapters 2 and 3.

The FS2 software was carefully tested by several experts. If you still find an error, I need the following information from you:

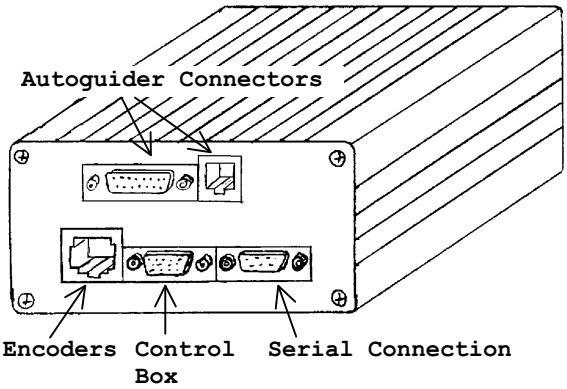
1. The version number of the software, which is displayed for a moment after switching on the FS2.
2. A complete list of all adjusted parameters.
3. A detailed description of how to reproduce the error. A problem can only be solved, if it is reproducable.

If you have a proposal for improving the FS2, please let me know.

It is a good idea to take the first steps in daylight in order to become more familiar with the handling of the FS2.

2.1 Control Box Connection

The control box has to be connected to the 15 pin jack. You may fasten the plug with the two screws to avoid unplugging it unintentionally.

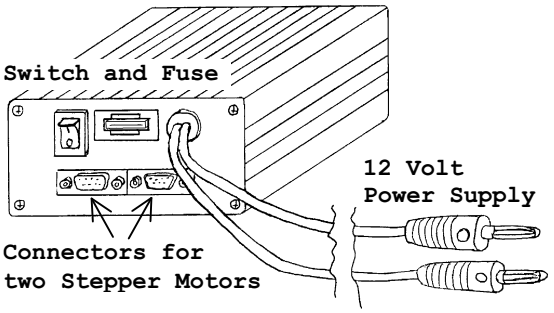


2.2 Motor Connection

If you bought the motor cables for your mount from Astro Electronic then simply connect them to the FS2 and your mount. The left jack is for RA and the right one for Declination. You can fasten the plugs with screws.

If you have a selfmade mount, or if you made the cables yourself, or if you have any doubts about the cables or motors, please read chapter 6.1 before you connect the cables to the FS2. However, you can test the FS2 even without the motors connected.

Important Note:
Please do not connect or disonnect the motor cables while the FS2 is switched on. Otherwise the electronics may be damaged. Of course this hint is valid for the connectors at the motors too.



2.3 Power Supply

Connect the red and black cables to your 12 Volts battery or regulated DC power supply.

RED = PLUS BLACK = MINUS

Caution: The aluminium case is internally grounded to minus!

The operating voltage may vary from 9 VDC to 15 VDC (9 VDC to 30 VDC for 30 volts version). Please don´t use unregulated power supplies as the output voltage of these units is often noticeably higher than 15 volts. When using a voltage of less than 12 volts the maximum speed may be reduced.
If the power supply is connected in a wrong manner, the fuse may be destroyed (but not the electronics).
Spare fuses are available at car accessory shops or at gas stations. Please only use fuses rated 5 Amps or less.
The FS2 version with built-in voltage converter uses a 10 Amps fuse.

The current input of the FS2 varies between 0.5 Amps and 5.0 Amps depending on the motor currents, on the supply voltage, the coil resistance and the display brightness.

Note:

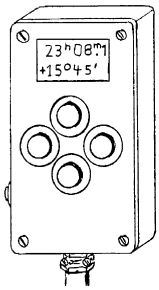
In the FS2 switching regulators are used to generate the stepper motor coil currents. This means that the current flowing from the supply to the FS2 may be noticeably smaller than the sum of all motor currents. A reduction of the supply voltage may result in an increase of current flow. Series resistors for the motor coils are not necessary, even if the coils have very small resistances. However, if you use series resistors the maximum speed is reduced.

For U.S. customers, an inexpensive supplier for power supplies is H&R 1-800-848-8001:

T4-081 13.8 VDC 4 A regulated $27.50
S7-004 24 VDC 4 A linear $53.95
(6/99 prices)

2.4 Buttons and Display

Hold the control box so that the display is on top. Switch on the FS2. For a short moment the software version number is displayed. Now the FS2 is in operating condition and the RA motor should run slowly.



In the display you see in the upper line:

Right Ascension (Hours, minutes and tenths of minutes)

And in the lower line:

Declination (Degrees and minutes)

The symbols in the lower right corner of the display have the following meaning:

?	The coordinates displayed are not valid, because the telescope has not been aligned to a reference object yet.
M	The coordinates displayed were calculated using the positions of the two stepper motors.
E	The coordinates displayed were calculated using the encoders.

Test the four buttons on the front side of the control box. (In the following text these buttons are called the direction buttons.)

N (top)	Telescope slews to North, Declination plus
S (bottom)	Telescope slews to South, Declination minus
E (left)	Telescope slews to East, Right Ascension plus
W (right)	Telescope slews to West, Right Ascension minus

Of course you can simultaneously slew both axles by pressing two buttons at the same time.

The button at the left side of the control box is the SHIFT button.

- If you press the SHIFT button for about one second (pressing no other button at the same time), you will get the flashlight function. Test it.

- If you press the SHIFT button together with other buttons you may use some other functions.

If it says e.g. "press SHIFT-N" in the following text this means: First press the SHIFT button, and while doing so press the "N" button too.

With "SHIFT-N" and "SHIFT-S" you are able to change the slewing speed rates. There are five speed rates available.

- **"Shift-N"** (top) switches to the next faster speed rate. For a brief moment the new speed rate is displayed.

- **"Shift-S"** (bottom) switches to the next slower speed rate. For a brief moment the new speed rate is displayed.

- **"Shift-E"** (left) cyclically switches to another tracking speed. The new mode is also displayed for a brief moment:

Moon	Mean Moon speed, 52m42s per day
Sun	Mean Sun speed, 3m57s per day
Comet	Tracking speeds programmable for both axles, see chapter 4.5 (Can also be used for fine R.A.tracking rate adjustment)
Earth	No tracking at all, e.g for adjusting the optics in daylight
Stars	Normal star tracking speed
Moon	...etc.

After switching the FS2 on the star tracking speed is always selected by default.

With **"SHIFT-W"** (right) you can get into the so-called menu system. There you find all other functions, which are described in chapter 3.1.

While you are in the menu system you cannot see the coordinates in the display.

You can always leave the menu system by pressing the "E" (left) button one or several times.

After you have left the menu system you are able to see the coordinate display again.

3.1 The Menu System

Note:

In case you have problems while testing the functions of the menu system the examples in chapter 3.2 might help you.

While being in the menu system the following functions are assigned to the four direction buttons:

N (top)	Plus, or next function
S (bottom)	Minus, or previous function
E (left)	Escape, leave the function without storing
W (right)	Enter, confirm the current function and store the new value

If you want to modify a numerical value you may hold the "N" or "S" button down. Using this autorepeat function the value will change at accelerating speed.

After pressing "SHIFT-W" (right) you are in the menu system and you see "Ref.Obj." in the display. This is the first function.

With the "N" and "S" buttons you can now scroll through all the other functions available.

Using the "N" button you switch to the next function and using the "S" button to the previous function.

After you have found the function you were looking for, confirm it by pressing the "W" (right) button.

You can always leave the menu system by pressing the "E" (left) button one or more times.

The following functions are available in the menu system:

Ref.Obj.	After aligning the telescope to a bright star or object you use this function to adjust the coordinate display. See chapter 4.1
Go to	This function slews the telescope to an object (Messier, NGC, IC, sun and planets, stars, RA and Decl.). See chapter 4.2
P.E.C.	Correction of periodic error See chapter 4.3
Brightn.	Adjusting the brightness of the display
Lamp	Adjusting the brightness of the flashlight
Spiral	Searching an object on a spiral-shaped track. See chapter 4.11
Low Curr	Energy saving mode: Both motors and the display are switched off, but the coordinates remain valid. See chapter 4.8
5 Rates	Adjusting the five speed rates. See chapter 4.4
Mot_1 RA	This menu contains many sub functions for the RA motor. See chapter 6.2
Mot_2 De	This menu contains the same functions for the Declination motor.
Misc.	This menu contains many sub functions.

In the menu "Misc." you find the following functions:

Comet_RA	RA speed for comet tracking. (Unit: minutes per day). See chapter 4.5
Comet_De	Decl. speed for comet tracking (Unit: minutes of arc per day). See chapter 4.5
Encoder	Here you may program whether you have encoders or not. See chapter 6.3
Limit	Acceptable difference between encoder position and motor position in degrees. See chapter 6.3
Teeth	Number of teeth of RA worm gear (used for PEC function). See chapter 4.3
PEC_Decl	Declination PEC corrections, yes or no. See chapter 4.3
Buttons	Exchanging the effect of the direction buttons. See chapter 4.6
LX200	LX200 coordinates data format: You can choose between short format "HH:MM.M" or long format "HH:MM:SS". The format can be toggled with the LX200 command ":U".
Language	Select English or German language
Timer	Timer function, yes or no. See chapter 4.7
Exposure	Exposure time from 1 to 1200 minutes. See chapter 4.7

The adjustment of the parameters is required only one time. All parameters are stored permanently even without power supply.

An additional note regarding the display brightness:

Normally you select a low display brightness for nighttime observation. If you switch on the FS2 the following day (in daylight) you will of course see nearly nothing on the display because of the low brightness. It will be difficult to set the display brightness to a higher level because you can´t see what you are doing. For this situation there is a special function: Keep the "N" button pressed down while switching the FS2 on with the main switch. Then release the button. This will set the display to maximum brightness.

3.2. Examples: Modification of Values in the Menu System

Example 1:

Let´s suppose you want to change the display brightness. At the beginning the display is in its normal condition: You can see the coordinates. (If not: press the "E" button (left) until you see the coordinates.)
Now press "SHIFT-W" (right). Now you can see "Ref.Obj." in the upper display line.
Press "N" (top). Now you see "Go to" in the upper display line. Press "N" again. Now you see "P.E.C.". Press "N" again. Now you see "Brightn.". This is the function you were searching for. Press "W" (right) to confirm.
In the lower display line a number between 1 and 20 will appear. The number tells you the actual brightness level. You may modify this number by pressing the button "N" (top) or "S" (bottom). After you have found a suitable value press the "W" button to confirm your selection. This will store the new level and leave the menu system. The display switches back to its normal condition.
If you didn´t want the new level stored, you would terminate the function with the "E" button instead of the "W" button.

Example 2:

Suppose you want to set the number of teeth of the RA gear to a new value.
In the beginning the display is in its normal state: You can see the coordinate display.
First press "SHIFT-W" (right) th get into the menu system. On the display the first function appears: "Ref.Obj.".
Press the "N" button several times until you see "Misc." on the display.
Then press "W" to confirm.
The first subfunction of the misc menu appears: "Comet_Re".
But this is not the funcion you were searching for. Again press the "N" button several times until you see "Teeth" on the display. This is the function you were searching for. Press "W" (right) to confirm.
In the lower display line a number between 24 and 2880 will appear: This is the number of gear teeth that is actually stored in the FS2.

You can modify this number by pressing the "N" (top) or "S" (bottom) buttons according to your specific needs.
Hold the "N" or "S" buttons down to use the autorepeat function.
After you have adjusted the correct value press "W" (right) to confirm your choice.
The numerical value in the lower line will disappear.
Now you are back in the menu system, in fact you are still in the sub menu "Misc.".
Now you have several choices:

- With the "N" (top) and "S" (bottom) buttons you may select other functions.
- With the "E" (left) button you can get back to the main menu. There you may select other functions too using the "N" and "S" buttons.
- By pressing the "E" button again you leave the menu system and the FS2 is back in normal condition.

4.1 The "Ref.Obj." Function

As reference objects you may use all 168 stars which are brighter than 3.0 mag. You will find a list of those stars in chapter 7.1.
Check through the list by using the buttons "N" (up) and "S" (down) until you have found the proper object. Then press the "W" button (right).
After that the FS2 will ask you what position the German mount is currently in (see chapter 5.1). Proper E-W selection is important.

At the end of the list of stars there are three additional functions:
(Using the "S" button you can move backwards through the list and , thus, get to these functions much quicker.)

Sun	During the day the only useful reference object. Using this function for the first time after switching on the FS2 you have to set the date and time in UT (UT = MEZ – 1h, UT = MESZ – 2h).
RA+De	Input of Right Ascension and Declination of any reference object.
Object	This refers to the coordinates of the object, that was last used in the "Go To" function, see chapter 4.2. Use this function to resync the coordinate display.

4.2 The "Go To" Function

Using this function, you may automatically slew the telescope to certain objects.

Before using this function two prerequisites have to be met:

- The mount has to be well aligned. A faulty alignment is the more noticable the further the target object is away from the reference object.
- The function "Ref.Obj." must have been used at least once before. This is shown with the letters "M" or "E" at the bottom right of the display.

When you use the "Go to" function it says "object" at the top of the display. Using the buttons "N" or "S" you may choose between different catalogues:

Messier	All 109 Messier Objects
NGC	A selection of 3169 NGC-Objects (up to a size of 13.9 mag)
IC	A selection of 344 IC-Objects
Planet	Sun and 8 planets
Re+De	Input of Right Ascension and Declination
Star	168 stars brighter than 3.0 mag

Choose the proper catalogue and confirm your choice with the "W" button (right).
Afterwards you may choose the number of the object and again confirm by pressing "W" (right).
The telescope will now automatically slew to the chosen object at its highest speed (rate 5) and will stop there.

If you want to slew to planets, you will be automatically asked to input date and time in UT before you may use this function (UT = MEZ – 1h, UT = MESZ – 2h).

The calculation of the planet coordinates is based on undisturbed orbits and is therefore not a precise calculation. However, the accuracy is good enough to find the planets.

Important remark:

The drive unit cannot sense whether your telescope touches the mount or an object near it. You will have to watch out for that yourself. Please use safety clutch on drive gears. Please also make sure that your telescope does not slew through the Sun during the day. You may always interrupt the automatic slewing process by pressing one of the four direction buttons.

There are two reasons why the reference object chosen should be a star not too far away from the target. First of all, an inaccurate polar alignment of the mount is not as strongly noticable and second of all, the slewing does not take as long.

In case you notice that the object is not exactly in the middle of the field of view after the slewing process is completed, please do the following:
By pressing the four direction buttons you may put the object in the middle of the field of view. Then you may go to the "Ref.Obj" function and choose "Object" as your reference object (this is the last item

on your list; if you check through the list backwards, you will find it rightaway).
This item holds the coordinates of your last goto object.
This action resyncs the coordinate display to show the proper values again.

Note: Pier flip

If a German mount is slewed around from East to West the Declination axle usually has to be turned past the +90° or -90° mark. This is not possible using the "Go To" function. Hold buttons to cross pier, then use goto.

In case you have encoders, you may loosen the locking of the axles before slewing and approximately adjust the telescope in the right direction. Then tighten the locking and leave it to the telescope drive to find the proper adjustment.

Remarks for troubleshooting, in case the "Go to" function does not work as expected:

- *Is the mount properly adjusted in direction of the Pole Star?*
- *Are you sure you entered the proper object of reference? If not, try some other star.*
- *Did you properly answer the question concerning the "Ref.Obj." function? If not, the declination motor will move in the wrong direction.*
- *Are all parameters adjusted properly for your mount?*
- *Is the speed rate 5 possibly too fast for your stepper motors or is your mount mechanically too sluggish or not well balanced?*
- *See 5.1*

4.3 Periodic Error Correction (P.E.C.)

The periodic error develops because of inaccuracies of the gearing worm in the RA drive. It repeats itself after every complete rotation of the worm. The period may be calculated from the number of teeth of the RA gear.

Example:

The gear has 360 teeth, one rotation takes one day (one siderial day, to be exact). So the gear moves as much as one tooth in 4 minutes. Within this time period the worm has completed one rotation.

The FS2 has the ability to compensate for this periodic error (Periodic Error Correction). In order to do so all tracking corrections are recorded and performed automatically in all following periods.

The PEC-function can only work if the following parameters are adjusted properly :

Teeth	Number of teeth of the RA gear. The permissible range is between 24 and 2880.
M_1 Gear	RA Gear Reduction Ratio
M_1 S/Rev	Full Steps per Motor Revolution of RA Motor
Rate 1	Tracking Speed for PEC

When you turn on the FS2, the PEC-function is turned off.
At first you look for a suitable guide star and place it in the middle of your reticule eyepiece, or let your autoguider track this star.
Then you turn on the PEC by going to the "P.E.C." function in your menu system.

Now there are three possibilies:

off	PEC is turned off
on	Corrections are made automatically.
learn	The Periodic Error is recorded during one period.

Choose "learn" and confirm your choice by pressing the "W" button (right).
Now you will see the coordinates display again, but the letter "W" is displayed at the top left .
"**W**" stands for waiting time. You have 15 seconds to adjust the star to the middle of your eyepiece.
Then the letter changes to "**L**".
"**L**" stands for learning phase, meaning that your (or your autoguider's) corrective measures are recorded during one period. The Declination corrections are also saved. Then the letter changes to "**P**".
"**P**" means that the PEC-function is activated and automatically performs corrective measures. Of course you may carry out corrections, too. In that case the two corrections are added or subtracted.

In your menu system under "Misc./PEC_Decl" you may adjust whether there should also be automatic corrections at the Declination axle while the PEC function is turned on. Possible adjustments: yes or no.

Using this you may balance a Declination drift, which is caused by an inaccurate alignment of the mount.
The declination drift of the Moon may also be balanced in a very simple way by using this function.
However, please note that there will be a rotation of the image field when frequently correcting Declinations in the same direction and having a long exposure time. This means that the stars in the middle of the image area look like spots while those at the outer limits of the image area look like lines. In this case you should adjust your mount better.
In order to prevent misunderstandings: Using "PEC_Decl" does not compensate for the periodic error of the Declination drive. However, this is not of importance because the Declination worm only turns very slowly. Only the Declination corrections which were recorded during the learning phase are repeated.

If you don't need the PEC function any more you may simply turn it off (function "P.E.C.", "off").

You may turn it back on at any point in time (function "P.E.C.", "on"). The drive unit remembers the position of the gearing worm also at high speeds and even if the PEC-function was turned off in the meantime.

You may also record a new learning curve (function "P.E.C.", "learn").

Remarks:

If you turn on the PEC function, speed rate 1 (.05x - .5x) will automatically be chosen. While the learning curve is recorded, you should not change the speed rate.

In case you change some of the parameters which are relevant for the PEC function (Gear, M_1 Gear, M1_S/Rev, Rate 1), you should not use the recorded learning curve any more but record a new one.

When you turn off the drive unit, the recorded correction chart will be lost. After turning on the FS2 the correction chart is cleared and you have to record a new learning curve if you want to use the PEC function.

4.4 Speed Rates

With the FS2 you may move your telescope using the direction buttons in 5 different speed rates, called "Rate 1" to "Rate 5" in the following text.

You may change the rates by pressing "Shift-N" (changes to the next faster speed rate) or "Shift-S" (changes to the next slower speed rate).

Rate 1 is the slowest rate. You may use it for minimal corrections when photographing. The PEC function and autoguider also work with this rate.
Because of the PEC function the rate 1 factor may not be greater than 0.5.

Rates 2,3 and 4 are medium speed rates you may use for different purposes, e.g. to move around on the Moon. Speed range is .05x to maximum.

Rate 5 is the fastest rate. It is used to slew the telescope to a certain point as fast as possible. The "Go to" function also uses Rate 5.

All 5 rates are adjustable according to your personal preference in the menu system under "5 Rates" / "Rate1" to "Rate5".
The recorded numbers are to be understood as factors relative to normal tracking speed.

Two examples:

Rate1	Rate2	Rate3	Rate4	Rate5
0.25x	1x	4x	16x	64x

Rate1	Rate2	Rate3	Rate4	Rate5
0.3x	0.8x	2x	10x	50x

The maximum factor at Rate5 is dependent on the type of motor, the transmission ratio, the mechanical load, the adjusted current and battery voltage and can only be established through experiments. You will be able to hear a high pitch sound from the stepper motor if it cannot follow the adjusted frequency any more. Please adjust Rate 5 to a slower speed so this does not even happen at low battery voltage.
It may also be useful to adjust the acceleration of the motor to a low value. If you don't use encoders the drive unit does not notice if the motor is not able to follow the frequency. Then the displyed coordinates won't be correct any more and must be reset.

4.5 Comet Tracking

Comets opposed to stars have a movement of their own, which may be disturbing during longer exposure times.
You may adjust this movement in the menu system using “Misc./Comet_Re” and “Misc./Comet_De” .

Adjustment in Right Ascension:

-327.68m/d ... +327.67m/d
(Unit: Minutes per day)

Adjustment in Declination:

-3276.8'/d ... +3276.7'/d
(Unit: Minutes of arc per day)

Example:

You know the coordinates of a comet at two points in time which are 10 days apart:

Date	RA	Decl
1997 Nov 05	9h19.0m	+4°56'
1997 Nov 15	9h35.9m	+0°56'

At first you calculate the comet’s own movement within those ten days:

9h35.9m - 9h19.0m = 16.9m

0°56' - 4°56' = -4°0'

To get the daily movement of the comet, you divide these values by 10:

16.9m / 10 = 1.69m -4°0' / 10 = -24.0'

These values are recorded under “Comet_Re” and “Comet_De”.

In order to activate the comet tracking function, please press the button combination “SHIFT-E” (left) until “Comet” appears in the display.

Note: You may also use the “Comet Tracking” function for the exact tracking of Sun and Moon or to vary sidereal tracking rate.

The movement of the Sun varies dependent on the time of year in its Right Ascenscion between +3.6 and +4.5 minutes per day and in its Declination between -24 and +24 minutes of arc per day.

The movement of the Moon varies in its Right Ascenscion between about +45 and +70 minutes per day and in Declination between about -400 and +400 minutes of arc per day.
Please also note that the apparent speed of the Moon undergoes a variation with a period of ca. 25 hours.
This effect is caused by parallax since the viewer moves around the center of the Earth.
In order to calculate the exact daily movement of the Moon you should calculate the Moon coordinates at one time and again 10 minutes later with an adequate program (e.g. Guide) and multiply the differences by 144.
An easier possibility for tracking the Moon is given with the use of the PEC function, which will accurately track on both axles after the learning phase has been completed.

4.6 Exchanging the Directions of the Buttons

If you try to keep a reference star in your eyepiece while photographing you would like to have an unambiguous and simple assignment between your four direction buttons and the movement of the reference star.
Some observers prefer the left button moving the reference star to the left, others like the reticule to move to the left of the star, so that the star moves to the right.
One very simple solution is to hold the control box turned by 180°, so exactly the opposite way around.
However, if a star diagonal is used this method does not work:
No matter which way you hold the control box, two buttons always appear the wrong way around.
That is the reason why you have the possibility to exchange the direction buttons of the FS2.
The exchanging only works if the direction buttons are pressed to move the telescope.
Thus, the exchanging doesn’t influence the functions of the menu. These always remain the way they are described in the instruction manual.
In the menu system under “Misc./Buttons” there are four possible adjustments:

Adjustment	Button Top	Button Below	Button Left	Button Right
Normal	North	South	East	West
E/W	North	South	West	East
N/S	South	North	East	West
N/S E/W	South	North	West	East

Note:

Please only make use of the possibility of exchanging the four direction buttons after you feel very confident using the FS2. Especially in chapter 6.4.”Adjusting the turning directions” the explanations are given on the basis that the direction buttons are not exchanged. The directions referred to will otherwise not be correct.

4.7 The Timer Function

As an astro photographer you would probably like to know for how long the camera has already been exposed while taking the picture.
Therefore, the FS2 has a function which shows you the current exposure time.
However, in order not to confuse you with too many functions right at the beginning this function is switched off at first.
Once you have gotten used to handling the FS2 and you would like to use the exposure time display, you may activate this function under "Misc./Timer" in the menu system. (Adjust to "yes" .)
The next function in the menu system is called "Exp.Time". Here you may adjust the necessary exposure time in minutes (from 1 minute to 1200 minutes). Then leave the menu system.

In order to make the timer visible and to start it you may adjust to the slowest speed rate (Rate1) by pressing "SHIFT-S"(bottom) several times, then you press "SHIFT-S" once more. Now you see the timer display with minutes and seconds.
If the previously adjusted exposure time has been completed the display starts blinking noticably, but the timer keeps running.
(If you find the blinking annoying, you may simply adjust a long exposure time under "Misc./Exp.Time".)
You may turn off the timer display by choosing the slowest speed rate (if that is not already done) and then press "SHIFT-S" once more.

When you turn on the timer again, it starts at 0.

4.8 Energy Saving Mode

You may reduce the energy consumption of your FS2 by turning on the energy saving mode.
Using this mode, both motors and the display is turned off, but the computer keeps running.
The coordinates are still valid and the encoders remain active.
The energy consumption is about 160mA (+90mA including encoders).
A blinking light on the display shows that the energy saving mode of the FS2 is in use.
By pressing any button you may leave the mode, the motors start running and you can see the correct coordinates on the display again.
Of course the coordinates have changed in the mean time due to the movement of the stars.

A useful advantage of the energy saving mode:
At nighttime you may properly adjust the coordinate display by using a reference star. Then you may activate the energy saving mode and go to sleep. The following day you may interrupt the mode and watch bright stars or planets during the day.

4.9 Autoguider Connector (CCD Tracker)

As an option, the FS2 can be fitted with a 15 pin ST-4 connector and a 6 pin modular connector for Meade Pictor and SBIG cameras. You may also have the tracker connector installed into your FS2 later.

The SBIG ST-4 has to be connected to the 15-pole jack. The junction cable has a 15-pole jack at the ST-4-end and a 15-pole plug at the FS2-end.
All wires are connected 1:1 but only the pins 4,5,7,8,10,11,13 and 14 are used.

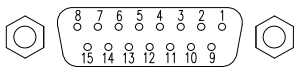
The Meade Pictor may be connected to the 6-pole Western Modular plug next to the 15-pole jack. The junction cable is part of the camera delivery and has a 6-pole Western Modular plug at both ends.
The wiring is as follows: Pin 1 to Pin 6, Pin 2 to Pin 5 etc.

The FS2 does not need any adjustment, the tracker connector is always ready for operation.

If the CCD camera sends a signal to the FS2, it automatically performs the proper corrective movement.
During the correction process Speed Rate 1 (.5x max) is always used, no matter which speed rate has been chosen before.
When a tracker correction is in process you can see this on the display, e.g. "TRACK->". (However, it is not displayed when the timer function is active.)

Note:
The autoguider input is completely independant of the four buttons, i.e. they are not wired parallel. Therefore you may also do adjustments in the menu system while the tracker corrections are performed or to jog the telescope to test tracker settings.

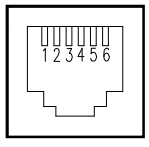
Pin Assignment of the FS2 ST4-jack:



10,11 relay contact "+X", normally open
4, 5 relay contact "-X", normally open
13,14 relay contact "+Y", normally open
7, 8 relay contact "-Y", normally open

Pin Assignment of the FS2 Meade Pictor jack:

1 not in use
2 ground
3 "left"
4 "bottom"
5 "top"
6 "right"



A special junction cable which is connected to the Meade Pictor jack is available for the cameras type SBIG ST-7 and ST-8.

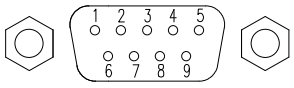
For the use of the Cookbook-CCD-Camera as an autoguider you may order an interface from ASTRO ELECTRONIC.

4.10 Serial Connection to your PC

You may connect your FS2 to your PC so that you have the following possibilities with the PC-programs “GUIDE6.0/7.0” or “TheSky”:

- You may let the display show you the sector of the star map which the telescope is pointed to at the moment.
- You may let the telescope slew to any object which is registered in your PC-programs.
- You may move the telescope in any direction at selectable speeds:
  “Slew” corresponds to Rate 5
  “Find” corresponds to Rate 4
  “Center” corresponds to Rate 2
  “Guide” corresponds to Rate 1
  (Rate 3 cannot be selected from PC)

Pin Assignment of the FS2 RS232-plug:



The junction cable has a 9-pole Sub-D-jack at both ends and is wired 1:1 (The pins 2,3 and 5 are sufficient).

Before you may slew the telescope to any point using your PC, the function “Ref.Obj.” has to be performed at least once. You may recognize this because the letters “M” or “E” appear in the lower right corner of the display.
Otherwise the PC will display an error.

Note concerning “Guide 6.0/7.0”:

Please pay attention to the corresponding paragraph in the “GUIDE6.0/7.0” manual. Please adjust the telescope type “LX200” and the used serial port in “GUIDE6.0/7.0”.

Note concerning “TheSky”:

Please start TheSky and go to the menu "Telescope / Setup". Adjust the telescope type to “LX-200 by Meade...”. Now click on "Settings...", enter the used serial port at "COM Port" and set the Baud rate to 9600. This is required only one time because TheSky will store the adjusted parameters.
Point the telescope to a known reference star and select this reference object with the FS2 control box, using the "RefObj" function. In the lower right corner of the display a "M" or "E" must appear.
Click on “Telescope / Link / Establish”. Now TheSky will show you the area where the telescope is just pointing at.
If you should get the error message "LX200 not responding..." please check if you used the correct serial port, if the cable is connected at both ends, if the FS2 is switched on and if the reference star was already entered.
Now if you click at an object on the screen an "Object information" window will appear. If you click on the small telescope icon the telescope will slew to this object.
If you want to fine center this object you can either use the control box buttons or click on "Telescope / Motion controls". Using the buttons in the small "Motion Control" window you can move the telescope in all directions.
After you have fine centered the object in the field of view you can re-sync the FS2 either by using the control box (RefObj / Object) or from TheSky: In the "Object information" window click on "Telescope" in the top line and then click on "Sync".
Please do not set the "cross hair update period" to a value smaller than 500 ms.

Note concerning “Skymap Pro”:

Please set the telescope type to “Vixen Skysensor2000PC(LX200)” in the menu Telescope/Configure.

Note concerning all Programs:

Since software manufacturers continue to change software versions, compatibility of features may vary, you can fax issues to Astro Electronic for help.

Note for Programmers:

The FS2 will accept these LX200 commands:
:GR :GD :Sr :Sd :MS
:Q :Qn :Qs :Qe :Qw
:Mn :Ms :Me :Mw
:RS :RM :RC :RG
:CM :U

All other commands are ignored.

4.11 Searching Objects on a Spiral Shaped Track

Suppose you have adjusted the telescope to a certain point in the sky but cannot find the object you are looking for. You know that the object cannot be far away, but it is not in the field of view.

In this case the "Spiral" function will help you. It causes the telescope to slew on a spiral shaped track around the starting position. This way the entire area is searched systematically.

If you want to use the "Spiral" function, you have to adjust the track distance (using the buttons "N" and "S"). This means the distance from one spiral circle to the next. It makes sense to use a track distance which is equivalent to half the diameter of the image area. Please confirm the track distance with the "W" button (right).

Now the telescope will start to go along the spiral shaped track. The speed is self-adjusting dependant on the chosen track distance.

Using the "W" button (right) you may interrupt the search at any time when you see the object you are looking for.

If you use the "E" button (left) to interrupt the process, the telescope will go back to its original position.

Otherwise the search is automatically stopped after 6 spiral circles have been completed and the telescope slews back to its original position.

Note:

This function only works if the Declination is between -80° and +80°. Otherwise the display will show "too close to Pole".

4.12 Guest Mode

Imagine a situation in which you are showing the Moon to a large group of guests. Every visitor will especially enjoy slewing around the telescope himself.

For this case the FS2 has a guest mode:

Please press all four direction buttons simultaneously to turn the guest mode on or off.

Please give your guests the following instructions:
"With these four direction buttons you may move the telescope back and forth."
Everybody will understand that at once.

The advantage of the guest mode is based on the fact that all functions other than the slewing functions are blocked temporarily. Speed rate cannot be changed while in guest mode, so select the rate before you enter this mode. The shift button only has the "Flashlight" function left, all other shift-functions are not working . This prevents an accidental readjustment of the FS2.

5.1 The German Mount

Please suppose you have a German Mount that is well adjusted towards the Pole Star. The telescope is pointed to the South towards a star near the sky equator, i.e. about 40° above the horizon.
Imagine you are standing north of the telescope, looking towards the South to your telescope. There are two possible positions for your telescope:

1. The telescope to the left and the counterweight to the right.
2. The telescope to the right and the counterweight to the left.

Generally one can state that there are always two possibilities to point a German Mount to an object. However, in reality there is oftentimes only one possible position because the telescope touches the mount or another object or the eyepiece is in a position which is difficult to reach.

Back to cases 1 and 2.
If you press the control button "N", you may rightfully expect the telescope to slew to the North, i.e. in direction to the growing Declination.
However, the problem is that the Declination motor has to turn in different directions in cases 1 and 2 in order to turn the telescope to the North.

How is the control supposed to know which direction the Declination motor has to turn to?
Answer: It cannot know.

Control has to be told which of the two positions the telescope is in: Every time you are adjusting a reference position using the "Ref.Obj." function, control will ask for the position.

Position
<-E W->

Please answer this question as follows:

- Please press "E" if the telescope is pointed to the East (telescope on top, counterweight at the bottom).

- Please press "W" if the telescope is pointed to the West (telescope on top, counterweight at the bottom).

- In cases which are not as obvious, please think about whether the telescope could slew to one of the very unambiguous positions, without moving the Declination axle past the -90° or +90° marks. (There is no necessity to actually move the telescope: it is sufficient to think whether it is possible.)

Example:

The above named case 1, the telescope is pointed to the South, the telescope is on the left (in the East) the counterweight is to the right (in the West). Now you may simply turn the telescope by 90° to the West. So you press "W". (In order to turn the telescope to the East you would have to turn the Declination axle by a full 180°.)

- In case you gave a wrong answer to this question you will notice that the Declination motor runs in the wrong direction and that Declination is not displayed correctly. In this case, please repeat the "Ref.Obj." function.

Note:

You may already inform control which position your mount is in, while turning it on:

Simply press "E" or "W" while you are turning on the FS2. "Position East" or "Position West" will be displayed. Then let go of the button.

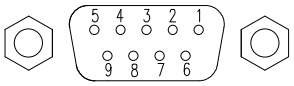
In case you own a fork mount you will not turn the Declination axle past the +90° or -90° mark i.e. the eyepiece will always be on the same side of the fork. In that case the turning direction of the Declination motor is always unambiguous. Please answer the question concerning the telescope position always using the "E" button.(If you like you may always answer this question by pressing the "W" button, however, it is important that your answer is always the same or Declination motor direction unexpectedly reverses.)

6.1 Connecting Stepper Motors

In case you did not buy the motors and/or the motor cables from me as a set, please complete the following test:

1. Connect the motor cable to the motor, but not to the FS2.
2. Check with an ohmmeter or a volume resistance detector at the 9-pole-plug:
3. Between pin 1 and pin 2 must be a coil of the stepper motor, i.e. a resistance of 0.5 to 100 Ohm.
4. Between pin 4 and pin 5 is the second coil of the stepper motor, the resistance should be about the same as of the first coil.
5. Between pin 1 and pin 5, i.e. between the two coils mustn't be any connection, so the resistance has to be infinitely high.
6. Between the coils and the pins 6,7,8 and 9 mustn't be any connection. These four pins are connected to battery minus in the FS2, only the cable shielding may be connected to them.
7. Repeat points 1 through 6 with the other motor and cable also.
8. In case these tests cannot be completed sucessfully, you should under no circumstances connect the motor cables to the FS2. Please find and eliminate the reason for the fault first. (However, you may test the FS2 without the motors in order to get used to it.)

Pin Assignment of the FS2 motor jacks:



Pin 1 Coil 1, beginning
Pin 2 Coil 1, end
Pin 3 Not connected
Pin 4 Coil 2, beginning
Pin 5 Coil 2, end
Pin 6 Ground (shielding)
Pin 7 Ground (shielding)
Pin 8 Ground (shielding)
Pin 9 Ground (shielding)

The motor cables should not be longer than 3 meters, because otherwise the losses in the electronics will be high due to the high capacitance of the cable!

6.2 Setup of Motor Parameters

Since there are many different stepper motors, your drive unit has to be adjusted to your motors. Concerning this the items "Motor1_RA" and "Motor2_De" and the subitems thereof are programmed in the menu system:

M1_Curr1	Peak current per coil for low speed, adjustable from 0.00A to 1.80A. The allowed current can be found in the data sheet of your stepper motor. A too high current will overheat and damage the motor!
M1_Curr2	Peak current per coil for high speed, adjustable from 0.01A to 1.80A. . The allowed current can be found in the data sheet of your stepper motor. A too high current will overheat and damage the motor!
M1_Freq1	Frequency in Hz, at which the current is swiched fron the lower value "Curr1" to the higher value "Curr2". If you set "Freq1" to zero then "Curr1" is used at zero speed and "Curr2" is used if the motor is running. Typical values are 0..50Hz
M1_Freq2	Frequency in Hz, at which the current regulators are switched to another operating mode. Above this frequency the motor becomes somewhat louder and the current intake a little bit higher, but a much higher frequency can be reached. Typical value: 30 Hz If the motor doesn't run smooth at low speed (especially if the supply voltage is more than 12 Volts) set this parameter to zero.
M1_S/Rev	Motor constant: full steps per motor revolution, typical values are: 24, 40, 48, 72, 100, 200. See data sheet of your stepper motor. Some data sheets only name the step angle: Then the number of full steps per rotation is: 360° / step angle.
M1_Gear	Gear transmission ratio from motor to the telescope axle (How often does the motor rotate while the telescope axle turns once?) Adjustable range: 1 to 65535. In case your transmission ratio is larger than 65535 or does not have whole numbers, you may multiply the transmission ratio with an appropriate number x and simultaneously divide the value of M1 S/Rev by x.
M1_Wave	current waveform, three possible adjustments: full step, half step or micro step. The best adjustment for almost all uses is micro step.
M1_F*4	Some cheap stepper motors don't run smooth even if the current is perfectly sine-shaped. Those motors may run smoother if the sine wave is modified by adding a current with 4 times the normal frequency to the sine wave. The typical setting is 0%.
M1_Accel	Acceleration, typical values: 10 to 50. Find out the best value by making tests at maximum speed (Rate 5). 1=slowest 255=fastest
M1_Clear	Time in seconds needed to correct gearing clearance. The gear clearance will be corrected always is the turning direction of the motor changes. If you don't need gear clearance compensation set this value to zero.
M1_Freq3	Frequency for balancing of gearing clearance in Hz, typical values: 40 Hz to 100Hz. This frequency determines how fast gear clearance will be compensated. Attention: This frequency is transmitted to the motor at once, i.e. without acceleration ramp. Therefore the frequency must not be too high.
M1_L/R	Rotating direction of motor, left or right, see chapter 6.4
M1_Enc.R	Encoder resolution, lines per rotation by 4 (e.g. 4096 with an encoder with 1024 lines). In case the encoder is not positioned directly at the telescope axle, but is driven by a cogwheel or friction gearing, the exact gear ratio must be taken into consideration. See chapter 6.3
M1_Enc.D	Encoder turning direction, left or right. See chapter 6.4

Here are some useful formulas for calculation:

(These formulas are valid for siderial tracking speed)

Frequency of motor:

$$f = \frac{\text{M1\_S/Rev}}{4} * \frac{\text{M1\_Gear.}}{86164\text{sec}}$$

Time of one motor revolution:

$$t = \frac{86164\ \text{sec.}}{\text{M1\_Gear}}$$

6.3 Connection of Encoders

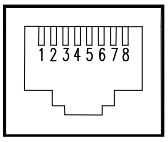
The pin assignment of the 8-pole Western-Modular plug is for both encoders identical with the pin assignment of the "Sky-Commander" and of the "NGC MAX" and "NGC MINIMAX".
So you may use the encoders that you might already have also for the FS2.

Attention: The encoders of "Skysensor" have a different pin assignment and therefore you need a special junction cable.

In case you wire the encoders yourself, please note that an accidental switching of the conduits may cause damage to the encoders.

Pin assignment of the FS2 encoder jack:

1: RA channel B
2: RA +5V
3: RA channel A
4: RA ground
5: Decl. channel B
6: Decl. +5V
7: Decl. channel A
8: Decl. ground



After having connected the encoders you have to program the following in the menu system:

Misc./Encoder	"yes"
Mot_1 RA/M1_Enc.R	Number of lines of the RA encoder times 4
Mot_2 De/M2_Enc.R	Number of lines of the Decl. encoder times 4
Mot_1 RA/M1_Enc.D	Slewing direction of the RA encoder
Mot_2 De/M2_Enc.D	Slewing direction of the Decl. encoder

In case the encoders are not directly placed at the telescope axle, but are driven by a gearing (gear, serrated belt or friction gearing), this will have to be taken into consideration when adjusting the number of lines. Then you will have to multiply the number of lines of the encoder times the gear ratio times 4.

$$GearRatio = \frac{\text{Encoder Angle}}{\text{Telescope Angle}}$$

Please note that the encoders may not be rotated at any speed desired, because the the angle would be measured wrongly. The FS2's maximum rotation speed is 2000 lines per second. This speed may not even be exceeded for a short time.

Examples:

- An encoder with 1000 lines, mounted directly at the telescope axle, may be rotated at a speed of 2 rotations per second.
- Using an encoder with 2000 lines, which runs at double the speed of the telescope axle by the means of a transmission, the speed of the telescope axle may not exceed half a rotation per second.

The angle resolution of an encoder is calculated as follows:

$$\text{Angle Resolution in Degrees} = \frac{360^\circ}{\text{Number of Lines} * \text{Gear Ratio} * 4}$$

Examples:

- An encoder with 1000 lines per revolution, mounted directly onto the axle, has an angle resolution of 0.09° = 5.4' = 324".
- An encoder with 2000 lines, running at double the speed of the telescope axle by the means of a transmission, has a resolution of 0.0225° = 1.35' = 81".

As you can see, the advantage of a high resolution is connected to the disadvantage of a smaller permissible maximum rotation speed.

Another very important parameter in connection to the encoders is "Misc./Limit".

When the encoders are connected, the FS2 has two independant methods of calculating the position of the telescope axles:

1. Through the position of the stepper motors:
   Advantage: very high resolution
   Disadvantage: As soon as you loosen the locking of the axles, the calculation of angles is not valid any more.
2. Through the encoders:
   Advantage: The calculation of angles is even valid if the locking is loosened, because the encoders are placed directly at the telescope axle. (That's why an encoder at the motor would be useless!)
   Disadvantage: The resolution is not as high as motor resolution.

The FS2 continuously calculates both angles and compares them. If the difference between the two angles becomes greater than a certain figure, the FS2 automatically switches from the exact angle calculation (stepper motors) to the less exact calculation (encoders).
You may adjust the permissible tolerance in the menu system under "Misc./Limit". Typical values are e.g. 0.2° to 1°.

After having adjusted a reference position using "Ref.Obj.", the coordinates are always calculated by means of the motor positions, that is, until the permissible tolerance is exceeded. If the locking is not loosened, the tolerance should never be exceeded.

6.4 Adjusting the Turning Directions

Please adjust all parameters in your menu system as it is required for your mount, or check whether all parameters are adjusted properly.

Important remark:
The function to exchange buttons may not be active for the following adjustments, i.e. the entry under “Misc./Buttons” has to be switched to “normal”!

Then you may perform some important tests with your mount:

At first the RA motor:

Turn the telescope to the South, choose a high speed rate and press the right button (RA -). The coordinates display is not important at that point. Now the telescope has to slew to the West. In case it slews to the other side, please change the adjustment of the turning direction in the menu system (M1_L/R).

Now the turning direction of the declination motor is tested:

Align your telescope roughly to the East and then go to “Ref.Obj.” in the menu system. Use the very first star (Alpha Andromeda), and answer the question about the position by pressing “E” (left button). Now the FS2 “knows” that your mount is positioned to the East. Adjust to a high speed rate and press the top button (Declination +). Again the coordinates display is not of importance. The telescope has to slew to the North (top) now. In case it slews downward, please change the adjustment of the turning direction in the menu system (M2_L/R).

In case you have connected encoders, please check their turning directions now.
If the bottom right of the display does not show “E” (encoders) please loosen the locking of one of the axles and slew the telescope a little back and forth by hand. “E” will be displayed then.

First the RA encoder:

Please adjust the telescope roughly to the South and then slew it to the West manually (i.e. in the normal tracking direction). The RA display has to become smaller then. In case it does not, please change the adjustment of the encoder turning direction in the menu system (M1_Enc.D).

And now last but not least the Declination encoder:

Please adjust the telescope roughly to the East and then go to the “Ref.Obj.” function in the menu system. Use the very first star (Alpha Andromeda), and answer the question about the position by pressing “E” (left button). Now your drive unit “knows” that your mount is adjusted to the East.
Now manually slew the telescope upwards, i.e. in direction to the Pole Star. The Declination display has to become larger. In case it does not, please change the adjustment of the encoder turning direction in the menu system (M2_Enc.D).

7.1 Reference Stars

Constellation	Abbr.	Stars
Altar	Ara	α, β
Andromeda	And	α, β, γ
Archer	Sgr	γ, δ, ε, λ, π, σ
Bull	Tau	α, β, η
Cassiopeia	Cas	α, β, γ, δ
Centaur	Cen	α, β, γ, δ, ε, ζ, η, ϑ, ι
Cepheus	Cep	α
Charioteer	Aur	α, β, ε, ϑ, ι
Crane	Gru	α
Cross	Cru	α^1, β, γ, δ
Crow	Crv	β, γ, δ
Dove	Col	α
Dragon	Dra	β, γ, η
Eagle	Aql	α, γ, ζ
Eridanus	Eri	α, β, γ, ϑ
Fly	Mus	α
Goat	Cap	δ
Great Bear	Uma	α, β, γ, ε, ζ, η
Greater Dog	Cma	α, β, δ, ε, η
Hare	Lep	α, β
Hercules	Her	β, ζ
Herdsman	Boo	α, ε, η
Hunting Dogs	CVn	α^2
Keel	Car	α, β, ε, ϑ, ι, υ
Lesser Dog	Cmi	α, β
Lion	Leo	α, β, γ, δ, ε
Little Bear	Umi	α, β
Lyre	Lyr	α
Northern Crown	CrB	α
Northern Water Snake	Hya	α
Orion	Ori	α, β, γ, δ, ε, ζ, ι, κ
Peacock	Pav	α
Pegasus	Peg	α, β, γ, ε, η
Perseus	Per	α, β, γ, ε, ζ
Phoenix	Phe	α
Poop	Pup	ζ, π, ρ, τ
Ram	Ari	α, β
Sail	Vel	γ^2, δ, κ, λ, μ
Scales	Lib	α^2, β
Scorpion	Sco	α, β^1, δ, ε, ϑ, κ, λ, π, σ, τ, υ
Serpent	Ser	α
Serpent Bearer	Oph	α, β, δ, ζ, η
Southern Fish	PsA	α
Southern Triangle	TrA	α, β, γ
Southern Water Snake	Hyi	α, β
Swan	Cyg	α, β^1, γ, δ, ε
Toucan	Tuc	α
Twins	Gem	α, β, γ, ε, μ
Virgin	Vir	α, γ, ε
Water Carrier	Aqr	α, β
Whale	Cet	α, β
Wolf	Lup	α, β, γ

7.2 Greek Letters

α	Alpha	ν	Nu
β	Beta	ξ	Xi
γ	Gamma	ο	Omicron
δ	Delta	π	Pi
ε	Epsilon	ρ	Rho
ς	Zeta	σ	Sigma
η	Eta	τ	Tau
ϑ	Theta	υ	Upsilon
ι	Iota	φ	Phi
κ	Kappa	χ	Chi
λ	Lambda	ψ	Psi
μ	Mu	ω	Omega

7.3 Stars with Proper Names

Albireo	β^1 Cyg
Aldebaran	α Tau
Alderamin	α Cep
Algol	β Per
Alioth	ε Uma
Almach	γ And
Alphard	α Hya
Alpheratz	α And
Altair	α Aql
Antares	α Sco
Arcturus	α Boo
Bellatrix	γ Ori
Benetnasch	η Uma
Betelgeuse	α Ori
Capella	α Aur
Castor	α Gem
Deneb	α Cyg
Denebola	β Leo
Dubhe	α UMa
Fomalhaut	α PsA
Gemma	α CrB
Hamal	α Ari
Kaus Australis	ε Sgr
Kochab	β Umi
Markab	α Peg
Merak	β Uma
Mirach	β And
Mirfak	α Per
Mizar	ζ Uma
Phecda	γ Uma
Polaris	α UMi
Pollux	β Gem
Procyon	α CMi
Ras Alhague	α Oph
Regulus	α Leo
Rigel	β Ori
Scheat	β Peg
Schedar	α Cas
Sirius	α CMa
Spica	α Vir
Vega	α Lyr

7.4 Technical Data of some Mounts

Mount	Motor Type	Coil Resistance	Coil Current (from...to)	Full Steps per Motor Revolution	Gear Reduction Ratio Right Ascension	Gear Reduction Ratio Declination	Encoder Resolution	Number of Teeth of the RA Gear	Maximum Speed (approx.)	Remarks
AOK WAM 30/300	SAIA UFD1 6V	9.5Ω	0.35A 0.63A	48	18000	18000	12288	125	50x	(1)
AOK WAM 40/400	SAIA UFD1 6V	9.5Ω	0.35A 0.63A	48	18000	18000	12288	150	50x	(1)
AOK WAM 440	SAIA UFD1 6V	9.5Ω	0.35A 0.63A	48	16895	16895	12288	109	50x	(1)
AOK WAM 60/600/ 650/650move	SAIA UFD1 6V	9.5Ω	0.35A 0.63A	48	18093	18093	24576	107	50x	(1)
AOK WAM 80/800	SAIA UFB3 6V	5Ω	1.2A	24	37693	37693	24576	107	?	(1)
Vixen ATLUX	Nippon	2x12Ω	0.4A	200	9600	7200	--	240	32x	
Vixen ATLUX (modified)	ESCAP PH632. 508.002	1.1Ω	1.5A 1.8A	200	9600	7200	--	240	80x	(2)
Vixen SP, GP	Nippon	2x18Ω	0.3A	48	17280	17280	--	144	32x	(4)
Vixen SP, GP (modified)	ESCAP P530 12:1	2.2Ω	up to 1.8A	100	1728	1728	--	144	ca. 500x	(3)
Celestron G11	Hurst SP-3192	2x68Ω	0.18A	24	54000	54000	--	360	32x	
Celestron G11 (modified)	ESCAP P530 12:1	2.2Ω	up to 1.8A	100	4320	4320	--	360	ca. 240x	(5)
MAM-20-P	Nanotec 4H4018M	2.4Ω	up to 1.4A	200	2160 or 9720	2160 or 9720	12960	120 m=1.0	ca. 300x	(6)
MAM-50-P	Nanotec 4H4018L	1.7Ω	up to 1.7A	200	2400 or 10800	2400 or 10800	12960	120 m=1.25	ca. 300x	(6)
MAM-100-P	Nanotec 4H5618X	1.2Ω	1.8A (max 3.5A)	200	3600 or 10800	3600 or 10800	12960	180 m=1.25	ca. 150x	(6)
MAM-150-P	Nanotec 5618X	1.2Ω	1.8A (max 3.5A)	200	3600 or 10800	3600 or 10800	12960	225 m=1.25	ca. 150x	(6)
Astro Physics CNC 400	?	39Ω	0.3A	48	28800	28800	--	192	ca. 20x	
AD-5	Berger	5.0Ω	0.7A	48	18750	18750	--	250	36x	
AD-5	ESCAP P520	0.7Ω	1.8A	100	15625	16666.7	--	250	150x	(8)
AD-6	Berger	5.0Ω	0.7A	48	20625	18750	--	220	36x?	
AD-6	ESCAP P520	0.7Ω	1.8A	100	13750	16666.7	--	220	150x	(8)
AD-7	Berger	5.0Ω	0.7A	48	20250	19687.5	--	270	32x	(7)
AD-7	ESCAP P520	0.7Ω	1.8A	100	16875	17500	--	270	150x	

The technical data of the AOK mounts were kindly made available by Beat Kohler from AOK Swiss.
The technical data of the MAM mounts were kindly made available by Manfred Mauz.

Remarks:
(1) Some older mounts have 12 Volts motors which should be operated at about 0.3 Amps. Many mounts with 6 Volts motors have built-in series resistances which are necessary when using the "Sinus2" control unit. These resistances are not necessary when using the FS2. By customer request the mounts are built with ESCAP motors too.
(2) The conversion to ESCAP motors is possible, but difficult.
(3) The conversion to ESCAP motors is not difficult. You only have to construct suitable parts to attach the new motors to the mount.
(4) In some older motors the two middle points of the coils are connected to each other. This connection must be cut if you want to drive the motor with the FS2. Otherwise the motor runs very uneven or not at all.
(5) For the conversion to ESCAP motors you need suitable shaft couplings and parts to attach the new motor.
(6) Using the original MAM Control Unit with 40 Volts and maximum current a maximum speed of about 500x is possible.
(7) Because the declination gear ratio is not a whole number, please set it to 39375 and set S/Rev to 24.
(8) Because the declination gear ratio is not a whole number, please set it to 14881 and set S/Rev to 112.