

## **INTRODUCTION**

The Intelligent Drive System supplied by AWR Technology gives you the features to drive a telescope mount of many different types with GOTO operation. It is completely configurable with modularised design and construction so it is possible to move on to the next mount by changing user settable parameters along with the motors.

The kit as supplied is pre-configured for the mount in question with the correct drive ratios already programmed so that it should work straight out of the box. The only setup maybe setting up the rotation sense of both motors to match how the motors are fitted to the mount. The only case where this may not be correct is a friction drive mount where the mechanical reduction ratio is not known precisely. However simple user Calibration will sort this out, but needs the Intelligent Handset to do it. It is not difficult for the user to do this.

The IH2 is extensible in its operation with many additional features available. Some of these are released only by AWR supplying an unlock code. These are 'paid for' options where a great deal of additional work has gone into creation of the feature and so you pay for the amount you use.

All firmware programmes are upgradeable to the latest version at nominal cost, either by chip exchange or reprogramming through the in-built bootloader (IH2 only). This is at nominal cost as the purchase of an AWR system includes support. If you buy a system second hand then the support package is available by paying a small sum.

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## PRODUCT LINEUP

The Intelligent Drive System comprises an Intelligent Handset and a drivebox. There is additional equipment and options that can be ordered. There are a few special builds of hardware that need to be built at time of specifying.

### **DRIVEBOX**

**Microstep** box available in standard and advanced versions. Available in 12 Volt, 24 Volt, 1 Amp and 2 Amp versions.

Motor cables are 6 pin DIN connectors for 1 Amp per phase motors and 6pin rectangular 'QUIKMATE' Connectors for 2 Amp motors. Extension cables can be made for both types. They are also interchangeable at the motor end to help in fault diagnosis when they can be swapped.

**FRGEN** drivebox available in standard and advanced versions only. This supplies pulse and direction signals for both axes for a third party motor controller. We have used Applied Motion Products and Compumotor drive modules which microstep much larger stepper motors (up to 10 Amps per phase). It can output pulses on both axes independently up to 25kHz without jitter with smooth accelerations.

See the related pages on MICROSTEP DRIVEBOX and FRGEN DRIVEBOX for more details.

The encoder pulses are derived from the signals sent to the motor, so the system operates open loop. If the telescope has clutches fitted then it may pay you to also fit external encoders so that it always knows where it is.

The **ADVANCED VERSION** has extra connectors and features to allow a more comprehensive setup. It has 3 extra connectors. The INDEX connector accepts a pulse from an opto-coupler and top hat generator to provide one pulse per revolution, typically used for periodic error control. There is a second CCD autoguider connector with different connection layout and the third has three relay outputs that can be wired into external equipment, and then controlled by the Intelligent Handset. There is also an override input signal that can be used to stop the telescope moving by means of a microswitch closure.

### **BARS BOX**

This forms the basis of a 'PUSH-TO' goto system where it is not possible to use motorised GOTO, such as older Heritage telescopes that have clutches on both axes. In these cases the Drivebox will probably be a non-goto system in its own right and the IH will be accepting external encoder signals with display on the Bars Box for the distance to go when pushing the telescope to the next object.

### **FOCUS MODULE**

The Focus module is an extra box fitted with the drivebox to provide extra hardware functions on the telescope. It drives an additional motor under command from the IH2. The IH2 drivebox cable plugs into this box then a short cable plugs from here to the drivebox. Extra menus appear for readout and control in the IH2.

### **INTELLIGENT HANDSET**

This has telescope movement buttons, a numeric keypad, the navigation of the menus and a large display.

Intelligent Handset first version. **This has a grey box.**

The Database option is an extra chip to plug in and supplied only by AWR. The code space is full and only bugs are now being fixed. Version 1.734 is current.

Intelligent Handset second version (IH2). **This has a yellow box** and is slightly smaller all round than the first model. It functions exactly the same as IH. In addition it can be factory fitted with a GPS receiver.

The Database option is self install but requires an unlock code to allow use of the feature. Contact AWR for payment.

Other features can be turned on or off through the FACTORY – SETUP menu. One of these is the Multiple Telescope feature but only available by AWR supplying an unlock code.

### **SIMPLE HANDSET**

The Simple Handset is a small hand paddle with speed and direction buttons and plugs separately in the drivebox. It can be used at the same time as the Intelligent Handset. It is used for changing the position of the telescope relative to the stars, the drivebox normally follows the stars without any intervention.

### **DISPLAY EQUIPMENT**

Model AD100 Observatory display units show one of 7 parameters (selectable) when connected to the Intelligent Handset. Several of these units can be fitted in series to display more parameters together. (RA DEC ALT AZ HA LST UT). These units have large dimmable red LED digits that can be seen from the other side of a large dome (15 metres).

### **LEADS**

IH-PC lead. Serial lead RS232 9pin D female at the PC end, 6 pin RJ12 at the IH end. The version supplied with the IH2 is also the programming lead.

DOCKING STATION. This has the IH-PC lead built in with an additional power supply. This can be used when updating the programme in the IH2.

DRBOX-PC lead. Serial lead RS232 9 pin D female at the PC end, 8 pin RJ45 at the Drivebox end.

USB-SERIAL converter. The one we sell is made by FTDI and guaranteed to work.

IH to Drivebox is a standard CAT 5 Network Lead RJ45. We have supplied up to 40 metres.

The motor leads can be 5 metres in length. The 2 Amp ones are also shielded so are very heavy. It is necessary to secure all leads properly to avoid strain on the connectors, especially near the motor.

### **TEST EQUIPMENT**

LIGHTS BOX to see the encoder pulse and direction signals of both axes. Fits in series with the IH to Drivebox lead, at either end.

AWR SEEKER fits into the autoguider socket and operates the telescope remotely to do a rectangular spiral. This shows up mount errors and how the motors load up when starting.

PULSE ANALYSER PA2 measures pulse lengths and buttons pressed from autoguiding cameras, fitting inline to the autoguider input socket on the drivebox. This allows you to get the best out of the camera and checks backlash settings.

RJ12 BREAKOUT BOX fits inline to the autoguider input socket to show you the signal levels from the autoguiding device and allows you to move the telescope in the four directions by remote control.

### **MISCELLANEOUS**

Customer Support Package. Essential if you want detailed explanations and you have bought the kit second hand.

ASCOM AWR Driver to take advantage of additional protocol enhancements. This is a third party product by TigraAstronomy. AWR have collaborated to make this product fit the requirements.

### **POWER SUPPLIES**

The common power supplies are:

PSU5 5 Amp 12V DC power supply mains operated. Fully enclosed type.

PSU9 6.7 Amp 24V DC power supply, mains operated enclosed by frame.

PSU10 5 Amp 48V DC power supply, mains operated enclosed by frame.

### **RELATED PAGE:**

- MICROSTEP DRIVEBOX
- FRGEN DRIVEBOX

## **WARNINGS**

### **POWER SUPPLIES LOW VOLTAGE**

- If you use your own power supply please make sure it has enough CURRENT rating for your drive system.
- If you use your cables then please make sure the rating is sufficient. 10 Amp loud speaker cable is ideal. It is 1mm<sup>2</sup> of copper for 10 amp.
- If you use a Lead-Acid car battery then please make sure you have a fused placed in the lead close to the battery, rated at 10Amp max else you can easily destroy equipment. Lead Acid batteries give out 100's of amps for a short time and can fry wiring very quickly.

### **ROTATING EQUIPMENT**

Even though the telescope can move very slowly the motors are geared up at least 300 times and can generate huge forces. Please be aware that the telescope is dangerous and moves slowly but inexorably.

### **HEAT**

Various parts of the Intelligent Drive System generate heat in use. This is normal. The Stepper motors are operated at full power all the time even when they are not turning so they will be very warm to the touch. Parts of the drivebox may also be very warm. These are designed to operate the way they do. Larger systems with a RESBOX contain the heat to this box. Some are fan assisted for cooling.

### **MAINS ELECTRICITY**

If your system is powered by mains then please pay attention to the setup. The installation should be protected by an RCD which cuts the supply if there is an imbalance Live to Neutral (that is there is earth current flowing). Metal parts should be earthed, including the mount with wiring capable of taking the full fault current – at least 20 Amps. Lengths of braiding found in shielded cables is ideal for this purpose. If you require some call AWR.

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## NOTES TO THE HANDBOOK

This handbook contains topics for understanding procedures and setups used in **BOTH** the Intelligent Handset (**IH**) and Intelligent Handset MK2 from August 2015 (**IH2**). The handset is the integral part of the AWR Intelligent Drive System (IDS) with a drivebox, either a Microstep Drive unit or a FRGEN box. There are also pages dealing with the types of drivebox.

To make sense of the menu system you need to download the menu tree for the version software you are using. There is also a Factory menu tree for entering parameters to do with setup that you only have to do once. See the AWR website, [DOWNLOADS](#) page for various revisions of these sheets.

There are a number of specials to cope with user requirements when older telescopes were updated, hence the software for the Intelligent Handset is available in different versions, as separate compilations for the IH, but combined in one release for the IH2 and selectable by setup on running the software.

The hardware and software features are much expanded on IH2, as it contains a modern ARM7 processor with plenty of onboard resources.

This handbook attempts to describe the operation of both models in their various stages of development. Certain functions are restricted to just IH or IH2 and this is indicated top right of each section in this handbook. The version number when it was implemented is shown if it is relevant, and it will work with all later versions.

On these pages, shortform menu routes are shown in RED at the top right for SETUP and USE of the function. Where we refer to Northern hemisphere observing sites there will be a square bracket for Southern hemisphere observers.

It is intended the user print out the pages that are relevant to the AWR drive system they have, so there are no page numbers! The bottom of each topic has a last update date so you can replace pages that are revised.

AWR will produce further pages on request that may also be of interest to others, please contact us.

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## GETTING STARTED

The product looks complicated but you can go step by step through an intuitive menu sequence. There are very few things you need to know before you can track an object. Some of it is astronomy terminology, and others deciding if the intelligent drive system is doing the thing you expect when operated.

The most important thing to understand is Local Sidereal Time and the movement of the heavens. Calibrating the Handset to this is key to getting it doing what you expect. The star coordinates are Right Ascension (RA) and Declination (DEC).

The sky is divided into two hemispheres, East and West and the dividing line from due North through the Zenith to due South is the Central Meridian. Along this line is your Local Sidereal Time (LST), that is the Right Ascension coordinate of a star on that line. Strictly it is from the Local Pole to the due South horizon in the northern hemisphere or to the due North horizon in the southern hemisphere. The rest of the line the star is travelling under the pole from West to East and it is 12 hours difference from LST. The LST is local to you and depends on the Longitude value you have entered.

The Altitude of the Pole is also the latitude of your observing site. We also talk about Azimuth (0 degrees at due North, moving to 90 degrees due East all the way round) and Elevation or altitude, both of which should be familiar.

So when tracking an object the movement is from East through South [North] to West. The more easterly you are the bigger the RA value compared to the Central Meridian and to the west of the Central Meridian the RA value is smaller. If you do not track then the RA coordinate will increase.

There is also a term called the Hour Angle which is the distance the star needs to travel to get to the Central Meridian, or the distance it has travelled from the Central Meridian.

The essential Handset setup is your SITE location and the clock RTC date and time (Universal Time is required). There is a mixture of using the 'F' functions keys to select units to go with number entry done with the keypad. Remember to press 'E' to Enter a field before it moves to the next one. We will assume for now the handset telescope calibrations have been setup for the mount.

Refraction in the Earth's atmosphere effectively makes a stellar object move slightly faster than strictly Sidereal rate and a good average rate is called the KING rate, so this is what the handset should be set to follow a star properly. We are assuming that the KING rate is running correctly for your installation and this is determined by adjustable 'constants' in the FACTORY menus that you can do if it is not tracking correctly. Polar alignment is also essential for good tracking.

Setting up the telescope to point the polar axis near to or at the local pole is required for good guiding, otherwise there will be DEC drift. It may be that your latitude scale is out, or the ground is sloping – a bubble level device is a good idea. Some mounts have these fitted. At some point you will need to check the alignment using a Polar Scope or Drift Alignment.

Then you need to find a star that you know the coordinates and use the calibration menu SYNC or CAL1 to calibrate the handset to the sky. Coordinates are entered the same way as site latitude and longitude using the keypad and the 'F' keys to put the tokens in the right place, with 'E' to move to the next field.

The ORIENTATION page takes you through this basic setup and checking that the controls are doing what they should, and when calibrated, how to check that it appears right.

It is possible to try all this out in daylight and get good agreement between the telescope and the sky. You may even find a bright planet!

- 1) Make sure you have TIME, DATE, SITE LAT and LONG correct and you are roughly polar aligned.
- 2) Alter the default display to show RA, DEC and LST by using the DISP menu for TIME and SKY Coordinate frame.
- 3) Take note of the LST in the default screen.
- 4) Add 6 hours and put the telescope tube pointing due East at the horizon. You can eye up the mount to check there is 90 degrees between the two axes. The telescope tube will also be horizontal.
- 5) Navigate to the Calibrate screen and enter the coordinate LST+ 6hr for the RA coordinate and 0 degrees for DEC. If the RA coordinate is over 23hr 59m then subtract 24 hours.
- 6) You have now SYNCed the telescope to the sky.
- 7) Once in SYNC you must drive the telescope round the sky using the motors else you will uncalibrate it.
- 8) Redo SYNC at any time when you discover your next object and it is in the centre of the eyepiece. If there is drift whilst you are watching then the polar alignment is not great and changing this could be of benefit, especially if you want to do GOTO's, but then you must redo SYNC if the mount is moved.

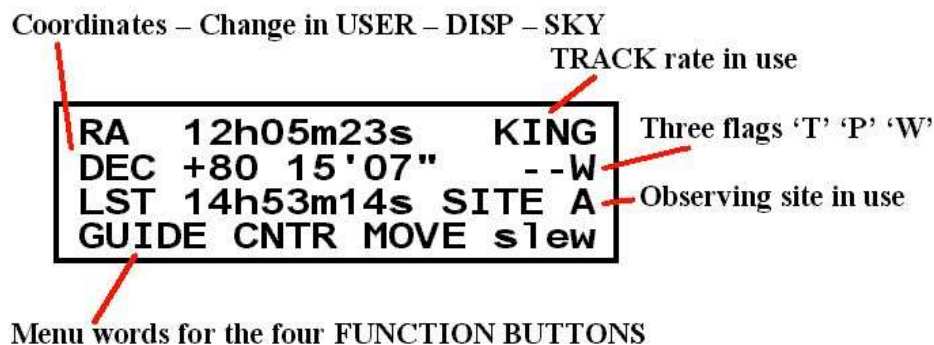
**RELATED PAGE:**

- ORIENTATION

Revised 12JUNE2016



## ORIENTATION



1. Power up the Intelligent Handset. The screen will look something like that above. The four function buttons take on the name of the word above them and 'M' is MENU, 'C' is CANCEL and 'E' is ENTER. Navigating the menus is easy - press 'M' repeatedly you will see all the top level menus. The MENU SHORTFORM (download) is a guide to all the sub-functions available. A '..' on the F4 function key means there are more options. The SOFTKEYS (F1, F2, F3, F4) take you one level down the menu tree into the function selected.

2. The Calibration status is shown by the end flag on the second line and will be '-' when not calibrated or 'E' 'W' or 'C' if calibrated. Periodic Error playback is in progress when the 'P' is shown. Two-star tracking is in operation if a 'T' is shown. 'KING' is the normal star tracking rate, just slightly slower than sidereal to compensate for refraction.

3. The four telescope movement keys are in the diamond pattern. The **UP key** must move the telescope towards your **local pole** (up towards Polaris for northern hemisphere observers). If the DEC motor sense is wrong then either reverse the tube in the cradle or enter the FACTORY – USTEP – DEC – DIR menu to change the sense. The **RIGHT key** must move the telescope towards the **West** (towards a lower RA coordinate) for both Northern and Southern observatories. If the RA motor sense is wrong then enter the FACTORY – USTEP – RA – DIR menu to change the sense. To get into the FACTORY menus hold the 'M' key down whilst powering up or hold the 'M' key down whilst press REBOOT from the INFO or STATUS screen.

4. If the unit is calibrated using CAL1 or SYNC, change the coordinate display to ALT – AZ (in USER – SKY) then you can check the coordinate matches up with your telescope attitude. This checks the entry for SITE latitude and longitude, the correct entry for Universal Time and the date. The Sidereal time is computed from these values and must be right else it will put the horizon and the central meridian in the wrong place, and GOTO's may indicate target BELOW HORIZON.

5. Make sure that your local horizon is set to 0 degrees. (The telescope stops driving when it detects the altitude is below zero degrees). The hour angle limitation should also be set to 12 hours for maximum sky coverage (FACTORY

– USTEP – MAXHA). The declination limitation should be set under 90 degrees if you do not want the telescope to drive over the pole and reverse the tube. (FACTORY – USTEP – MAXDEC).

6. For GEM scopes you need to be able to let the telescope FLIP automatically when doing a GOTO from one side of the meridian to the other. Enable this by setting MREV to YES (FACTORY – USTEP - MREV) and set MAXDEC to 90 degrees.

7. The KING rate is the default for tracking stars. This is refraction corrected sidereal tracking which is correct for tracking the stars and planets. The lunar and solar rates are greatly different so there are separate settings in the menu function DRIVE. You will also see TRACK as one of the options but this allows setup for differential tracking to following comets.

8. The **FACTORY MENU** is accessed by holding down the 'M' key when powering up, or holding the 'M' key down when REBOOT is pressed. A complete printable Factory menu tree is downloadable from the AWR website, as is the normal menu tree. The Factory Menu contains all sorts of configuration setup, mostly to do with getting the mount to cooperate and drive at the correct rate in the correct directions.

9. The AWR website DOWNLOADS page contains version history and documentation for various issues of software. There are trees present for different issues of software so you can match the documentation to what you have.

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## **NORMAL BEHAVIOUR**

### **NO IH CONNECTED**

The Drivebox in the system (Microstep or FRGEN) will already have been programmed and it drives the telescope with star tracking on. The SIMPLE handset is necessary and provides speed and direction control. The autoguider input works (CCD1 connector) so you will be able to take photographs with autoguiding equipment. If the polar alignment is good the exposure can be very long without any field rotation (hours).

All the speeds are available, ramping in speed works and backlash compensation works if it has been set. There is a method for direct connection to a PC for basic control but it does not convey the virtual encoder position information unless you understand what you are doing. You need a special lead (DRBOX-PC) from AWR.

### **WITH AN INTELLIGENT HANDSET CONNECTED (IH and IH2)**

Every time the IH powers up with the Drivebox connected, the IH reprogrammes the Drivebox and star tracking begins. There is a SETUP option to have power up stop until it is unparked. There is a Copyright screen with the IH version number then the default screen appears. The DRIVE CONNECT message appears and the IH beeps. The IH tells you if there are any errors or warnings by a long beep and a message that appears on the bottom line of the display for two seconds. The last message is also displayed in the INFO screen. Events or warning messages are also flagged up the same way, such as HOST CONNECT or MERIDIAN CROSSED. If the Meridian Crossed message is not when you are pointing due South / North then suspect either the time or longitude of the site or the star calibration is wrong. The basic orientation and display options shown in the DEFAULT SCREEN should be familiar so it becomes easy to know how to diagnose and fix this. (See the ORIENTATION page).

Both the Simple and Intelligent Handsets can be fitted to the drivebox together, and both can be used in the same session. The coordinate display will always be maintained in the Intelligent Handset.

Pressing the telescope UP key on the Intelligent Handset should always move the telescope towards your local pole. This is true even after a meridian flip, or operation in the Southern Hemisphere. It is possible when re-mounting telescope tubes on mounts to get them on a different way to last time, in which case the DEC drive Sense becomes reversed. There is a new menu function in SETUP – DECDIR to alter the motor sense from V1.733 onwards. Before this version the DEC drive sense alteration is in FACTORY – USTEP – DEC – DIR.

There is an envelope of operation defined by quite a few parameters and it is intended the controller stops driving when it reaches one of these limits. It will always be possible to manually drive out of the limit. The limits are:

HORIZ Artificial horizon lower altitude limit, default 0 degrees  
MAXHA Maximum hour angle from due South [North]  
MAXDEC Maximum declination + or -  
MAXOR In GEM setups it is the maximum hour angle overrun past the meridian.

Handset illumination dimming is in the USER – DISP – LIGHT menu where the display and keyboard (IH2) can be dimmed in brightness in 15 levels.

### **DRIVBOX and MOTORS**

It is normal for these components to get warm.

The motor has to work at maximum rated power all the time in order to maintain a microstep position where the rotor is inbetween poles and the coils are fighting each other. So it will get warm.

The Drivebox is supplying constant currents to maintain the microstep position. We generate these by PWM modulation with a resistive dropper from the power supply. The motor voltage is generally only a few volts, so the rest is dropped through resistors from the power supply in the system. Therefore this box also gets warm.

If the load changes and it is above what the motor can supply then the motor will make a loud brrrr noise if slewing or clicking at low speed. Check the rotation of the motor armature, you may find it is going backwards and forwards. To facilitate this draw a line on the end of the motor shaft so you can see the rotation. There is no damage to the motor but you need to investigate why the load has changed.

### **RELATED PAGE:**

- ORIENTATION

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## **ABNORMAL BEHAVIOUR**

The Intelligent Handset will tell you if there are breakdowns in sub-systems at various times of operation. The motors by their sound, vibration or movements will tell you if there are drive system faults.

### **INTELLIGENT HANDSET POWER UP**

Various internal circuits can give an error message before the Copyright screen. It is not possible to continue and advice is needed from AWR. When apparently working normally the RTC clock can suddenly stop keeping the time. There is an internal coin cell that keeps the clock running, replaceable by the user on the IH2 but only Factory replaceable on the first version IH. The keys can become difficult to make contact after many years. The short term answer is cleaning to remove deposits of perished rubber but the key mat needs replaced to do the job properly. AWR have spares of this custom part. Keeping the KEY – BEEP – ON allows you to tell when the key has been pressed.

### **RELATED TO DRIVEBOX**

If the Handset is not getting any replies from the Drivebox then further errors are generated. Occasionally the solution is to unplug the handset and plug it in again.

Lots of beeps when the IH is plugged into the drivebox. There is an extra diagnosis screen in the IH2 – see the sheet on DRIVEBOX TESTS.

### **MOTORS**

- STALLING when the motor should slew up to a high speed. A loud buzzing noise comes from the motor. No damage is done. Too much mechanical load. Could also be power supply droop.
- CLICKING or VIBRATING at slow speed. The motor may be missing a drive wire. It is a possible electrical fault or wire fallen off a connector. Swap over the motor cables to see if the fault transfers. It is also possible for a connector to become partly disconnected – this applies to the RA and DEC little blue connectors inside the drivebox – at the motor cable end.

In most systems it is possible to swap the RA and DEC motor cables. If the fault transfers then it is the cable or the electronics. Inside the drivebox there are little blue connectors at the motor drive end – swapping these over will output the RA signals down the DEC cable. By swapping at this point you can determine if the fault is in the cable or the electronics.

### **COMMUNICATIONS**

Programmes like ASCOM require access to both IH and Drivebox. A message 'Cannot Connect' on the PC screen can mean several things. The advice is to remove both leads from the Intelligent Handset, connect the Drivebox and make sure it connects properly with a DRBOX CONNECT message and beep. Then connect the HOST cable. A good sign is if it beeps and says HOST

CONNECT. This does not guarantee that there is also serial data flow but it is a start. Data flow would then be 'connection established' message at the PC end.

### **RETURNS**

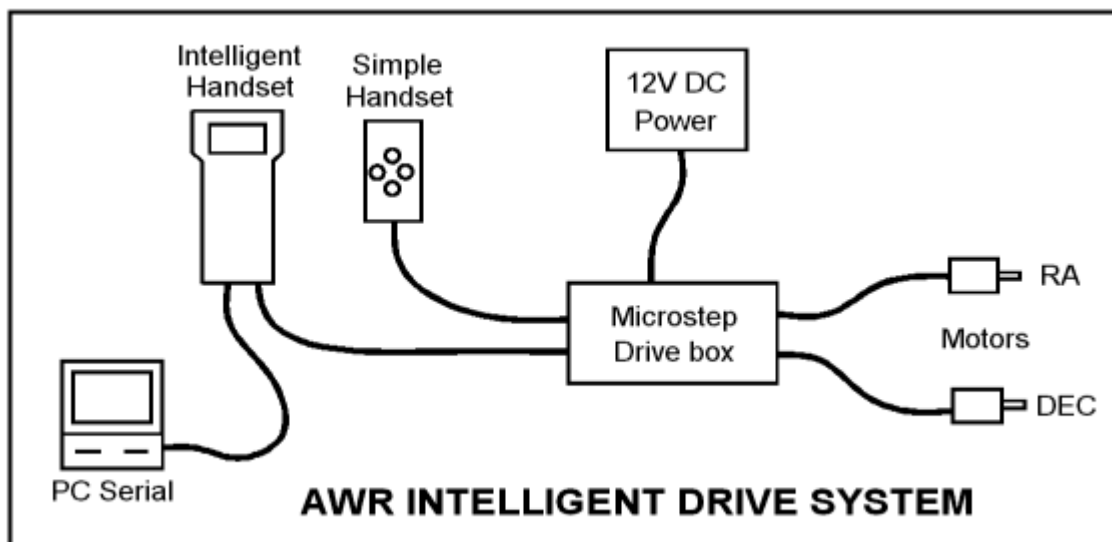
Please contact AWR before returning. There may be experiments you can perform under direction to narrow the fault. If outside the warranty period there will be a small charge enough to cover transport costs and maybe other items depending what was found.

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## HARDWARE INSTALLATION

### BEFORE ADDING MOTORS

You should power up the whole system on the kitchen table before installation. There are very few alternative holes to put in connectors. Most of it is straight forward. The only serial connectors (RS232) are in the HOST connector on the Intelligent Handset which is a 6 pin RJ12 connector – a special lead is needed from AWR to connect to the computer. The other serial connector is the IH connector on the Drivebox (8 pin RJ45 or network cable). All the other 9 pin D connectors have other purposes. This diagram will help.



Go through the maintenance schedule in the leaflet  
<http://www.awrtech.co.uk/maint.htm>

The point the motor is applied must be turning freely without any stiff points, ideally examined over the whole rotation of the primary axis of the mount, RA and DEC. Backlash should be minimised without making the rotation too stiff. Balance is also important. Radial balance is usually the one that fools you – all off axis weights need to be balanced on the other side of the tube.

### NON-GOTO SYSTEM

The Drivebox (MICROSTEP or FRGEN) will have already been configured for the drive reduction ratios. The motor sense direction may not be correct. There are internal jumpers in the Drivebox to change this for RA and DEC. Open up the drivebox at the handset connector end and slide out the pcb gently. Next to the 40 pin processor are two internal jumpers on 3 pin headers, usually RED. Slide off the shorting jumper link and put it from the middle to the other end.

For systems where the exact reduction ratio is not known it is possible to change the register settings by connection of a PC. It needs a special serial lead, 9pin D to RJ45 available from AWR.

## **GOTO SYSTEM**

The GOTO system is completed by adding the Intelligent Handset to the Drivebox. The parameters to enter in the factory setup menus may have been done but are included in the Factory Build Sheet. There are many other settings to do with your observatory that need to be entered. Go through the Orientation Sheet to get familiar with the handset operation.

## **COMMISSIONING**

This is a procedure to make sure the equipment is doing what it is supposed to do. If you exercise the hardware aspects in all the possibilities then you have done it. The standard software will work as given. Special software should also be exercised fully. There is very little to do to the mount itself. Make sure the motors work properly and with even rotation – you can draw a line across the end shaft of the motor to see the rotation and feel it for out of the ordinary vibrations and jumps. The main item is getting the slew speed up without stalling, making loud noises or taking too long to stop.

The RA axis should be tracking the stars properly, with no DEC drift. Check this above 30 degrees altitude so that refraction effects in the Earth's atmosphere will not confuse the issue. The DEC axis should be orthogonal (exactly at right angles) but it may not be so. This may make GOTO pointing with error. There are further mechanical and optical errors that could cause pointing issues. See the AWR leaflet on "Telescope Pointing errors and Corrections"

Tidy up the leads making sure there is a strain relief close to the connectors.

Also check the connection to the computer is operational.

## **FAULT FINDING**

RA and DEC components are nearly always identical, so you will be able to swap over motors, or leads. It should be possible to determine if there is a fault in the motor, the lead or the electronics.

Checking the motor rotation by drawing a line across the accessible end of the motor shaft will help you in determining what is wrong.

There is a range of faultfinding equipment that AWR provides, mostly to do with testing guidance accuracy

## **RETURNS**

Please contact AWR before returning. There may be experiments you can perform under direction to narrow the fault. If outside the warranty period there will be a small charge enough to cover transport costs and maybe other items depending what was found.

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## **MICROSTEP DRIVE BOX**

This comes in several versions.

All driveboxes have an input socket for autoguiding devices marked CCD or CCD1. It is the standard SBIG RJ12 socket with active low signal levels to operate as a remote relay box. The connector marked SIMPLE is for a Simple handset, just a hand paddle with direction and speed controls. The connector marked IH is for the Intelligent Handset, both versions work.

The Advanced version has additional sockets for an Index pulse generator, a more versatile CCD autoguider input socket which is also opto-isolated from the rest of the circuitry and an output connector with three uncommitted relays and an input for an electrical override stop signal.

The Microstepping is the same for both versions. It comes configured to drive specific motors, either 1 Amp per phase or 2 Amp per phase. There may be an additional Resistor Dropper box connected if there is a lot of heat to dissipate.

The system can also be supplied in 12 Volt or 24 Volt operation. The higher voltage allows the phase current to get in the winding quicker, so the mechanical power is present earlier. In other words the motors run up to about 1.8x as fast as the 12 volt version.

This makes eight different versions but we have done specific versions for a variety of other motors, making many systems unique.

Communication with the Microstep Drivebox is using a protocol that we have published, involving simple commands and programming registers with appropriate values. There is a feed through or pipe command to the Intelligent Handset allowing all of these to work by direct control from the HOST PC.

We use two types of connectors for the motor leads. For 1 Amp per phase systems we use audio DIN connectors with fixed leads coming out of the Drivebox. For 2 Amp per phase systems the cables are much heavier and we use rectangular 'Quikmate' connectors with sockets on the drivebox. All the leads are extension leads and are usually made for a length to suit the application. We can supply additional leads to increase the length for both type of lead. Leads may be screened with an extra wire coming out at an end and this is usually connected to earth. This type of cable reduces interference to sensitive CCD cameras.

For NON-GOTO systems there is a pair of jumper links that allow the motor direction senses to be changed over. Open up the drivebox at the handset connector end and locate the two jumpers on the main board, they are labelled RA and DEC

## **CALCULATIONS**

The RA tracking rate for sidereal is defined purely by mechanical items.

Using the mechanical reduction ratio (including motor gearbox) multiply by 200 for full steps per revolution of the motor. This is the number to put in for **RATIO**.

**MSTEPS** is fixed at 64 on AWR Microstep units and represent the number of microsteps per encoder count.

**XTAL** is the drivebox crystal frequency and must match the device fitted – see the Factory Construction sheet for this.

**RELATED PAGE:**

- INTERROGATION from the HOST
- DRIVEBOX TESTS

Revised 26MAY2016

## FRGEN UNIT

This comes in several versions.

All driveboxes have an input socket for autoguiding devices marked CCD or CCD1. It is the standard SBIG RJ12 socket with active low signal levels to operate as a remote relay box. The connector marked SIMPLE is for a Simple handset, just a hand paddle with direction and speed controls. The connector marked IH is for the Intelligent Handset, both IH and IH2 versions work.

The Advanced version has additional sockets for an Index pulse generator, a more versatile CCD autoguider input socket which is also opto-isolated from the rest of the circuitry and an output connector with three uncommitted relays and an input for an electrical override stop signal.

The unit supplies pulse and direction signals for two motor drive units, typically third party, driving large stepper motors with large phase currents. Versions have been supplied with up to 30,000 steps per second independently on two axes at once. The unit has smooth acceleration and deceleration with set up for rates etc exactly as a Microstep unit.

The motor end has input connectors for a 12 Volt DC supply (for the AWR electronics) and an input to power the motor drive, typically 48Volts at several amps.

For NON-GOTO systems there is a pair of jumper links that allow the motor direction senses to be changed over. Open up the drivebox at the handset connector end and locate the two jumpers on the main board, they are labelled RA and DEC

### CALCULATIONS

If the mechanical reduction ratio is 500:1 then the motor needs to turn at 1 revolution in roughly 1436/500 minutes for sidereal rate = 172 seconds.

Multiply by 15 to get the number of arc seconds of movement = 2580.

If you want the stepper motor to move without vibration then the step size needs to be small, say 0.1 arc seconds per step. So we need  $2580 * 10$  microsteps per revolution on the motor = 25,800 steps per rev. This value can be programmed into the ST5 units.

The number of steps per second for sidereal rate is  $25,800 / 172 = 150$  as the telescope needs to move at roughly 15 arc second per second to match the rotation of the stars.

The FRGEN will output a maximum of 25,000 steps per second. So the maximum slew speed is  $167 \times$  sidereal or 0.7 degrees per second assuming the motors can rotate the load at this step rate.

The number of microsteps per second can be adjusted to suit your telescope – a smaller telescope may work perfectly adequately without vibration at 100

steps per second, or a bigger telescope may need 200 steps per second. Adjust the calculations accordingly, but note there is a compromise between the following rate and the maximum slew rate.

Inside the FRGEN box there is a bank of settings with a jumper link per axis to select the MSTEP rate sent back to the IH. This is either /16 /32 /64 /128. These are located at the motor connector end of the main pcb and are labelled. Usually the /64 setting is entirely adequate.

Now the value for RATIO. To get the rates suggested, take the mechanical reduction ratio and multiply by the ST5 steps per rev and divide by the FRGEN divider.  $500 * 25800 / 64 = 201562$

Finally check it by making sure the RA motor rotates once in 172 seconds.

You should have

ST5 Steps per revolution as outlined above.

**RATIO** as calculated above programmed into the IH.

**MSTEP** is the jumper link setting you have decided, enter into IH.

**XTAL** is the drivebox crystal frequency and must match the device fitted – see the Factory Construction sheet for this. Also enter in IH.

**RELATED PAGE:**

- INTERROGATION from the HOST
- DRIVEBOX TESTS
- ST5 DRIVE UNITS

Revised 04JUN2016

## ST5 DRIVE UNITS

## FRGEN

For the larger telescope running motors more than 2 Amp per phase we supply microstepping units supplied by Applied Motion Products. This page is a collection of notes for you to install these to suit your telescope. The ST5 unit outputs a maximum of 5 amp per phase and the ST10 unit outputs a maximum of 10 Amp per phase to control stepper motors. The units operate from a 48V power supply. To cope with large peak current requirements this should be rated at 5 amp 48 volt DC. One supply is sufficient for both RA and DEC axes.

One ST5 (or ST10) unit is required per motor. It can be mounted close to the motor or metres away. There is less RF radiation if the units are mounted close to the motor, although shielded cables will work but they must have the current carrying capacity and the shielding needs to be grounded.

The signalling wires from the FRGEN box and step pulse and direction are optically coupled in at the ST5 unit. Note the FRGEN unit will require its own 12 Volt DC supply.

Stepper motor coils should be wired in parallel (8 lead motors) except on 6 lead motors where the common wires are not used. 4 lead motors (bipolar) are wired straight in. The Applied Motion Product instruction sheet should be followed for wire colours, but please find your motor in the literature to make sure of the connections.

Setup is through the ST Configurator, download from Applied Motion Products website, and install on your computer. Connection is through a serial port.

- Connect the serial lead and the 48V power supply. Turn on the power.
- Run the ST Configurator
- Press CONNECT
- Press UPLOAD from DRIVE
- Change the motor A/PH figure to that suggested for the motor. If the motor is rated 0.6A/ph in 4 phase Unipolar operation then it is safe to specify 0.85A/ph for coils in parallel.
- Change the STEPS/REV to match your mechanical configuration and that suggested by AWR.
- Press DOWNLOAD to DRIVE

You will need to power up the full system to try it. Make sure everything is connected. The RA coordinate on the Intelligent Handset should be static with the RA motor just turning slowly following the stars. Check the rotation of the motor is approximately right for your mechanical reduction. The control on this is the programming of the values for RATIO, XTAL, MSTEPS in the FACTORY menu screens. The Factory Test Sheet supplied with the system (or consult AWR) details the figures the drivebox has been built with.

The configurator gives warning screens when there is a fault. There is also a sequence of green and red flashes on the ST5 unit to help you, so the Configurator is only run once during install or if a problem develops.

**RELATED PAGE:**

- FRGEN Unit

Revised 04JUNE2016

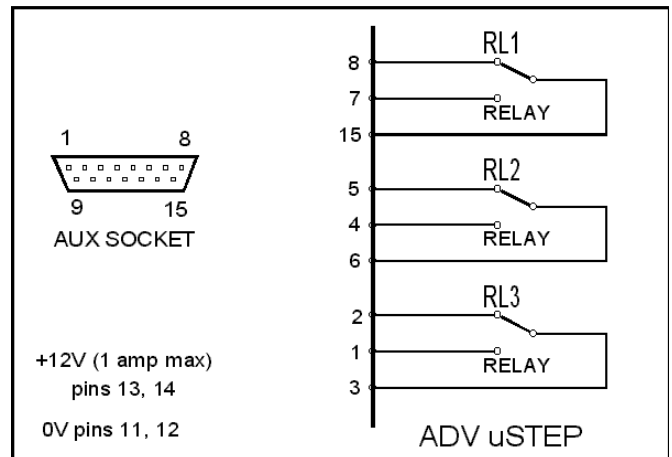
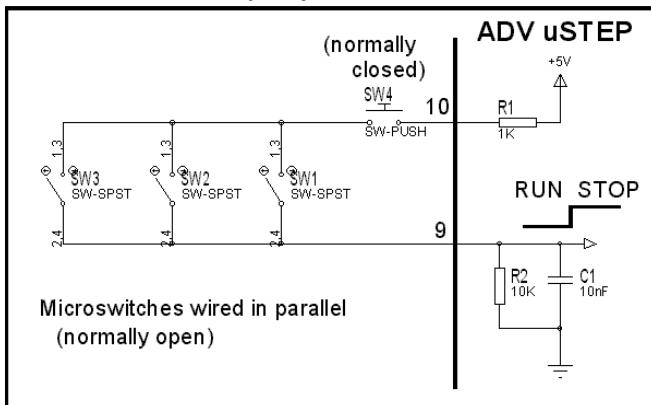
## ADVANCED DRIVEBOX INTERFACES

Applies to ADV MICROSTEP and ADV FRGEN units.

The ADV versions of the drivebox have extra connectors:

### AUX

The 15 way 'D' connector provides facilities for OVERRIDE STOP and three uncommitted relays operated by the Intelligent Handset. External connections are made to other equipment or limits switches to add extra control which can be wired up by the user.



To help you here are some ideas.

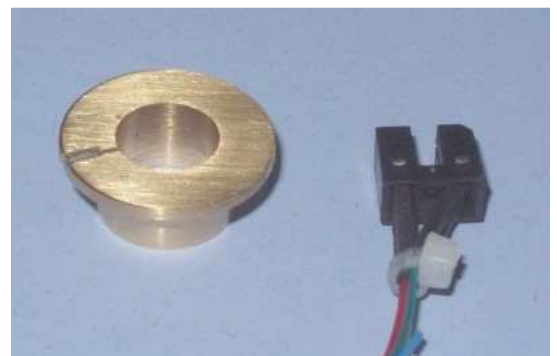
Failsafe tracking - Use U1 button (controls RL1) to provide a safe automatic stop if the power dies. Wire the NC contacts (pins 8 and 15 across pins 9 and 10). Set up U1 as TOUCH TOGGLE and use this to turn on and off the tracking via the override input. At power up it is now in override STOP.

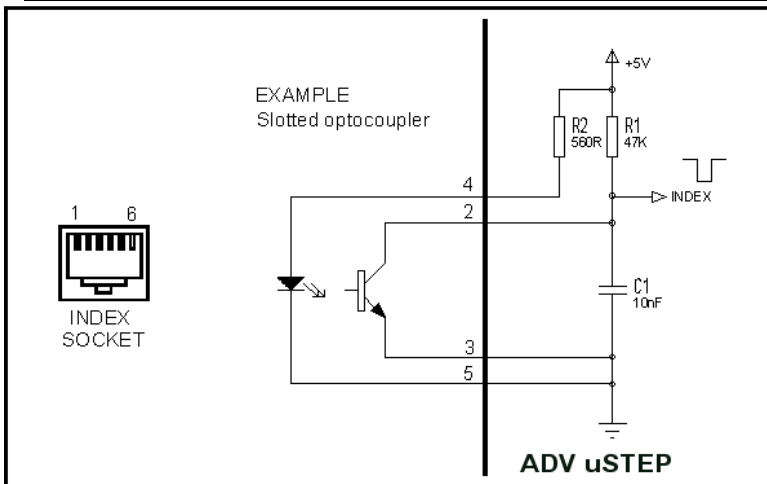
Dome rotation - if you have a manual electrical system with two buttons for dome left and right then use two of the relays to wire across these buttons. Then you control it with two of the U buttons on the handset.

The Override input pins can be used for limit switches to stop the scope. These would typically be on a tangent arm indicating the limits of travel. It could be wired up so that the scope operates a switch if it is about to hit an obstruction, or by using tilt switches could be used to keep the tube elevation above 20 degrees.

### INDEX

The Index connector is for a dedicated opto coupler to generate an index pulse once per revolution of the axis it is monitoring. This is normally the slow motion RA axis.





The circuit diagram shows how it is connected. AWR have a small circuit board with the correct connector and optocoupler on it using a standard RJ12 lead to connect to the INDEX connector.

### CCD1

This is a standard 6 pin RJ12 input for an autoguider. The relevant connections are 0V and active low open collector control lines for the four directions.

### CCD2

This is a different arrangement for autoguider signals which can be wired in to a 9 pin D plug by the user.

### SIMPLE and IH2

These connections are for the Simple and Intelligent Handsets exactly the same as the standard drivebox interface.

Revised 17DEC2016



## DRIVEBOX TESTS

## 1.736 IH2

There is another power up sequence to enter a specific test for Drivebox communications. Without this it is quite difficult to determine where an error could lie.

It is useful try this out if the Drivebox displays any USTEP error, or continually beeps at power up.

The power on sequence is hold '3' down whilst powering up. This backdoor does not do the normal start up sequence and no menu keys are active. The telescope movement keys are active so you can see the effect of sending the command and if it responds.

You will see the following screen.

<b>Pwr</b>	<b>Comms</b>
<b>Chr</b>	
<b>DRBOX Test</b>	

It is a live reporting screen that will show all chars received and sends a single 'RA IDLE' command every second. The screen is refreshed every second.

- **PWR** shows 'Y' for drivebox powered and 'N' for no power
- **COMM** shows 'S' when a command sent, 'Y' when a reply received else blank.
- **CHR** shows the full form of the data received. Eg :X00# received in the last second.

Revised 26MAY2016

## SELF TESTS – INTELLIGENT HANDSET

In the FACTORY menu of the Intelligent Handset is an option for TESTS. This is a collection of tests that the IH can perform to exercise features of the handset.

- **PROM.** Produces a CRC of the whole programme code. It was intended to make this result zero with an additional byte programmed to make it so but this feature never got finalised. It now reports just the CRC value.
- **RAM.** Checks the RAM holds values that are written. It does not disrupt the information already present.
- **DISPLAY.** Checks all pixels are working.
- **BACKLIGHT.** Alters the brightness in 15 steps.
- **KEYBOARD.** Press all the keys and that key comes up on the display. There should be no gaps. Make sure you press F4 last. We find it useful to have KEY – BLEEP – 1 SHORT so that there is always a bleep when a key is pressed.
- **EEPROM.** Contains the non-volatile registers containing all the setup information that the User types in. It checks that each byte can be written and erased. It does not disrupt the information already present.
- **RTC.** Displays the time and date (updating). Checks on the interrupt status of this device should be a toggling 0 / 1 on the display, with a command to PRESET it if necessary.
- **SRAM.** Tests the battery backed ram within the RTC. This area is used to hold the encoder values, updated once per second. It does not disrupt the information already present.
- **RS232.** Requires a LOOP BACK connector box to be fitted with an external power supply input socket.
- **ENCODERS.** Requires a LOOP BACK connector to be fitted with an external power supply input socket and needs access to an internal test pin.
- **BLEEPER.** Puts on a few long beeps.
- **FLASH.** ERASES the FLASH area which contains the DATABASE of OBJECTS. **Do not do this if the DATABASE option is fitted!** You will need to erase the FLASH if you are trying to create the database and it says 'FLASH\_OVERWRITE error message.
- **SLEW RUNDOWN.** Measures the distance travelled and time to stop in the slewing stage of a GOTO procedure. The figures can be used to check the parameters entered. Hence the performance can be refined resulting in closer first stage slews to the target.

## **ONE STAR CALIBRATION**

This procedure orients the handset with the night sky. It is the basic calibration or synchronising that must be performed. If the mount is polar aligned properly then doing this calibration will allow the telescope to follow the stars by only rotating the RA axis. Once calibrated it will then be possible to do all the other procedures such as GOTO and PARK. There are several ways to do it depending if you have the database option loaded. An illuminated cross-hair eyepiece may help you in deciding when it is in the centre of the field of view. Without one of these a high power eyepiece will have a small field of view and reduce the uncertainty in the positioning of the object.

### **TRUE LEVEL**

Orient the telescope into a position where the coordinate is known. On a GEM mount it is convenient to aim due East at the horizon. This will mean that parts of the equatorial head are at right angles or parallel to fixed parts of the mount and easy to judge. Setting the telescope horizontal is also easy – a spirit level could be used. The setting you have put the scope in has a coordinate of RA = LST + 6 hr and DEC = 0 degrees. Being familiar with the modes of display and how to alter them will give you the LST at the moment and so you can work out the coordinate. (Subtract 24 from RA if it is bigger than 23). Follow the OBJECT COORDINATE entry below.

### **KNOW THE SKY**

If you know your way around the sky and can align the telescope on a known object easily then it is a simple matter to enter the coordinates of your known object. Follow the OBJECT COORDINATE entry below.

### **OBJECT COORDINATE**

To calibrate, navigate to the SYNC CAL2 CAL3 menu and press SYNC (F1). Enter the coordinate for the RA hours using the numerical keypad then press 'h' (F1) to move onto the minutes entry. Two more digits and 'm' (F2) then press E for ENTER. If the RA is acceptable it will move on to the DEC entry where you press '0' and 'deg' (F1) and ENTER. The screen changes to the default and will show the coordinate.

### **WITH CALSTARS (DATABASE)**

You need to know which star you are pointing at. If you can find one of the stars in the CALSTARS catalogue – they are listed in this handbook – then it is easy to align.

To calibrate navigate to the COORD CAT LIST FLIP menu.

Press CAT (F2)

Press CATLG (F1) until the top line shows CAL STARS

Press OBJ (F2)

At the flashing cursor use the keypad to enter the cal star number eg '4' then 'E' for ENTER for object number 4 (Alpha CAS - Schedar). Complete details come up for this object and a new menu SYNC ADD NEXT STEP

Press SYNC (F1) and the calibration is done.

### **ALREADY CALIBRATED**

You have landed up at a point close to but not on your object. Move the motors until it is central then re-synchronise by inputting the coordinates – it will be in LIST if you have already done a GOTO to it – using the OBJECT COORDINATE or WITH CALSTARS procedures above.

Using the CAL STARS route you will find the menu line changes from 'GOTO ADD LIST STEP' before you have done the GOTO to 'SYNC ADD LIST STEP' afterwards, allowing you to nudge the scope with the telescope buttons then press SYNC.

Revised 14SEPT2016

## TWO STAR CALIBRATION

Having done a ONE STAR CALIBRATION this second calibration will allow you to find the pointing errors in your polar alignment – for equatorially mounted telescopes. Of course this is quite a tall order as the mount must also have two axes at right angles of the same order as the errors you are looking at for this to work properly. So this should be used as a guide to help in polar alignment but not the ultimate arbiter of correctness.

The theory is that you find and enter coordinates for two objects separated by about 60 degrees in RA (4 hours) and about 60 degrees in Declination with both objects in either the Eastern or the Western hemisphere only. The computation then gives you Maz (Azimuth error in the polar alignment) and Mel (Elevation error in the polar alignment). Then physically move the mount by the amounts indicated then the alignments should be spot on. It should follow properly in RA without any DEC drift.

There are a number of other small mechanical errors and optical alignment that can thwart this but to a first order it should work. The ultimate arbiter is a check on DEC drift over different parts of the sky. Drift alignment has two critical areas – DEC drift when the telescope is in the East around 20 degrees elevation and secondly when DEC drift when pointing due South. The drift when in the East is mostly elevation error. The drift in the South is mostly azimuth error. You should consult a reference work on how to do this correctly – AWR directs you to 'Norton's Star Atlas and Reference Handbook'.

If you are ready with your two stars then do the first calibration then do a GOTO to the second star, centre it and press CAL2. It will ask you for the coordinates which you enter the same way that CAL1 was done. Having done this up pops the answer. Both points are also in the LIST so when you move the mount a little bit to reduce the polar alignment error, the information is already entered for when you repeat it. Either star can be used as a starting point but it must be CAL1 (or SYNC) first, then CAL2 having centred the second star.

This should only be done once if you have a permanent installation. You will not want to do it again! If the residuals do not reduce then it is possible that something else is going on. Remember once the alignment is OK it is only necessary to do the SYNC and the tracking will then follow a star by turning the RA motor only.

Smaller mounts such as an EQ5 you may not want to do this at all, relying on the Polar Scope to align the pole properly. If the polar scope is set up correctly, the pole will be in a reasonable place (a few arc-minutes).

Revised 14SEPT2016

## FOCUS MODULE

## 1.736 IH2 FACTORY – SETUP – FOCUS SETUP – FOCUS

The Focus module is an extra item of hardware fitted in addition to a drivebox to provide extra hardware functions on the telescope. It drives an additional motor under command from the IH2. The IH2 drivebox cable plugs into the FOCUS box then a short cable plugs from here to the DRIVE box.

The module needs enabling in the IH2 and this is done through the environment setup procedure to select the various hardware configurations associated with the drive. See FACTORY – SETUP. 'Focus Module' option must be set to 'YES'

In operation, the FOCUS menu is selected from the normal operation – SETUP screen. The IH2 menu for the FOCUS screen is a live display of the focus value and the temperature at the two sensors as shown on the front panel of the drivebox. This information and screen is only available on IH2.

<b>INDEX = 1010</b>
<b>T1 -8.5 T2 -10.9</b>
<b>Focus</b>
<b>DN UP ZPROC ..</b>

The menu functions allowing manual winding the focus in or out and performing the calibration procedure. These are also available as manual functions on the front of the Drivebox Focus section and also on the small dome Hand Paddle

Winding the focus in or out continues as long as the button is pressed.

The calibration procedure winds the focus stage completely in to trip the limit switch and sets a count of zero. The focus motor stops at this point.

There are further controls available remotely through ACP communicating to the drivebox via the ASCOM link.

There are further setup registers to control the motor speed with various settings.

### RELATED PAGE:

- PROTOCOL EXTENSIONS

Revised 15MAR2016

## SETUP ENVIRONMENT

## 1.736 IH2 FACTORY – SETUP

The IH2 has an environment setup procedure to select the various configurations associated with the drive. This menu runs through all the various hardware and configure options required to match the IH2 with the Intelligent Drive System. Select an option by selecting 'UP', otherwise 'DN'.

Ext Encoders - NO		
SYSTEM Configuration		
DN	UP	NEXT

Version V1.736 introduces these options so that there is only one version of download covering all the different arrangements of IH2 systems. Not all are present initially. All the options available are listed. Some are explained on further sheets (noted '^').

**MOST IMPORTANT:** After selecting the option list it is necessary to power down and power up again as some options do different initialising procedures only at startup.

- **OBSERVING MENU.** [not present before 1.740] A shortform set of menus in the normal operation to reduce number of button presses. It allows inexperienced observers to use the system effectively once it has been set up. The menus are:
  - GUIDE CNTRE MOVE SLEW (with the normal default screen)
  - INFO DECDR LGHT HOME
  - GPS FOCUS (if allowed)

By default it will show RA/DEC and LST and will move at KING. Cal flags will be shown as at present. Sub menus will be the same.

- **^ EXTERNAL ENCODERS.** Normally the internal virtual encoders are used. This is an open loop control system. However if external encoders are fitted it becomes a closed loop control system and all operations (including de-clutching) are catered for and it remains calibrated as long as it is powered. The required QUAD DECODER BOX must also be fitted. Selecting External Encoders produces another factory menu setup for the encoder ratio (ERATIO) and encoder direction (EDIR) for both axes.
- **HIGH SPEED SLEWS** on small motors. Operating at high voltage the motors can go at an equivalent over 65535 counts. It must be selected only if the Microstep Drivebox code is HS version fitted. It allows an extra 4x dynamic range in the setting of the slew speed.
- **^ FOCUS BOX** hardware box inserted between IH2 and Drivebox. There are extra functions to control a stepper motor fitted to the focus for

driving in and out and a zero calibrate procedure. It will only perform if the extra hardware box is purchased.

- **TRACK AT START** This allows you to control the behaviour at power up. Larger scopes may want to be in halt mode until the user is ready to go otherwise the telescope will track at power up. It is useful if you operate remotely and want to stop power cuts upsetting it.
- **^ DOUBLE ENCODER COUNTS** By counting both edges of the incoming pulse train the encoder resolution is much finer by a factor of two. This works with all pulse trains whether coming from virtual encoders or external encoders. If you already have a fine resolution (5 arc seconds or smaller) then you probably do not need to select this option, but it offers real improvements for mounts fitted with external encoders. If the value for **RATIO** or **ERATIO** is under 150,000 then you will benefit.
- **^ MULTIPLE TELESCOPES [not present before 1.740]** A paid for option that stores parameters for up to three telescopes configurations. If you select this feature it will say **FEATURE LOCKED** and take you to an **UNLOCK SCREEN** where you enter the unique code that AWR will provide. This has only to be done once but you will need to go through the **FACTORY – SETUP** again to enter **YES** for this option and this time it will say yes. Each telescope setup will have different drivebox setup parameters (for **RATIO** and **DIR**) and will be identified by a unique tag for each telescope.
- **DUAL MOTORS** Some older mount configurations got round the slewing problem by using dual motors per axis with various arrangements for clutches and brakes. This is catered for with this option as extra menu setup parameters appears at the correct points, so the second motor can be characterised. There will also be a custom nature to the drivebox and this has been catered for by further hardware developments in use at several installations. This can cope with tangent arm drive, limits switches, clutches for motor selection and brake.
- **EQ on ALTAZ [not present before 1.740]** Alt-Az mounts can be driven to follow the stars using this option, which drives both motors together. This is a whole different approach and not one to be recommended normally. It is ok for a large radio telescope where the dish is huge and an Alt-Az mount is the only mounting method available. The main drawback is field rotation so it has drawbacks for optical telescopes. Field de-rotators are available but may cost as much as your scope.
- **BARS BOX [not present before 1.740]** Display unit for Push-To systems. Ideal for Heritage telescopes with a large dome. The bars illuminate as a distance to go when doing a GOTO. When the bar goes out it is on target.

It is not possible to operate an option if the associated hardware alteration is not present! Contact AWR if you would like to explore the possibilities.



## MULTIPLE TELESCOPES OPTION

**1.736 IH2**

The Multiple Telescope feature when enabled through the FACTORY – SETUP procedure allows storage of three telescope configurations so you do not have to enter all the configuration values each time the mount is changed.

You will find a FACTORY – SCOPE setting where it will invite you to save the current configuration for telescope number 1, 2 or 3. You will be able to send a name for this telescope from the computer by using the protocol entry:

**:TLaFS MK IV#**

where **a** is 1 or 2 or 3 and the name field is FS MK IV in this example.

This can be done whenever the Multiple Telescope Option is enabled. The text string is not overwritten by saving the configuration. The maximum number of chars in the Telescope String is 20 printable characters taking up the whole of line 2.

At power up after the Copyright screen is shown it will give you a message.

<p>Using telescope FS MK IV</p> <p>ACCEPT                      NEXT</p>
---

The default action is ACCEPT and will action 2 seconds after the screen is displayed. On pressing NEXT the next telescope will be displayed etc. The configuration for the selected telescope will be used.

If the configuration is changed it is up to you to remember to resave in the FACTORY – SCOPE menu over the top of the correct telescope. The unique configuration for a mount includes all the variables listed on the CALIBRATION page of this manual and the FACTORY – SETUP configuration.

Revised 02APR2016

## **DOUBLE ENCODER COUNTS OPTION      1.737    IH2**

When this has been selected the encoder signal is counted in the IH2 on the rising and the falling edge of the signal. You will need to change various setup values so the motors will still track at the right rate and the coordinate display matches the sky.

### **NO EXTERNAL ENCODERS**

The value for RATIO should be doubled. The value for MSTEP should be halved. So read the values present in these two fields. (FACTORY – USTEP – RA – RATIO and FACTORY – USTEP – RA – MSTEP). Do both axes.

### **WITH EXTERNAL ENCODERS**

The value for ERATIO should be doubled. There are no other changes.

The value for RATIO or ERATIO is the number of clicks in a full circle, so you can work out the resolution. There are 360x3600 clicks in a circle (=1296000) and MSTEPS is the number of microsteps per click, allowing you to work out the stepping rate.

There will be a limit to the ability of the processor to keep a correct count at high step rates, but this must be around 10,000 counts per second, so not likely for telescopes, even if push-to is used.

Revised 19NOV2016

## FACTORY MENUS

The Factory Menus need some explanation. They are all to do with controlling how the system works, options to work with different hardware and how it interacts with the User.

The FACTORY first line menus are self explanatory. COMMS mode is to the Host computer, STATUS is the same as INFO. USTEP has all the telescope parameters to configure for your mounting, DEF returns all parameters to a working set, TEST are handset tests and SETUP is for overall system configuration (SETUP ENVIRONMENT). AWR used to compile different versions of firmware depending on the hardware attached, but now in the IH2 it is selectable. There are many options that are not applicable to your setup.

Start out with DOUBLE ENCODER set to NO

The USTEP – RATIO is the number of encoder clicks for a full circle and is calculated from all the gear ratios and the motor steps per revolution.

The USTEP – MSTEP is the number of microsteps per encoder click.

The other USTEP – xxxx menu function setup the envelope to which the telescope movements will be bounded – MAXHA and MAXDEC.

It is recommended the drive system is configured by modifying the default settings by firstly changing values for RATIO and SLEW only. TRY IT to make sure it follows a star. The Factory Construction sheet will have values for other settings which are important here, such as XTAL which is the crystal frequency fitted in the drivebox. It is normally 4.9152 MHz but some systems (usually FRGEN types) have 20.000 MHz fitted.

When all is well, select DOUBLE ENCODER if necessary and adjust the values in RATIO and MSTEP for both axes. Try it again to make sure it still follows a star.

Finally write down the values you end up with for all the user settings. To prompt you there is a blank page at the end of this manual.

### RELATED PAGE:

- MICROSTEP DRIVEBOX
- FRGEN DRIVEBOX
- DOUBLE ENCODER COUNTS OPTION
- CALIBRATIONS
- SETUP ENVIRONMENT

Revised 30MAR2018

## CALIBRATIONS

### FACTORY – USTEP

#### FACTORY MENU ADJUSTMENTS

The RA and DEC tracking rates and performance are controlled in the FACTORY settings menu where the characteristics of the telescope are input in various screens. AWR supply a system with these preset where possible but the User can adjust these to vary the tailor the performance (such as slew and ramp rates).

The important parameters are:

USTEP – XFREQ	Drivebox crystal frequency
USTEP – MREV	Meridian Reversal allowed (YES or NO)
USTEP – MAXHA	Maximum Hour Angle for telescope envelope.
*USTEP – MAXOR	Maximum Hour Angle Overrun past meridian.
USTEP – MAXDEC	Maximum Declination for telescope envelope.
USTEP – RA – RATIO	Motor full steps for 1 telescope revolution
USTEP – RA – SLEW	SLEW rate for TRACKING motor
USTEP – RA – RAMP	Ramp time to slew of tracking motor
USTEP – RA – DIR	RA tracking motor direction sense
USTEP – RA – MSTEPS	Microsteps per full step
USTEP – RA – BLSH	Arc seconds of backlash in the RA
USTEP – RA – ERATIO	External encoder ratio
USTEP – RA – EDIR	External encoder direction sense

And a similar set for DEC

- = extensions available for IH2 only

These parameters are tied in with the hardware and as such they are worked out at design time for the drive system. The numbers are given in a 'FACTORY CONSTRUCTION SHEET' and should be kept safe. AWR maintain a full record of all drive systems supplied if the data becomes mislaid.

#### NORMAL MENU ADJUSTMENTS

The NORMAL MENU screens contain the following adjustable entries:

SETUP – HORIZ	Minimum altitude for telescope envelope
SETUP – DECDIR	Dec motor sense. UP to drive telescope to POLE

GUIDE, CENTRE and MOVE speeds are also adjustable through the RATES menu.

Revised 26OCT2016

## MERIDIAN REVERSAL

**FACTORY – USTEP – MREV  
GOTO screen – FLIP**

### TELESCOPE TYPES

The mounting of a telescope has a bearing on its use and setup. A German Equatorial Mounting (GEM) type needs to be flipped somewhere around the central meridian. A Fork Mount is generally ok and does not need to be flipped, or may be impossible to flip as it will not pass through the forks. If the telescope is flipped, it has gone over the pole and the DEC direction buttons would work backwards but the IH is organised so that the DEC SENSE is changed after going over the pole. So the UP keys always move the telescope UP to your local pole. The IH automatically introduces a flip (if enabled) on GOTOs if the target object is in the other hemisphere (east or west), else you can perform one manually.

The MREV and MAXDEC functions are provided to characterise the telescope mount for these instances. Both functions are in the FACTORY – USTEP menu screen. The MREV function must be changed to YES if the automatic flip function is required.

In use, the Central Meridian crossing is flagged (beep + MERIDIAN CROSSED) and you can do a manual flip when it is convenient. The button for this is in the GOTO screen which appears after the scope has CAL1 done. It is possible to do it ½ an hour before the Central Meridian, or any time after it. The IH2 window is wider (see below). The only time an automatic flip is used is when a GOTO is commanded. In this instance it works out the shortest route (direct or over the pole) and drives accordingly.

**MAXDEC** entry is the maximum declination that the tube is to work through. If the tube must not swing through the forks then set this value below 90 degrees. In this case a FLIP cannot be performed and a GOTO will always take the long way round without a flip.

In the IH2 there is a new function called **MAXOR** which is the allowable hour angle overrun after crossing the central meridian before it must be flipped. It is assumed to be symmetrical and allows a lot more freedom for flipping – manual flip can be performed anywhere within the MAXOR setting, before or after the Central Meridian. This introduces another limitation on the telescope movement envelope. The telescope will stop moving if it reaches this limit and so avoid damage by the telescope running into the mount.

There is no command in the serial HOST protocol to perform a manual flip, but an automatic flip is performed on a GOTO to the other hemisphere if the flags and settings allow it.

## **EXTERNAL ENCODERS OPTION**

The IH2 has an environment setup procedure to select the various hardware configurations associated with the drive. See FACTORY – SETUP. 'External Encoders' option must be set to 'YES'

The accuracy of the system is primarily based on the encoder information reaching the Intelligent Handset. Each axis generates pulse and direction information which is counted to keep track of the position. There is a display of the raw pulse and direction signals on the front panel of the DRIVE section of the drivebox.

Setup information required is the counts per revolution of the main telescope axis and direction sense. These are available through the FACTORY – USTEP – RA – ERATIO and EDIR menus, similar for DEC.

Calibration is checked and adjusted by making sure the coordinates keep track of where the telescope is pointing. On doing CAL1 or SYNC the coordinate counter is zeroed. On moving the telescope to a second known object it will display the correct coordinates if the ERATIO value is correct. If it is slightly out, adjust the ERATIO value and on going back to the main default screen, the coordinate will have changed. If they are now correct, ERATIO is correct. If this is done over two points at least 60 degrees apart, this adjustment / check will be reasonably accurate.

So do this procedure for the DEC axis then the RA axis. By swapping over the inputs at the Quad Decoder box it is possible to get the correct ERATIO in the DEC axis section for both the RA and the DEC components. Then the display is not affected by time and is easier to get right.

Note this procedure can be done with the telescope de-clutched and freely moving on both axes. All that is needed is the Quad decoder box and Intelligent Handset to be powered for this calibration to be done.

There is a display of the encoder count for RA/DEC in the direction sense setup screens. This is in MAIN and FACTORY menu screens for both INH and IH2. It is most convenient to view at SETUP – DECDIR. The value is shown as signed HEX 32 bit number.

Revised 12JUNE2016

## PROTOCOL EXTENSIONS – SUMMARY

The Microstep Protocol between the Intelligent Handset and the Focus and Microstep boards is enhanced with the following additions. Note, the pipeline command allows all of these to be sent from the computer

### COMMANDS SENT TO FOCUS BOARD

COMMAND	ACTION	DETAILS	REPLY
<b>FG</b>	<b>Get focus</b>	Return focus position.	<b>Fgsdddd</b>
<b>Fha</b>	<b>Get tempr</b>	Return temperature, sensor 'a'	<b>fhasdddd</b>
<b>FE</b>	<b>Get status</b>	Return error and status	<b>fex</b>
<b>FMdddd</b>	<b>Move focus</b>	In (-ve) or out by xxxx steps	<b>Y</b>
<b>FZ</b>	<b>Focus ZCAL</b>	Initiate Zero procedure	<b>Y</b>
<b>FDb</b>	<b>Debug</b>	1 = on	<b>Y</b>
<b>F&lt;??</b>		Return motor setup registers	
<b>F&lt;zz?</b>		Return motor setup register zz	
<b>F&lt;zzxxxx</b>		Programme motor register zz with HEX value xxxx	

Where: s = sign  
 dddd = decimal number  
 xxxx = hexadecimal number  
 a = temperature sensor number (1 or 2)  
 b = 0 or 1 representing OFF or ON  
 zz = hexadecimal number for motor register set

### GPS MODULE

COMMAND	ACTION	DETAILS	REPLY
<b>\$-</b>	<b>GPS OFF</b>	Puts GPS module in RESET	<b>Y</b>
<b>\$+</b>	<b>GPS RUN</b>	Allows GPS module to run from RESET	<b>7 NMEA strings once per second</b>

### EXTENSION COMMANDS

COMMAND	ACTION	DETAILS	REPLY
<b>TLa&lt;string&gt;</b>	<b>Set Scopename</b>	Name for scope 'a' (No more than 20 chars). 'a' is 1,2,3	<b>Y</b>

Revised 15MAR2016

## INTERROGATION FROM THE HOST

There is a terminal type programme specifically written by our company which we use all the time in development of our products (WINDISP). It is available to you and gives a firm method of detecting any character flow between the host computer (PC) and the Intelligent Handset and the Drivebox. All characters received are printed out, including non-printing characters.

From the Downloads section of the AWR web site download the WINDISP installer programme and the WDC Windisp configuration files. Run the installer to put Windisp in your system.

Double click on the WDC file for the Intelligent Handset and Windisp will open. Select the COM port and press CONNECT. When connected the IH will beep (HOST CONNECT). Then in the TRANSMIT window you can type in a command and see the reply in the RECEIVE window.

Type **:GR#** and back comes the RA coordinate.

**:GVN#** is Get Version Number of the IH code.

The rest of the commands can be found in the Serial Protocol Appendix.

Similarly the Microstep drivebox can be commanded by using the pipe command (**^**). See the Microstep Protocol for a list of these commands. So if you type in **:^FF?#** you get the version number of the code in the Drivebox returned and displayed.

This method of interrogation can be extended to write your own application if you want, or just to test out the various interfaces to make sure they are working.

In the IH, setting the FACTORY – COMMS mode to DEBUG will send a lot of information continually to Windisp. This will include all transactions to and from the Microstep box made by the IH showing in the RECEIVE screen of Windisp.

Revised 11JAN2016



## GPS MODULE

## 1.733 IH2 SETUP – GPS

This option has a hardware element so must be factory fitted. The application configures itself for the new hardware and offers a new menu option and operation procedures.

In the SETUP menu there are extra options on a second screen. Selecting **GPS** gives a live display of data gathered from the NMEA strings transmitted by the GPS module.

```
0 Satellites
UT 00/00/00 10:25:42
Gps info
TIME  POS  ECHO
```

The display updates at each set of NMEA strings (once per second). From power up it takes several minutes to find satellites. The correct time to 5ms is available only when the date field is filled in. The number of satellites varies and at least three are required to provide accurate coordinates.

- **TIME:** Sets the onboard RTC to the satellite time at the next update from the module. So it is accurate to around 5ms.
- **POS:** Takes you to a second screen where the latitude and longitude is displayed. The options are to set one of the four observing site coordinates (A, B, C, D) to the data shown. It is then stored in non-volatile memory and used immediately as the observing site.
- **ECHO:** Toggles a flag (puts the word ECHO top right) and copies the NMEA strings to the HOST serial port when ECHO is ON.

For operation within the IH2 a reduced set of two NMEA strings are needed: GPRMC and GPGGA. This is set up at IH2 power up.

There are seven NMEA strings available and can be accessed by the following procedure:

- From the HOST computer send **:\$-#** then **:\$+#**

This performs a reset procedure on the module and is typically done using 'windisp.exe' and a config file with macro functions set up for the purpose. The ECHO function will then send all seven strings once per second.

In use it is recommended to display the GPS time and set the onboard clock at the start of the observing session. The position update will only be required if the observing site changes.

Occasionally there is a GPS string CRC error and this is indicated to the user with a warning message **GPS NMEA CRC**. There is no action, it is self recovering, but is usually at the start of good data. This warning appears whatever menu screen the Intelligent Handset is currently displaying.

If the time data is used too early it is inaccurate and a second warning **DATA INVALID** is issued and the data is not used. If the position data is all zeroes then it is likely the data is not ready yet, go back to the GPS screen and wait for the satellites.

The module may not work indoors and is best suited to remote observing sites. Metal domes may also be problematical although an open shutter may give enough signal to work. At least three satellites are required to get an accurate time and position fix.

The GPS module is a Quectel L80-M39. A datasheet is available to decode the protocol.

Release version 1.733 ties into the American GPS network.

Revised 03JAN2016

## **PARKING PROCEDURE**

### **v1.730** **SETUP – SETPARK** **USER – HOME**

There are two parts to getting this working.

Once the telescope is calibrated in the sky (SYNC or CAL1) then a position can be selected for the parking position. Move the telescope by the motors to this position and press SETPARK. The ALT-AZ coordinate is stored permanently. It is recommended that this position is at least 1 hour from the central meridian and not higher than 80 degrees declination.

In use when you are ready to park it press HOME.

The telescope does a GOTO to the position indicated. The IH display shows the instantaneous ALT and AZ coordinates as it goes. When the GOTO finishes it gives a double beep and stops both motors. You can stop it at any time by aborting the GOTO – press any of the four telescope buttons. You still get the OFF / UNPARK screen and it will still stay calibrated if you press OFF.

A new screen is presented, offering UNPARK and SHUTDOWN (OFF) options.

- UNPARK starts up the tracking and the default screen is shown.
- SHUTDOWN (OFF) turns off the display and a power cycle is required to start it up again. It is safe to turn off the whole system power. It will remain calibrated.

### **Before V1.730** **USER – SHTDN**

Earlier versions of software provided a means of keeping calibration whilst the power is turned off by using the SHTDN option. Drive the scope to the park position by operating the motors then operate the SHTDN button. The display will go out and the motors stop, then turn the power off. At the next observing session it will still be calibrated at power up.

Revised 12JUNE2016

## **INFO, STATUS and REBOOT**

This useful screen provides the version numbers of the software fitted in the IH, the Drivebox and the Database. The top line presents the last error message with a button to CLEAR it.

<b>Meridian Crossed</b>	
<b>IH v1.733H</b>	<b>US v0079</b>
<b>Status</b>	<b>D01 B</b>
<b>CLEAR</b>	<b>REBOOT</b>

It is available from the main operating menu and also the Factory menu. If calibrated, the IH will stay calibrated during a reboot.

It also shows you the version numbers of the fitted software and if there are any special versions of Handset software being used. Here the IH version is 1.733 with 'H' option fitted, the Drivebox (FRGEN or Microstep) is version 0.79 and the Database is version 01 revision B

REBOOT is useful as it allows you to press various buttons to get into the backdoor modes.

REBOOT starts up the IH and starts up the Drivebox from afresh. This is the same as Power Up where it programmes all the registers in the drivebox.

Press key 'M' + REBOOT to get into the FACTORY menu

Press keys '1+2' + REBOOT to get into the Bootloader programme for the IH2. This allows reprogramming the application software via a PC computer. There are separate instructions for this process.

Press key '3' + REBOOT to get to a Drivebox test screen for communication performance.

Revised 12JUNE2016

## DATABASE INSTALLATION

**v1.6 IH**

This is done by the user for both models of IH. It is a paid option offering major benefits with it running.

The IH upgrade involves fitting a database chip internally in a socket. The programmed chip comes from AWR. There is only one place for it to go and the white spot must be top right. Do not use menu option FACTORY – TEST – FLASH as it will erase it.

The extra menu options appear when it is fitted correctly.

**v1.733 IH2**

The IH2 DATABASE upgrade is done solely through the HOST serial port. All IH2 units can accept it, but you will need to get an UNLOCK CODE by contacting AWR. The recommended method for installing the database is to use '**Windisp**' programme and either '**win\_ih\_db.cfg**' for version IH or '**win\_ih2.wdc**' for version IH2.

To prepare, put the IH2 into the GOTO menu screen which does not have any updating going on. The first line is used to report information on how the transfer is going.

To invoke the unlock procedure send the HEADER FILE. This is in the Windisp main screen where you right click the mouse for the macros. You will see the column for the database files to send. Click on the line to send it. If it is locked it goes to a new menu screen where it asks for the unlock code. Enter the code and it will accept or reject it. When accepted, send the HEADER FILE again, then all the remaining files in turn by clicking on them. Make sure the Intelligent Handset is accepting the information (it counts up the objects) and it says FILE LOADED at the end of each section. Only send one file at a time and wait for all the object information to go across, the handset counts up to the number of records (= number of objects) transferred.

If it gives an error message '**FLASH\_OVERWRITE**' then you have to erase the flash in FACTORY – TEST – FLASH.

Revised 19NOV2016

## ERRORS and WARNINGS

A persistent error could indicate a failure of the handset or the drivebox. Seek advice from AWR. Things like 'Object below horizon' rely on correct orientation of the handset with the sky and there are various setup errors that can put the local meridian in a different place to actual. It is important to remember what you did to produce the error and is it repeatable. See the related pages to troubleshoot.

"UNKNOWN ERROR",	
"RTC I2C FAIL",	Startup - RTM
"EEPROM I2C FAIL",	Startup - RTM
"EEPROM TIMEOUT",	
"EEPROM FAIL",	
"FLASH FAIL",	
"FLASH TIMEOUT",	
"FLASH OVERWRITE",	Use FACTORY – TEST – FLASH to wipe the contents.
"FLASH ADDRESS",	
"DISPLAY INIT",	
"DISPLAY TIMEOUT",	
"DR CONNECT",	ADVISORY
"DR DISCONNECT",	ADVISORY
"HOST CONNECT",	ADVISORY
"HOST DISCONNECT",	ADVISORY
"USTEP TIMEOUT",	
"USTEP COMMS ERR",	
"EVENTS STORE FULL",	ADVISORY
"HOST BUFF O/FLOW",	
"DR BUFF O/FLOW",	
"OVERRIDE ACTIVE",	ADVISORY
"OVERRIDE RELEASED",	ADVISORY
"GOTO ABORTED",	ADVISORY
"MERIDIAN CROSSED",	ADVISORY
"VALUE CLIPPED",	Register destined for the drivebox – the number is too big
"DATA INVALID",	
"BELOW HORIZON",	ADVISORY
"SCOPE STILL MOVING",	ADVISORY
"NOT CALIBRATED",	ADVISORY
"INVALID OPERATION",	ADVISORY
"GPS BUFFER OVERFLOW",	
"GPS NMEA",	ADVISORY
"PERIMETER EXCEEDED",	ADVISORY
"UPDATE USTEP F/W",	ADVISORY
"DR UNKNOWN ERR",	
"USTEP WATCHDOG T/O",	Thrown error from drivebox.
"USTEP EE CRC ERR",	Do.
"USTEP EVENT BUFF O/F",	Do.
"USTEP EE VERIFY ERR",	Do.
"USTEP EE OTHER ERR",	Do.
"USTEP MCLR RESET",	Do.
"USTEP BROWNOUT RESET",	Do.
"USTEP DIVIDE BY ZERO",	Do.
"USTEP DIVIDE O/F",	Do.
"USTEP SERIAL O/R",	Do.
"USTEP SERIAL RX ERR",	Do.

"USTEP PROTOCOL ERR",	Do.
"DBASE ERROR",	
"FEATURE LOCKED",	ADVISORY
"CODE REJECTED",	ADVISORY for locked functions
"CODE OK",	ADVISORY for locked functions

**RELATED PAGE:**

- ORIENTATION
- DRIVEBOX TESTS
- ABNORMAL BEHAVIOUR
- INTELLIGENT HANDSET SELF-TEST

Revised 30MAR2018

## CALIBRATION STARS

This list is of the 84 stars selected for brightness and position to cover the whole sky. Northern hemisphere observing sites should use this marked 'N' (star Declination above +20 degrees) and southern observers 'S' (star Declination below -20 degrees). Unmarked stars are suitable for both hemispheres. This list is downloadable from the AWR website if you wish to format / edit and laminate. The star number in the first column is the object number you would select in the database part of the IH menus.

0001	15	21Alp	And	And000823.3+290526	2.06	N
0002	21	11Bet	Cas	Cas000910.7+590859	2.27	N
0003	98	Bet	Hya	Hya002545.1-771515	2.8	S
0004	168	18Alp	Cas	Cas004030.5+563214	2.23	N
0005	188	16Bet	Cet	Cet004335.4-175912	2.04	
0006	337	43Bet	And	And010943.9+353714	2.06	N
0007	424	1Alp	UMi	UMi023148.7+891551	2.02	N
0008	472	Alp	Eri	Eri013742.9-571412	.46	S
0009	603	57Gam	And	And020354.0+421947	2.26	N
0010	617	13Alp	Ari	Ari020710.4+232745	2	N
0011	936	26Bet	Per	Per030810.1+405720	2.12	N
0012	1017	33Alp	Per	Per032419.4+495140	1.79	N
0013	1208	Gam	Hya	Hya034714.3-741420	3.24	S
0014	1457	87Alp	Tau	Tau043555.2+163033	.85	
0015	1708	13Alp	Aur	Aur051641.4+455953	.08	N
0016	1713	19Bet	Ori	Ori051432.3-081206	.12	
0017	1790	24Gam	Ori	Ori052507.9+062059	1.64	
0018	1791	12Bet	Tau	Tau052617.5+283627	1.65	N
0019	1852	34Del	Ori	Ori053200.4-001757	2.23	
0020	1903	46Eps	Ori	Ori053612.8-011207	1.7	
0021	1948	50Zet	Ori	Ori054045.5-015634	2.05	
0022	2004	53Kap	Ori	Ori054745.4-094011	2.06	
0023	2061	58Alp	Ori	Ori055510.3+072425	.5	
0024	2088	34Bet	Aur	Aur055931.7+445651	1.9	N
0025	2294	2Bet	CMa	CMa062242.0-175721	1.98	
0026	2326	Alp	Car	Car062357.1-524145	.72	S
0027	2421	24Gam	Gem	Gem063742.7+162357	1.93	
0028	2491	9Alp	CMa	CMa064508.9-164258	1.46	
0029	2618	21Eps	CMa	CMa065837.5-285820	1.5	S
0030	2693	25Del	CMa	CMa070823.5-262336	1.84	S
0031	2891	66Alp	Gem	Gem073436.0+315318	1.98	N
0032	2943	10Alp	CMi	CMi073918.1+051330	.38	
0033	2990	78Bet	Gem	Gem074518.9+280134	1.14	N
0034	3165	Zet	Pup	Pup080335.1-400012	2.25	S
0035	3207	Gam2Vel	Vel	Vel080932.0-472012	1.78	S
0036	3307	Eps	Car	Car082230.8-593035	1.86	S
0037	3485	Del	Vel	Vel084442.2-544230	1.96	S
0038	3634	Lam	Vel	Vel090759.8-432557	2.21	S
0039	3685	Bet	Car	Car091312.0-694302	1.68	S
0040	3699	Iot	Car	Car091705.4-591631	2.25	S
0041	3748	30Alp	Hya	Hya092735.2-083931	1.98	
0042	3982	32Alp	Leo	Leo100822.3+115802	1.35	
0043	4301	50Alp	UMa	UMa110343.7+614503	1.79	N
0044	4534	94Bet	Leo	Leo114903.6+143419	2.14	
0045	4730	Alp1Cru	Cru	Cru122635.9-630557	1.33	S
0046	4731	Alp2Cru	Cru	Cru122636.5-630558	1.73	S
0047	4763	Gam	Cru	Cru123109.9-570648	1.63	S
0048	4819	Gam	Cen	Cen124131.0-485735	2.17	S



0049	4853	Bet	Cru	Cru124743.2-594119	1.25	<b>S</b>
0050	4905	77Eps	UMa	UMa125401.7+555735	1.77	<b>N</b>
0051	5054	79Zet	UMa	UMa132355.5+545531	2.27	<b>N</b>
0052	5056	67Alp	Vir	Vir132511.6-110941	.98	
0053	5132	Eps	Cen	Cen133953.2-532759	2.3	<b>S</b>
0054	5191	85Eta	UMa	UMa134732.4+491848	1.86	<b>N</b>
0055	5267	Bet	Cen	Cen140349.4-602223	.61	<b>S</b>
0056	5288	5The	Cen	Cen140641.0-362212	2.06	
0057	5340	16Alp	Boo	Boo141539.7+191057	.04	
0058	5440	Eta	Cen	Cen143530.4-420928	2.31	<b>S</b>
0059	5459	Alp1Cen	Cen	Cen143935.9-605007	.01	<b>S</b>
0060	5460	Alp2Cen	Cen	Cen143936.1-605008	1.33	<b>S</b>
0061	5469	Alp	Lup	Lup144155.8-472318	2.3	<b>S</b>
0062	5563	7Bet	UMi	UMi145042.3+740920	2.08	<b>N</b>
0063	5793	5Alp	CrB	CrB153441.3+264253	2.23	<b>N</b>
0064	5953	7Del	Sco	Sco160020.0-223718	2.32	<b>S</b>
0065	6134	21Alp	Sco	Sco162924.4-262555	.96	
0066	6217	Alp	TrA	TrA164839.9-690140	1.92	<b>S</b>
0067	6241	26Eps	Sco	Sco165009.8-341736	2.29	<b>S</b>
0068	6527	35Lam	Sco	Sco173336.5-370614	1.63	<b>S</b>
0069	6553	The	Sco	Sco173719.2-425952	1.87	<b>S</b>
0070	6556	55Alp	Oph	Oph173456.1+123336	2.08	
0071	6705	33Gam	Dra	Dra175636.4+512920	2.23	<b>N</b>
0072	6879	20Eps	Sgr	Sgr182410.3-342305	1.85	<b>S</b>
0073	7001	3Alp	Lyr	Lyr183656.3+384701	.03	<b>N</b>
0074	7121	34Sig	Sgr	Sgr185515.9-261748	2.02	
0075	7557	53Alp	Aql	Aql195047.0+085206	.77	
0076	7790	Alp	Pav	Pav202538.9-564406	1.94	<b>S</b>
0077	7796	37Gam	Cyg	Cyg202213.7+401524	2.2	<b>N</b>
0078	7924	50Alp	Cyg	Cyg204125.9+451649	1.25	<b>N</b>
0079	8162	5Alp	Cep	Cep211834.8+623508	2.44	<b>N</b>
0080	8414	34Alp	Aqr	Aqr220547.0-001911	2.96	
0081	8425	Alp	Gru	Gru220814.0-465740	1.74	<b>S</b>
0082	8636	Bet	Gru	Gru224240.1-465305	2.1	<b>S</b>
0083	8728	24Alp	PsA	PsA225739.1-293720	1.16	<b>S</b>
0084	8781	54Alp	Peg	Peg230445.7+151219	2.49	

Revised 14SEPT2016

## **AUTOGUIDING**

Autoguiding is performed with an additional camera mounted on or looking through the telescope. There are some models that are stand-alone and they have an autoguider lead to plug in to an SBIG style 6 pin RJ12 connector on the mount. Others require a computer to take the images and output correction signals for the telescope – this can be through serial to control via the Intelligent Handset or by a Remote Relay box adapter (GPUSB) to control via the Drivebox.

The direct connection to the Drivebox connector labelled 'CCD' has the least processing elements in the way and offers the most direct and predictable control of the motors. This connector complies with the SBIG 6pin RJ12 standard protocol. It has 4 direction wires with active low signals required and a common 0V wire. The ADVANCED Microstep Drivebox has an opto-isolator interface when using the direct method, so there is no electrical connection between the Autoguider and the drive system.

Sending the signals through the serial protocol from the computer to the Intelligent Handset includes extra delays due to the transmission of the signals, reception and then re-transmission to the Drivebox.

Autoguiding is far superior to periodic error correction, which has to be trained and drive errors are assumed periodic. If you can afford the camera and can mount it and the telescope with the optical axes rigidly fixed together then the solution can give you sub-arcsecond drive corrections.

### **RELATED PAGE:**

- ASCOM Compatibility.

Revised 04MAR2016

## **USER LIST**

**V1.5**

This is a list of places that the telescope has been when the GOTO function has been used. All coordinates entered or objects selected through the onboard catalogues add into this list. It has a depth of 32 objects only and throws away the oldest but only keeps unique objects.

Its use is invaluable as the information can be recalled when performing GOTO's or calibrations. A key option appears – PREV – when you can fill in the coordinates, keep pressing PREV to circulate through the whole list and press E when it is the one you want.

A further menu option – LIST – allows maintenance of this list whereby it can be cleared. A Locked list cannot be added to or cleared until unlocked.

Revised 03JAN2016

## **ASCOM COMPATIBILITY**

## **V1.700**

A third party ASCOM driver is available for the PC. It adds an interface to many types of programme to create a very powerful system. It is possible to get full remote control operation. In operation it is transparent, like a printer driver, and it is a channel through which a Planetarium or other programme will take to the Intelligent Handset. However there is a setup screen for specific extras to further control the complete drive system.

It is advised to change the firmware to the latest available to ensure the most trouble-free operation with the ASCOM driver. Also if you have a working set that you are happy with then do not change it! Odd advice but Tigris only support windows CURRENT and the two previous versions. As of Windows 10 supported, there is no support for XP version and the latest driver will not install on Windows XP.

This is the preferred way to link in with a planetarium programme. It is advised to set COMMS mode to AWR to take full advantage of the extended protocol that we offer.

You will need to establish a serial link with the Intelligent Handset (IH and IH2). There is a special cable RJ12 6 pin to 9 way D that is needed to get compatibility with the RS232 hardware interface (IH-PC cable). You may also need a USB-SERIAL converter and the recommended one has the FTDI chipset. Both of these items are available from AWR. Up to date computers do not have a serial interface connector.

In use, it is required that commands do not flow too quickly over the serial interface. With older handsets change the PC settings to no more than 4 transactions per second. The original protocol was also specified as being half duplex, that is a command is sent to the mount, a reply comes back, then the next command is sent.

The ASCOM driver specifically for AWR adds a level of functionality not present.

- There is a hardware method of stopping the scope from moving at power up. A Safety Interlock, with an additional dongle but it needs the ADVANCED version drivebox.
- Pulse guiding is implemented.
- Satellite tracking made simple.
- Pre-Park Slew to get better accuracy for this function. Important if you have a large scope and you need to park it in a restricted space.

It is recommended to use this programme for completely remote working. There are several users who operate their telescope from the next county.

Revised 30MAR2018

## **IH and MICROSTEP FIRMWARE UPGRADES** **IH**

The Intelligent Handset and the Microstep box have firmware upgrades by CHIP EXCHANGE. The chips are in the most reprogrammable so we can re-use devices replaced.

### **INTELLIGENT HANDSET**

This applies to the Grey box models used on the first design Intelligent Handset only.

Programme memory is contained in a 28 pin device (IC9) which is in a socket. The object database is contained in a 32 pin device (IC17) which is in a socket. Both of these devices are within the Intelligent Handset. Read all the instructions below. If you do not feel able to do this then contact AWR for advice.

To gain access:

- 1) Remove power and undo the eight screws on the rear of the handset.
- 2) Separate the case halves noting there is a connector between the keyboard and the main pcb.
- 3) Note the orientation of both of these IC's is the same. Pin 1 is to the right, with a notch on that end of the IC or the socket (note WHITE SPOT).
- 4) Using an IC puller supplied, locate the ends under the IC (but not the socket) and pull gently. Make sure the IC comes out evenly.
- 5) Place the new IC on the socket, check it is the right way round, move it gently to locate the legs in the holes. Pin 1 of the replacement IC is marked.
- 6) When both sides of legs appear to be located then press gently. Examine the legs to make sure they have gone in the holes and not bent outwards or underneath. Look edge-on between the socket and the IC to check this.
- 7) Give the IC a good squeeze to make sure it is home.
- 8) Re-assemble by locating the keyboard socket onto the 10 pin connector, making sure that all the pins locate correctly. Press the case halves together and power up and check that the display messages appear correct and the keyboard operates. Then replace the case screws.
- 9) Return the old device to AWR Technology.

After the upgrade there may be extra settings that need entered otherwise it will apparently not be able to do anything.

In the FACTORY menu the ones to check and adjust are:

- ACCEL (both axes) now RAMP time. Setting in range 1 to 2 seconds.
- MAXHA. 12h allows moving over the whole sky.
- MAXDEC. Must be 90 degrees if you want to slew over the pole for the meridian reversal (MREV) FLIP function.

In the NORMAL MENU the HORIZ parameter must be set at 0 degrees, or slightly higher if you have a horizon restriction.

### **DRIVEBOX**

All versions MICROSTEP and FRGEN drivebox have replaceable programmed processors. These have version number labels and white spot for pin one and fit in sockets in the drivebox. The Microstep version is 40 pins.

- 1) Remove power and undo external connectors.
- 2) Undo the four box screws at each end.
- 3) Slide the pcb's towards the serial connector end about 2 inches, enough to expose the 40 pin IC with the label on it.
- 4) Note that pin 1 of the IC is close to the long edge of the pcb.
- 5) Using a flat bladed screwdriver carefully lever the IC out of the socket, working from both ends.
- 6) Place the new IC on the socket, check it is the right way round, move it gently to locate the legs in the holes. Pin 1 of the replacement IC is marked.
- 7) When both sides of legs appear to be located then press gently. Examine the legs to make sure they have gone in the holes and not bent outwards or underneath. Look edge-on between the socket and the IC to check this.
- 8) Give the IC a good squeeze to make sure it is home.
- 9) Re-assemble by sliding the pcb's back in. Check that no wires get trapped when the end plates are screwed back on.
- 10) Return the old device to AWR Technology.

Revised 14JUNE2016

## IH2 FIRMWARE UPGRADES

## IH2

Upgrades are installed through a PC computer and the IH-PC link serial cable. The website will carry a range of firmware releases so you can go backwards if a new feature is not to your liking.

To prepare, create a directory on the PC specifically for the purpose of upgrading. Navigate to the DOWNLOADS page of the AWR website.

[www.awrtech.co.uk/ih/ih\\_dl.htm](http://www.awrtech.co.uk/ih/ih_dl.htm)

and download the following files from the IH2 section:-

- APP Loader (bootload.exe)
- IH2 FIRMWARE Version X.XXX (zip file)

You may have problems downloading and running in some PC operating systems but you have to 'RUN ANYWAY' otherwise you will not be able to upgrade the firmware.

The downloaded files appear in the "My Documents/Downloads" folder on your PC and copy these to your specific folder. You will need to unzip the firmware file. Make sure you have the EXE and SREC files in this folder.

1. Connect the IH2 to the computer via the serial lead (with a USB-Serial dongle if you only have USB).
2. Power up the IH2 with keys '1' and '2' pressed. This will mean powering it up through the Drivebox cable. The screen will show the bootload copyright screen and the current version of the IH2 fitted.
3. Run 'bootload.exe' on the PC by double clicking on it.
4. Follow the instructions in the pop up box, press 'BROWSE' to select the directory with the SREC file in it.
5. Press 'AUTOFIND' to locate the correct comms Port. The IH2 will change screen at this point and the PC will say device found.
6. Press 'START' and the file goes over the link and programmes. An update of progress is given in the PC screen and also on the IH2 screen
7. At the end it tells you which version is now present and the PC has 'bootload complete' box.
8. Click on the OK button in the 'Download Complete' box.
9. Finally remove the power from the IH2. On next power up it will be running the new version.

The bootload screen on the IH2 can also be entered from the INFO screen by holding down keys '1' and '2' when the REBOOT key is pressed.

The VERSION HISTORY for IH2 on the website will give you information about bug fixes and whether it is important for you to upgrade to the latest version.

## INTERNAL CLOCK (RTC)

The internal RTC is maintained at all times, and powered by an internal button cell when not powered. Accurate time is necessary as one of the ingredients to placing the Central Meridian in the right place when you synchronise to the stars. Without this in the right position in the sky, various error messages to do with the object being unreachable or below the horizon will appear when it is not expected.

Further the internal time should be set to Universal Time (GMT) without daylight saving. This may be an issue with planetarium programmes as they invariably send the computer time to the handset at connect.

Modification of the set time is achieved through the SETUP – RTC menu. Follow the instructions and use the up or down arrows (F1 or F2 buttons) to modify the flashing field. The SECONDS display is zeroed at the change of the MINUTES display. The fractions of a second are intended to be adjusted with reference to audio pips, through the telephone service. Both pips heard should be in synchronism and the IH version is advanced or delayed when the up or down buttons is used. This increments in 10ms steps. It is possible with practice to set this within 20ms.

One would only do full precision setting if you are doing occultation work and require to store many events with the 'Ev' key.

The running accuracy is entirely adequate for full precision over an evening's observing session (within 20ms). Drift is unavoidable, so it is best checked and reset if necessary at every observing session.

When the IH is powered from either the Drivebox or the Host connector then the oven is powered. The crystal then reaches around 40 deg C and then runs at the calibration rate. We adjust this to within 0.02ppm and it should stay reasonably accurately over the next six months. Accuracy will degrade with time due to crystal frequency drift (ageing). It is not easy for the user to re-calibrate the crystal.

The GPS option if fitted on the IH2 allows automatic update of the time and date stores. The information is supplied as UT correct to the nearest 5ms and updates all the relevant stores at a key press.

The internal Lithium button cell lasts 10 years. The version on the IH is not user replaceable, AWR will do it. The IH2 version is user replaceable. A CR2032 is required.

Revised 30MAR2018



## **BACKLASH CALIBRATION**

The software compensates backlash by a programmable amount in either axis and is used when either motor changes rotation direction.

The knowledge of the rotation direction is stored in the drive box so that the telescope can be used just with the Simple Handset and it will operate backlash. When the Intelligent Handset is used the coordinates are also compensated, so the true pointing position is always shown. The internal software to achieve this got very complicated as the UP button has been arranged to always move the telescope towards your local POLE. In German Equatorial Types where the telescope can go over the pole between Eastern and Western hemispheres the motor sense is reversed so complicating backlash as far as the coordinate readout is concerned.

The backlash amounts for the two motors are entered in the

### **FACTORY - USTEP - RA - .. - BLSH**

screen and similarly for DEC. It is best to determine these amounts with a star and a crosshair eyepiece working at high power.

It is also likely that the backlash amount varies depending on which portion of the worm wheel is involved. For the RA set the backlash amount for the worst part of the wheel. It does not matter that the motor actually overcompensates backlash on the better parts of the wheel (and so moves the telescope). The RA movement involves two backlashes so it cancels out. For the DEC set the backlash to the BEST part of the wheel as it must not move the telescope when performed.

So although you have the facility for entering an adjust value it is better to sort out mechanical issues first so that you do not need to programme it, or it is small enough to ignore.

When the backlash is set to non-zero and the motor is reversed then there is a high speed blip of motor pulses to travel through the backlash period quickly. In this way we go through the backlash in a much shorter time than normal drive rates. This is especially important on DEC as autoguiding may need frequent DEC corrections in both directions.

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## PERIODIC ERROR CALIBRATION

This function is used to remove small periodic errors in a worm wheel. During calibration all RA key presses are recorded and during playback this trace is repeated with accuracies of better than 0.1 seconds. The data is kept permanently even during power down.

The Intelligent Handset can be configured to operate with a TIMED period for the worm rotation period, or can operate with an INDEX pulse generated physically by the worm rotation. Programming must be done at the GUIDE rate and playback can only be done at the same adjust speed. It can however be programmed for rates other than sidereal. A cross hair eyepiece at about 400x magnification is ideal to keep the star on the crosshair during programming. A GUIDE RATE of 10% sidereal will be sufficient to cope with periodic errors up to 2 arc minutes. All RA button presses are stored and become the playback trace at the start of every cycle. When the period is complete the IH beeps and tells you if there is any residual drift in RA. There is an INHIBIT function to stop the trace playing back. There is also a method of starting the playback again at the correct point in-between the worm INDEX pulse points (that is in mid-cycle) when the scope starts tracking again after a GOTO by setting the adjust speed to CENTRE and then to GUIDE when in the default screen.

The recorded data is stored in EEPROM and so is permanent. The rotation point of the worm in its cycle is also kept during power down so that it can be re-acquired at power up.

If the worm period is TIMED, that is there is no hardware to generate an INDEX pulse from the worm rotation, then it is important to use the complete SHDN or PARK function. The motors stop rotating and then you can turn off the power. Then there will be no rotation at power up until the Intelligent Handset re-programmes the drive box for the sidereal rate tracking. Otherwise synchronisation will be gradually lost and reprogramming of the periodic error will be required. At POWER UP the Intelligent Handset MUST be connected so that ALL encoder counts generated by the DRIVE BOX will be captured.

Without INDEX PULSE hardware you have to enter the time for the correction to take place. This is one revolution of the worm at the speed used for the main drive. Normally this would be the star tracking rate (KING) and is calculated by the number of seconds in a KING day divided by the worm reduction ratio. Use 86188 seconds in a day. So for 180 tooth worm enter 478.8 seconds.

Another simple way of inhibiting the playback of the recording is to set the adjust speed in the default screen to CENTRE. It will start up again when GUIDE is selected, when the 'P' reappears on the display.

The only function that will uncalibrate a periodic error recording is by doing another recording OR pressing ABORT when in the PERIODIC - CAL screen at any time. Even doing a default (FACTORY - DEF) will not uncalibrate the periodic error.

The periodic error correcting facility can only do so much and is relying on the mount to be repeatable from worm revolution to worm revolution. This may be true over the segment of the worm normally used but may not be true after doing long GOTO's. There may also be a loading effect in that a larger telescope load (such as when a camera is added) may change the size of the periodic error to be adjusted. As a general rule the periodic error should be calibrated with as near to the exact conditions as to be used for the photography that is to follow. It cannot take out non-periodic errors which could be small jumps caused by the worm wheel from with tooth to tooth variations.

One way of getting precise photographs in the presence of all forms of drive error / mount mis-alignment is to use a CCD camera with autoguiding facility. These operate the four direction buttons remotely as a result of small changes in the position of the image.

Revised 26OCT2016

## GLOSSARY

<b>EPOCH (Jxxxx)</b>	The date and time of the catalogued position of the star or of the observation.
<b>CENTRE RATE</b>	Select this speed option when you wish to centre a star in the eyepiece.
<b>GUIDE RATE</b>	Select this speed option with guiding photographic exposures.
<b>Jnow</b>	Jnow is the coordinate frame of the moment and is used for calibration to find objects for most precise work. Objects within the databases are precessed to Jnow when doing GOTO's. When using the IH this is the epoch in use.
<b>LST</b>	Local Sidereal Time is the RA coordinate at Jnow of a star on the Central Meridian
<b>KING RATE</b>	The normal drive rate. A Sidereal telescope drive rate but which has a correction for refraction in the Earth's atmosphere. It is the best compromise rate at 45 degrees in altitude and allows following a star for a long time before it drifts. The RA coordinate on the display will stay constant when the star is being followed.
<b>MOVE RATE</b>	Select this speed option when centering a star as seen in the finderscope.
<b>OBSERVER'S MERIDIAN</b>	The great circle from north point, through the pole, zenith and the south point. This line separates the Eastern Hemisphere from the Western Hemisphere
<b>PRECESSION</b>	A gradual change in the coordinate frame of the sky with time due to the wobbling of the Earth's rotational axis. The catalogue position of a star of different EPOCH must be PRECESSED to the current EPOCH before use
<b>TRACK</b>	The TRACK rate allows a differential rate in RA and DEC to be entered for following a relatively fast moving object such as a Comet or Asteroid.

IH Serial Number \_\_\_\_\_ Date of Purchase \_\_\_\_\_

Telescope size and type \_\_\_\_\_

OPTIONS for CONFIGURATION

EXT ENCODERS	DOUBLE ENCODER	BARS BOX
HS SLEW	DUAL MOTORS	
FOCUS BOX	ALT-AZ	

USTEP

XFREQ	_____	RA WORM	_____ secs
MREV	_____		
MAXHA	_____		
MAXDEC	_____		

USTEP - RA

RA reduction ratio	_____
Gearbox	_____
Motor steps per rev	_____
RATIO	_____
SLEW	_____ d/s
RAMP	_____ s
DIR (sense)	_____
MSTEPS	_____
BLSH	_____
ERATIO	_____
EDIR (sense)	_____
SSLEW	_____ d/s
SRAMP	_____ s
SDIR (sense)	_____

USTEP - DEC

DEC reduction ratio	_____
Gearbox	_____
Motor steps per rev	_____
RATIO	_____
SLEW	_____ d/s
RAMP	_____ s
DIR (sense)	_____
MSTEPS	_____
BLSH	_____
ERATIO	_____
EDIR (sense)	_____
SSLEW	_____ d/s
SRAMP	_____ s
SDIR (sense)	_____

SITE A LOCATION

Latitude \_\_\_\_\_  
Longitude \_\_\_\_\_

SITE B LOCATION

Latitude \_\_\_\_\_  
Longitude \_\_\_\_\_

SITE C LOCATION

Latitude \_\_\_\_\_  
Longitude \_\_\_\_\_

SITE D LOCATION

Latitude \_\_\_\_\_  
Longitude \_\_\_\_\_

## MENU CROSS REFERENCE

- APPLY** Allows you to try the setting you have just entered before confirming with `E`
- BLEEP** Select bleep requirement on events and errors
- `C`** Cancel key – Clear data or return to previous menu
- CAL1** See **SYNC**
- CAL2** Enter second calibration point for determine polar position error.
- CAT** Enter catalogue menus
- CATLG** Select next catalogue
- CAT+** Select next catalogue
- CAT-** Select previous catalogue
- DECDIR** Set motor sense direction for Declination axis.
- DISP** Select parameters on the default screen
- `E`** Enter key – Always press `E` after entering data.
- ECHO** Copy NMEA GPS strings to the HOST port.
- `Ev`** Store event key
- EVNT** Fetch details of previously stored events
- FILTR** Select objects to filter when using the database catalogues
- FIX** Apply filter of current constellation for selecting objects
- FLIP** Perform a meridian reversal for GEM mounts
- GOTO** After selecting object from the catalogue use this to drive to it.
- GPS** Enter GPS menu if option fitted
- GUIDE – CENTRE – move – SLEW** Selects the telescope move speed when a telescope direction button is pressed. In this example the MOVE rate is selected.
- HOME** Once calibrated with SETPK press to return home.
- HORIZ** Set artificial horizon below which the telescope stops tracking.
- INFO** Last error message, software versions and **REBOOT**
- KEY** Select bleep requirement when a key is pressed
- LIGHT** Change backlight value for screen and keyboard, range 0 (off) to 12
- LIST** Store of previous positions visited during GOTO's or **SYNC**
- `M`** Menu key
- NEXT** Select next catalogue object according to the filters
- OBJECT** Enter RA, DEC coordinates or from previously entered value in **LIST**

**OFF** Power down handset after reaching HOME position

**PER** Go through the Periodic Error setup screen

**POS** Update current site position from GPS

**PREV** Recall positions entered previously in the **LIST**

**RATES** Change speeds to go at GUIDE, MOVE and CENTRE rates

**REBOOT** Start as if power has just been applied. Useful in going to Backdoor options

**RTC** Set real time clock

**SETPK** Set the current position as the park position

**SITE** Set latitude and longitude of one of four sites.

**SKY** Set coordinate units in default screen, either RA-DEC or ALT-AZ

**STATUS** See **INFO**

**STEP** Select next object in catalogue

**SYNC** Synchronise the handset coordinate frame with the sky objects.

**TIME** Set time display in default screen, either LST or UT

**TIME** Update internal time from GPS

**TRACK** Select tracking rates – Solar, Lunar King or differential track

**'U1-U2-U3'** keys operate relays in the ADV DRIVEBOX. Select toggle, timed or standard.

**UNPARK** Go into normal tracking.

**'..'** Select more menu options

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