NanoStep™ STEPPER MOTOR CONTROL MODULE

Model Number 17MST001

MELLES GRIOT

About the Company

Melles Griot is an established global force in the design and manufacture of mechanical hardware, motion control systems, vibration isolation systems, machine vision products and multi-element optical systems for fiber-optic, semiconductor and repro graphic applications.

We offer customers an in-depth understanding of fiber component manufacture, allowing us to quickly and confidently develop optimal positioning solutions.

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Revision History

Issue No.	Date	Summary
1	020798	Initial Issue
2	121201	CN 2792

Contents

Chapter 1

Introduction

1.1 How to Use this Handbook

This handbook contains all the information necessary to set up, program and operate the 17MST001 NanoStep^{TM} Stepper Motor Control Module. For the continuing safety of the operators of this equipment, and the protection of the equipment itself, read the Safety Information in Chapter 2 before using the equipment, and carefully heed all cautionary notes. If you have any questions or comments about this handbook please call your local sales or service office or contact the factory at +44 (0) 1353 654500 and ask for Customer Service.

Alternatively, visit our website at www.mellesgriot.com/technicalsupport

1.2 Handbook Structure

Chapter 1, Introduction, gives an overview of the handbook structure and draws attention to the importance of the safety information. Chapter 2, For Your Safety, provides critical information needed for the safe installation and operation of the equipment. Chapter 3, Getting Started, gives an overview of the front panel controls and their use. Chapter 4, Principle of Operation, explains how to use the module to control external devices. Chapter 5, Set up, describes how to configure the module using the MG17_Config configuration program. Chapter 6, Programmed Operation, explains how to operate the module, from software. Chapter 7 lists the specifications. Finally, Chapter 8, Installation, provides electrical installation instructions together with general information and guidelines on mounting and siting the equipment. Instructions on mounting the module into the rack are contained in Handbook *HA0088 – Main Rack and Controller*, which also contains details of system configuration.

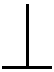
For Your Safety

2.1 Safety Information

For the continuing safety of the operators of this equipment, and the protection of the equipment itself, the operator should take note of the **Warnings, Cautions** and **Notes** throughout this handbook and, where visible, on the product itself.

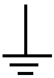
The following safety symbols may be used on the equipment:

Read the operating instructions before use



Connection to Earth

High voltages present



Earth point

The following safety symbols may be used throughout the handbook:

Warning. An instruction which draws attention to the risk of injury or death.

Caution. An instruction which draws attention to the risks of damage to the product, process or surroundings.

Note. Clarification of an instruction or additional information.

This unit complies with the European Standard EN61010 as a POLLUTION DEGREE I, INSTALLATION CATEGORY II piece of equipment.

The Equipment, as described herein, is designed for use by personnel properly trained in the use and handling of mains powered electrical equipment. Only personnel trained in the servicing and maintenance of this equipment should remove its covers or attempt any repairs or adjustments.

Getting Started

3.1 Description

The 17MST001 Stepper Motor Controller has been designed to integrate seemlessly into the Melles Griot Modular Nanopositioning System and provides the user with the ability to control the NanoStep^{TM} stages and actuators in the Melles Griot nanopositioning product range.

3.2 Front Panel Controls and Indicators

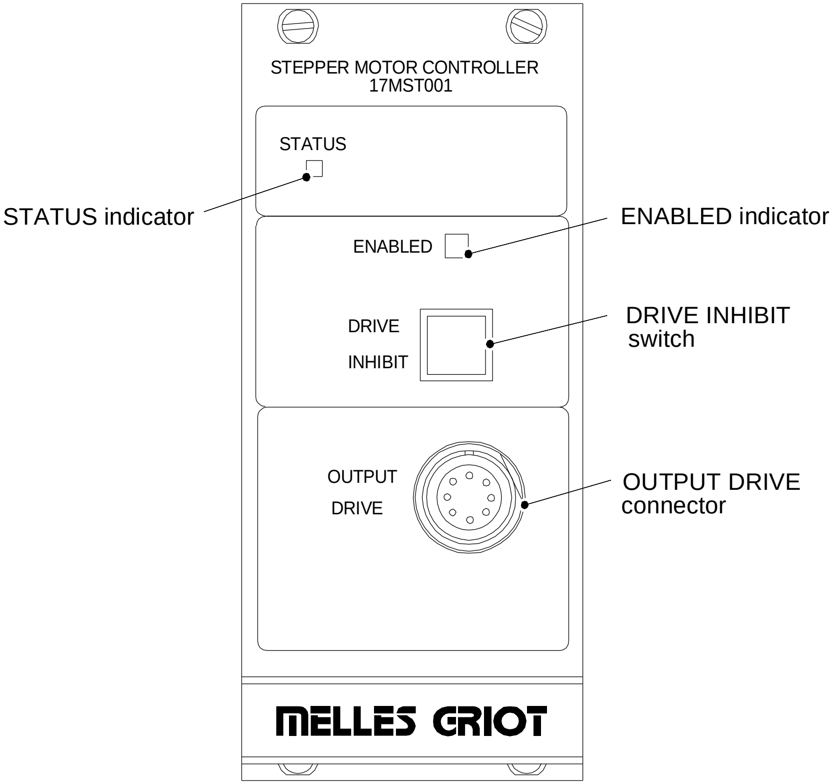


Fig. 3.1 Front Panel Indicators

STATUS indicator – lit when the controller is addressing the module.

ENABLED indicator – lit when the motor drive is energized.

DRIVE INHIBIT switch – removes power from the stage so that it can be positioned manually, using the adjustment knob on the motor shaft. The switch can also be used as an emergency stop, (e.g., if the stage is heading for a collision). With the drive inhibited, the red ENABLED indicator is extinguished.

OUTPUT DRIVE connector – providing connection to the actuator.

Chapter 4

Principle of Operation

4.1 How A Stepper Motor Works

4.1.1 General Principle

The NanoStep^{TM} actuators use a stepper motor to drive a precision lead screw.

Stepper motors operate using the principle of magnetic attraction and repulsion to convert digital pulses into mechanical shaft rotation. The amount of rotation achieved is directly proportional to the number of input pulses generated and the speed is proportional to the frequency of these pulses. A basic stepper motor has a permanent magnet and/or an iron rotor, together with a stator. The torque required to rotate the stepper motor is generated by switching (commutating) the current in the stator coils as illustrated in Fig. 4.1.

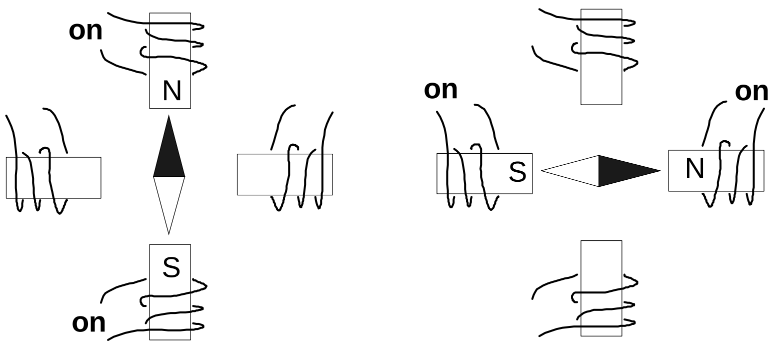


Fig. 4.1 Simplified concept of stepper motor operation

Although only 4 stator poles are shown above, there are really numerous tooth-like poles on both the rotor and stator. The result is that positional increments (steps) of 1.8 degrees can be achieved by switching the coils. If the current through one coil is increased as it is decreased in another, the new rotor position is somewhere between the two coils and the step size is a defined fraction of a full step (microstep). The smallest angular adjustment possible is 0.018 degrees.

The size of the microstep depends on the resolution of the driver electronics. The mechanical resolution achieved by the system may be coarser than a single microstep, primarily because there may be a small difference between the orientation of the magnetic field generated by the stator and the orientation in which the rotor comes to rest.

4.1.2 Positive and Negative Moves

Positive and *negative* are used to describe the direction of a move. A positive move means a move from a smaller absolute position to a larger one, a negative move means the opposite.

In the case of a NanoStep^{TM} linear actuator, a positive move takes the platform of the stage further away from the motor.

In a NanoRotator^{TM} stage, a positive move turns the platform clockwise when viewed from above.

4.1.3 Velocity Profiles

To prevent the motor from stalling, it must be ramped up gradually to its maximum velocity. Certain limits to velocity and acceleration result from the torque and speed limits of the motor, and the inertia and friction of the parts it drives.

The motion employed is described by a trapezoidal velocity profile, reflecting the shape of the velocity *vs.* time graph (see Fig. 4.2.), thereby driving the stage to its destination as quickly as possible, without causing it to stall or lose steps.

From the initial velocity *u*, the stage is accelerated at *a* to a maximum velocity *v*. As the destination is approached, the stage is decelerated at *a* so that the final position is approached at velocity *u.*

When the system is configured, MG17_Config sets default velocity profiles appropriate for the stages. These profiles may be changed later but the maximum default values cannot be exceeded.

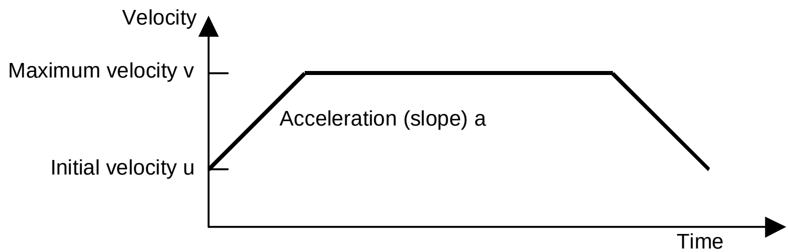


Fig. 4.2 Graph of a trapezoidal velocity profile

4.2 Positioning the Stage

4.2.1 General

Whenever a command to move a stage is received, the Controller converts the movement specified in motion units, (e.g., mm) to a number of microsteps. It then sends a signal to the stage to move by this number of microsteps. The Controller also uses an electronic counter to keep a record of the net number of microsteps moved. If the Controller is requested to report the position, the value of this counter is converted back into motion units.

In the instance when the motor shaft is turned by hand, no signal is sent to the motor and the counter is not updated. Therefore the position reported subsequently will not be true.

4.2.2 Home position

When the system is powered up, the counters (one for each NanoStep™ Control module) are all set to zero. The system has no way of knowing the position of the stages in relation to any physical datum. At this moment, it is recommended to home the stages. This means driving them negatively until a limit switch is reached and then driving them positively a fixed distance. The stages are then in the Home position, and the counters are reset to zero.

The important point about the Home position is that it provides a fixed datum that can be found even after the system has been switched off and on.

4.2.3 Linear and rotary stages

A linear stage moves between two stops, and movement outside these limits is physically impossible. Linear stages can include stages that control the angle of a platform within a certain range, although the movement of the platform is not really linear but angular. Rotary stages can rotate indefinitely, like a wheel.

Linear and rotary stages both contain microswitches that detect certain positions of the stage, but they differ in the way these switches are used.

All linear stages have a –ve limit switch, to prevent the stage from accidentally being moved too far in the –ve direction. Once this switch is activated, movement stops. The switch also provides a physical datum used to find the Home position. Some linear stages have a +ve limit switch also, whereas others rely on a physical stop to halt the motion in the positive direction. A rotary stage has only one switch, used to provide a datum so that the Home position can be found. Movement is allowed right through the switch position in either direction.

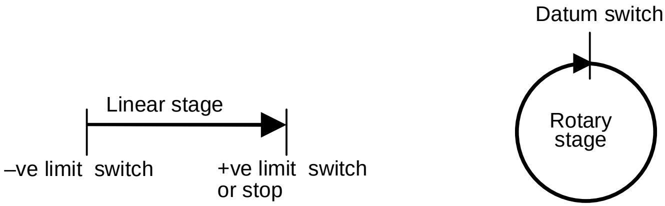


Fig. 4.3 Stage microswitches

4.2.4 Power Saving

The current needed to hold a motor in a fixed position is much smaller than the current needed to move it. It is usually better to reduce the current through the stationary motor to reduce heating. Although this heating does not harm the motor or stage, it is often undesirable because it can cause thermal movements through expansion of the metal of the stage.

For this reason, power saving is implemented by default from the software drivers.

4.3 Error Correction

4.3.1 Backlash correction

The term *backlash* refers to the tendency of the stage to reach a different position depending on the direction of approach.

Backlash can be overcome by always making the last portion of a move in the same direction, conventionally the positive direction. A *positive* move, say from 10 to 20 mm, is carried out as one simple move. But a *negative* move, say from 20 to 10 mm, first causes the stage to overshoot the target position and then move positively through a small amount.

This ‘backlash correction’ is the default mode of operation, but it can be overridden if, for example, the overshoot part of the move is not required.

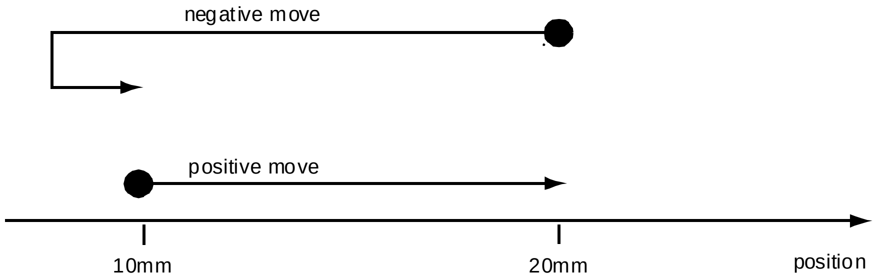


Fig. 4.4 Backlash correction

4.3.2 Mechanical Errors

The mechanical parts of an actuator, such as the leadscrew and mechanical linkages, can only be machined to a certain accuracy, e.g., the pitch of a leadscrew might be nominally 1 mm, but the real pitch could be 1.0005 mm, presenting an error of 0.5 micron.

In practice, errors accumulate from a number of sources. Most errors are, however, repeatable. Melles Griot offer the option to calibrate a stage against an interferometer. Through calibration, the total error is measured at a large number of calibration points. The calibration procedure produces a look-up table stored as a simple text file. The file is then linked to the appropriate axis of the system as part of the configuration process using MG17_Config. Whenever the stage is moved, the look-up table is consulted to find out the precise move command needed internally to get the desired movement with the maximum accuracy.

The use of a calibration file is optional. Without it, the repeatability and resolution of the stage are not affected, but no compensations are made to enhance accuracy.

Chapter 5

Setup

5.1 Configuration

5.1.1 Introduction

The Stepper Motor Control Module is a component of the Melles Griot Modular Nanopositioning System and is configured using the system configuration software – MG17_Config.

The program annotates a unique name or ‘handle’ to the module which aids identification during subsequent testing/operation. (See *HA 0088 - Main Rack and Controller Handbook* for a general description of MG17_Config).

Fig. 5.1 shows the configuration program screen when a NanoStep^{TM} module is included in the rack.

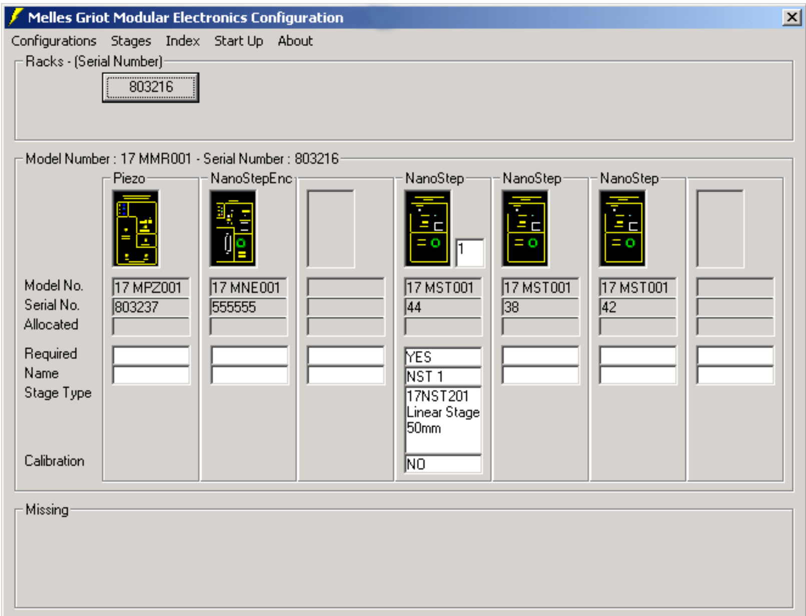


Fig. 5.1 MG17_Config Configuration Program

Note. Each NanoStep module in the system must have a discreet address. If the controller cannot recognise that a particular module is fitted, it is probable that the address allocated conflicts with another NanoStep module already fitted. In this case, power down the system, remove the module and change the address as detailed in Section 8.3.

5.1.2 Creating a System Configuration

1) Run **MG17_Config**, which can be found in the folder **Start/Programs/ MellesGriot\MelHost\Config**.
2) In the 'Modular Electronics Configuration' window (see Fig. 5.1) LH Click on the icon of the NanoStep™ module. The green 'status' light on the front panel of the actual module flashes once as an aid to identification.
3) LH Click and drag the module icon into the slot on the screen that corresponds to the actual position of the module in the rack (this allows easy identification of the module).
4) LH Click on the **Required** field for the applicable module and select YES to include the module in the configuration.
5) LH click in the **Name** field and enter a unique name. During programming, this name is used as a 'handle' to identify the module. Alternatively it is possible to use the default name given by the configuration program.
6) LH click in the **Stage Type** field and from the 'Select Stage' pop up menu, select the appropriate type for the stage connected to the module.
7) LH click in the **Calibration** field and select the appropriate calibration file to apply to the axis (see Section 4.3.2.). If no calibration is required, select 'NO'.
8) RH click on the relevant module icon to access the 'Jog NanoStep' window – see Fig. 5.2 and set up the Jog size. Any values set can be overridden in the software.
   - **Jog size.** Set the size of the step taken when the jog arrows are clicked. The setting can be typed directly into the field or selected from the drop down list.

Note. This window also provides the capability to view the current position, and the option to send 'Home' or 'Jog' instructions to the stage – see Section 6.2.2.

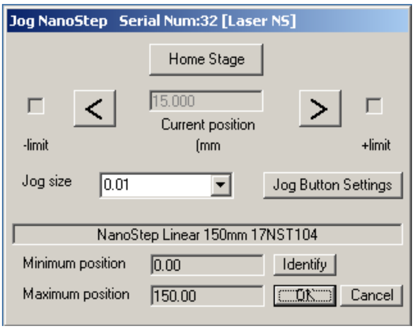


Fig. 5.2 Setting Parameters

9) Repeat steps 2 to 8 for each module you wish to configure.
10) From the Configurations menu (top left-hand corner of screen), save the configuration(s) created using a meaningful name. This name may be used later in the initialization part of a program.

5.1.3 Configuration Parameters for a Stage

The configuration parameters for each type of stage are viewed using the Stages menu – see Fig. 5.3. To display this menu click on ‘Stages’ in the top menu bar.

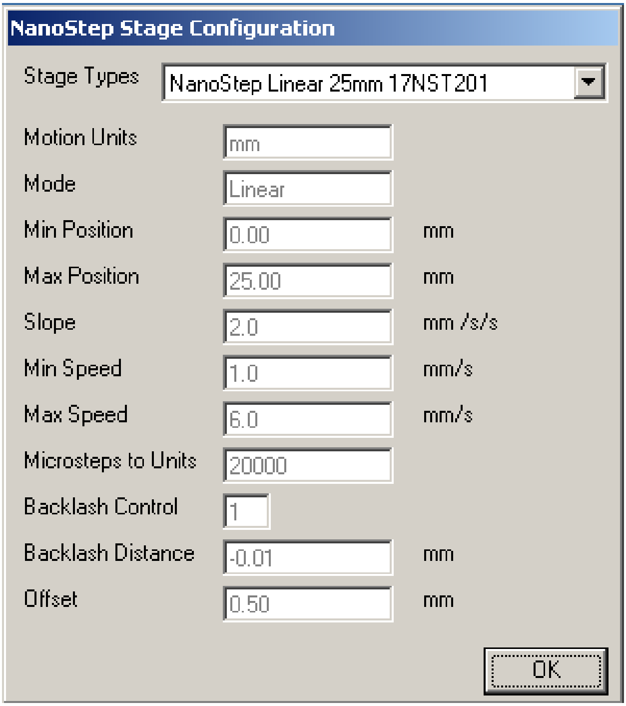


Fig. 5.3 Configuration Parameters

The following parameters are default settings dependent upon the stage type and cannot be adjusted:

Motion units: Units in which motion is specified from any high-level application, conventionally mm or degrees.

Mode [linear or rotary]: For linear stages, travel beyond the –ve and +ve limit switches is prohibited. For rotary stages, unlimited rotation is allowed and the -ve ‘limit switch’ provides a datum only.

Min Position: The minimum useful position of the stage relative to the Home position, dependent upon the stage type.

Max Position: The maximum useful position of the stage relative to the Home position.

Microsteps to units: The number of microsteps needed to move one motion unit. This depends on the lead screw pitch and any gearing in the mechanical system. A microstep is the smallest distance the motor can be commanded to move.

Backlash control: 1 to apply backlash correction, 0 for no backlash correction. This default setting may be used or ignored in high level applications.

Backlash distance: The amount of overshoot the motor is commanded to move when making negative moves.

Offset: The distance from the –ve limit switch to the Min Position.

The following parameters are set in the SingleSetVelocityProfile method – see Handbook *HA 0104 ActiveX Drivers, NanoStep Object.*

Slope: The acceleration and deceleration (motion units/s^2) used in the velocity profile.

Min Speed: The initial velocity (motion units/s) used in the velocity profile.

Max Speed: The maximum velocity (motion units/s) used in the velocity profile.

Fig. 5.4 explains how the Minimum and Maximum positions are used in the case of a linear stage. The distance from the Minimum position to the Maximum position, is the 'useful travel' of the stage. It is often the case that the Minimum position is zero. The Home and Minimum positions then coincide, with movement always occurring on the positive side of the Home position.

Rotary stages have effectively no limits of travel. The Minimum and Maximum positions are conventionally set to 0 and 360 degrees respectively. When the position of a rotary stage is requested, the answer will be reported as a number between 0 and 360 degrees, measured in the positive direction from the Home position.

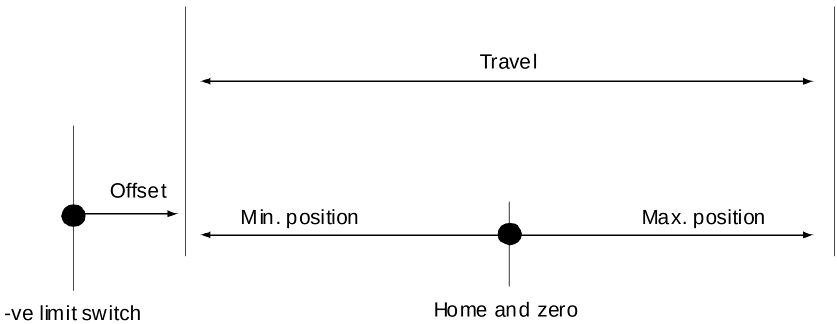


Fig. 5.4 Minimum and Maximum Positions

Chapter 6

Programmed Operation

6.1 Introduction

The Melles Griot Nanopositioning Modular System has been designed to allow custom nanopositioning applications to be developed in a Microsoft Windows environment. The use of ActiveX interfacing technology means that programming of the module can be achieved in any compatible language (LabVIEW, Visual Basic etc.) without the need for an extensive library of language-specific functions.

6.2 Software Functions

The ActiveX drivers consist of several 'objects', which in turn contain 'Methods' and 'Properties'. The 'NanoStep™' object contains the methods which facilitate the programmed operation of the module.

The methods apply to several axes. They are called using an array of handles and arrays of parameters (e.g. positions) in matching order. Position arrays can be thought of as geometric vectors. Single-axis movement can be obtained either by using single-element arrays, or by using the single axis methods (prefixed by 'Single' in the method name) – see handbook *HA 0104 – ActiveX Drivers*.

Moves are specified in motion units, conventionally millimetres or degrees.

Multi-axis moves begin simultaneously on all axes, but generally finish at different times. At the end of a move, the green STATUS lights are turned off and, to avoid heating of the motor coils, the current is reduced.

More detailed information on objects, methods and parameters, including a full description of the NanoStep™ object, can be found in handbook *HA 0104 –ActiveX Drivers*.

6.2.1 Typical Procedure

The NanoStep^{TM} control module can be driven by a software application written in any language compatible with ActiveX.

1) Load the configuration file ensuring that the handles for the modules to be controlled (see Section 5.1.2.), are compatible with those used in the software application.
2) Run the software application which performs the desired task (written using the methods described in handbook *HA 0104 – ActiveX Drivers*). A typical application contains the following main steps:
   - Using the methods described in the ActiveX handbook, configure the velocity profiles for subsequent moves. If this step is skipped, the default velocity profiles are used. The velocity profile can be configured and reconfigured at any point in the application.
   - Home the axes, bringing the stage platform to a known position. This is necessary each time the equipment is switched off and on.
   - Move the axes (axes can be moved simultaneously). This part is usually the main body of the application. For example, you may wish to move through a sequence of positions, dwelling at each position to take readings or perform operations from other instruments.

6.2.2 Operation from the Controller

RH Click on the relevant module icon to access the ‘Jog NanoStep’ window.

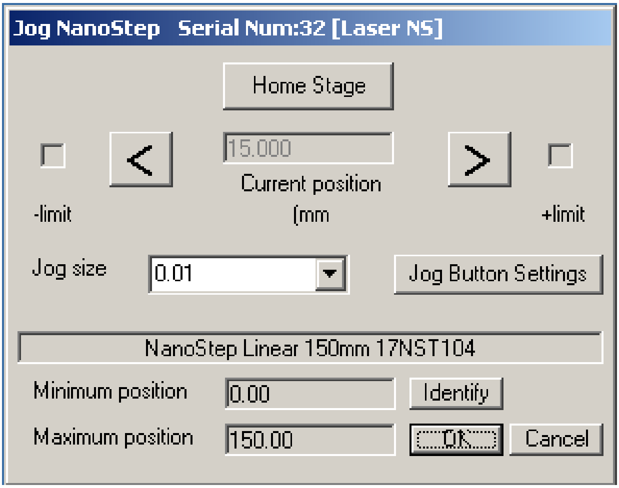


Fig. 6.1 Operation from the controller

The window provides the following functions:

- The option to send simple control instructions to the stage via the ‘Home’ or the jog ‘< >’ buttons. Jogging the NanoStep™ from this window does not affect any stored configurations, however the stage should first be ‘homed’ if the **Current position** field is to show a meaningful value.
- Easy identification of the module position. Clicking the ‘Identify’ button lights the green ‘Status’ light on the front panel of the module.
- Display of the Stage Type, Minimum and Maximum positions, and indication when the –ve and +ve limit switches have been activated.

Specifications and Parts List

7.1 Specifications

Front panel control	Drive enable /inhibit
Dimensions	12 HP x 3 U (61 mm x 134 mm x 220 mm)
Weight	880 g
Microstep capability	20,000 steps per revolution
Motor Output current	1 A
User output 0 to 3	5V digital @ 10mA per channel
In-motion signal	0 to 5V (for high impedance load)

7.2 Associated Products

Product Name	**Part Number**
Main Rack and Controller	17MMR001 17MRC001 17MRC002
Main Rack and Controller Handbook	HA0088
NanoStep^{TM} Module	17MST001
NanoStep^{TM} Module Handbook	HA0085
ActiveX Software	17CDM002
ActiveX Software Handbook	HA0104

Installation

8.1 Mechanical Installation

8.1.1 Introduction

The NanoStep^{TM} Control Module is intended for installation in the Main Rack as part of the Melles Griot Modular Electronic System. Full installation instructions are contained in handbook *HA 0088 – Main Rack and Controller Handbook*.

Caution. When mounting the module in the rack, ensure that proper airflow is maintained to the unit

8.1.2 Environmental Conditions

Warning. Operation outside the following environmental limits may adversely affect operator safety.

Location	Indoor use only
Maximum altitude	2000 m
Temperature range	5^{o}C to 40^{o}C
Maximum humidity	Less than 75%

8.1.3 Identifying Unsafe Equipment

Whenever it is suspected that the safety of the product has been impaired, it is recommended that an appropriate label, recognized by your company, be attached and that the unit be removed to a place of repair.

8.2 Electrical Installation

8.2.1 Fuses

The following fuses are located internally and should be replaced only by trained personnel authorised by Melles Griot.

F1	T type 20 x 5mm	0.5A
F2	F type	1.6A

8.3 Changing the Module Address

When a module is ordered as part of a system, the address of each module is configured at the factory and no conflicts should arise. However, if a module is added to a system at a later date, it is possible that the address allocated will be the same as a module already fitted and the module will not be recofnised by the controller. In this case, change the address as follows:

1) Close down the system and remove the power.
2) Remove the module – see *Handbook HA 0088 Main Rack and Controller.*
3) Referring to Fig. 8.1, insert a small flat blade screwdriver into the adjustment hole and adjust the potentiometer to allocate a different address. There are 16 settings, 0 to F corresponding to address 32 to 47.
4) Refit the module.
5) Create the configuration as detailed in section Section 5.1.2.

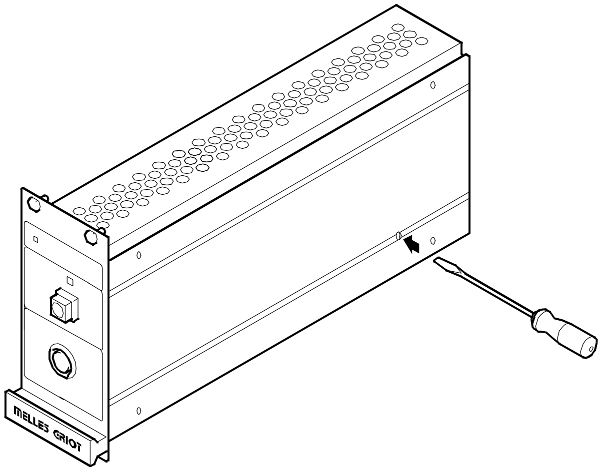


Fig. 8.1 Changing the module address

8.4 Preventive Maintenance

The unit normally requires no maintenance, however the fascia may be cleaned with a soft cloth and mild detergent. Do not saturate the unit or use solvents.

Products and Customer Support

A Comprehensive Product Range

Optical Components,

Singlets, Doublets and Triplets; Cylindrical Optics, Mirrors, Prisms and Retroreflectors, Beamsplitters, Polarization Components, Filters, High Energy Laser Optics, Diode Laser Optics, UV Optics, Machine Vision.

Opto-mechanical Hardware

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Nanopositioning

Stages, Mechanical Accessories, Piezo-electric and Stepper-motor Controllers, Autoalignment, Modular System Controllers.

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Laser Measurement Instrumentation

Laser-beam characterization, Photodiodes, Power and Energy Meters.

Lab Accessories

Technical Support

Melles Griot provides a comprehensive after sales service. Contact us through your local representative, or at the address below:

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email: nanosupport@mellesgriot.com

Client Warranty

Prior to installation, the equipment referred to in this handbook must be stored in a clean, dry environment, in accordance with any instructions given. Periodic checks must be made on the equipment’s condition.

It is always helpful to have detailed and accurate information about any problems encountered by customers.

We welcome comments or suggestions about any aspect of the equipment and instruction handbooks.

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