
Declaration of Conformity

according to ISO / IEC Guide 22 and EN 45014

Manufacturer: Physik Instrumente (PI)
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The manufacturer hereby declares that the product

Product Name: **Precision Linear Stage**
Model Numbers: **M-5x1.xx**
Product Options: **all**

conforms to the following EMC Standards and normative documents:

Electromagnetic Emission: EN 61000-6-3

Electromagnetic Immunity: EN 61000-6-1

Safety (Low Voltage Directive) : EN 61010-1

Safety of Machinery : EN 12100

August 24, 2004
Karlsruhe, Germany

W.Bitterwolf
Quality Management

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This manual has been provided for information only and product specifications are subject to
change without notice. Any change will be reflected in future printings.

About this Document

Users of this Manual

This manual is designed to help the reader to install and operate M-5x1 Linear Positioning Stages. It assumes that the reader has a fundamental understanding of basic servo systems, as well as motion control concepts and applicable safety procedures.

The manual describes the physical specifications and dimensions of the M-5x1 Linear Positioning Stages as well as the motion control parameter settings which are required to put the associated motion system into operation.

This document is available as PDF file on the Motion CD. Updated releases are available via FTP or email: contact your Physik Instrumente sales engineer or write info@pi.ws

Conventions

The notes and symbols used in this manual have the following meanings:



WARNING

Calls attention to a procedure, practice or condition which, if not correctly performed or adhered to, could result in injury or death.



CAUTION

Calls attention to a procedure, practice, or condition which, if not correctly performed or adhered to, could result in damage to equipment.

NOTE

Provides additional information or application hints.

Related Documents

The motion controller card and the software tools, which might be delivered with M-5x1 Linear Positioning Stages, are described in their own manuals. All documents are available as PDF files on the Motion CD or special product CD. Updated releases are available via FTP or email: contact your Physik Instrumente sales engineer or write info@pi.ws.

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1 General Design of M-5x1 Series Linear Stages

M-5x1 series linear stages are low-profile, high-accuracy linear translation devices for industrial use and laboratory applications. Used in the fields of semiconductor quality control, metrology test equipment, disk drive test setups and general R&D tasks, the M-5x1 series stages are designed to meet demanding positioning requirements.

The stages combine a functional flat design to allow multi-axis combinations, and feature a precision-machined base from high-density, stress-relieved aluminum for exceptional stability and minimum weight. Precision-ground recirculating ballscrews, with better accuracy than rolled ballscrews, and preloaded nuts guarantee low-friction, backlash-free positioning.

Versions with integrated linear scale encoder provide 0.1 μm minimum incremental motion and 1 μm full-travel accuracy. High-precision linear guiding rails with recirculating ball bearings guarantee 1 μm / 100 mm straightness and flatness.

All versions are equipped with non-contact Hall-effect origin sensors and limit switches. An optional motor brake is available for the DC-Motor Direct Drive versions (M-511.DDB) to secure the stage position when power is off. This brake option is recommended for vertical stage orientation with loads over 1 kg (10 N),

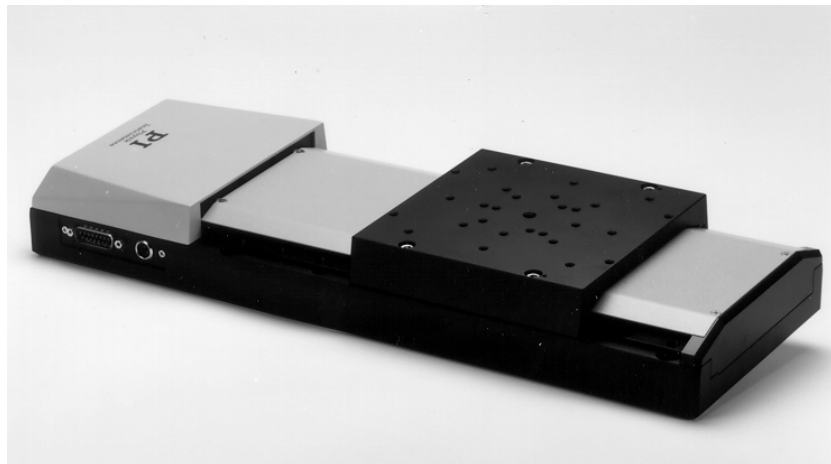


Fig. 1 M-511.DD

1.1 Safety Precautions



WARNING

To avoid damage or injury, do not put anything in the gap between the moving platform and the motor cabin.

Never put your finger anywhere where the moving platform or any connected object could possibly trap it.



CAUTION

M-5x1 stages are powered by powerful electric motors and can accelerate to high speeds. Be aware that automatic limit switch halt may not be supported by, or activated at, the motor control electronics.

Be aware that failure of the motor controller may drive the stage into a hard stop at high speeds.

When the stage is first connected to the motor controller, be aware that the stage could start an undesired move.

1.2 Shipment Contents

M-5x1 series stages are delivered with

- 4 metric screws M6x30 w. hex wrench, (purpose: mounting the stage onto a flat plane and mounting objects onto the moving platform).
- 4 metric screws M4x30 w. hex wrench, (purpose: mounting two stages as an XY combination).
- Connecting cable, type C-815.38
- This MP 33E User Manual

1.3 Model Survey

M-5x1 series stages are available with travel ranges of 102, 204 and 306 mm. Depending on the application, integrated drives using DC motors with or without gearheads and 2-phase or 5-phase stepper motors are offered.

All direct-driven stages (.DD) can be equipped with an electrical motor-brake option (model numbers .DDB).

	Travel Range [mm]	Gearhead Ratio [:]	Design Resolution [$\mu\text{m}/\text{count}$]	Translation Ratio * [counts/ μm]	Repeatability (uni-directional) [μm]	Max. Velocity [mm/s]	Motor Power [W]	Weight [kg]
M-511.DD	102	---	0.1	10	0.1	50	30	5.0
M-511.DG	102	29.6:1 [†]	0.033	30.3533827	0.2	6	3	4.9
M-511.PD	102	---	0.5	2	0.5	125	30	5.0
M-511.5S	102	---	0.1	---	0.2	20	5-phase SM	4.9
M-511.2S	102	---	0.1	---	0.2	20	2-phase SM	4.9
M-521.DD	204	---	0.1	10	0.1	50	30	6.1
M-521.DG	204	29.6:1 [†]	0.033	30.3533827	0.2	6	3	6.0
M-521.PD	204	---	0.5	2	0.5	125	30	6.1
M-521.5S	204	---	0.1	---	0.2	20	5-phase SM	6.0
M-521.2S	204	---	0.1	---	0.2	20	2-phase SM	6.0
M-531.DD	306	---	0.1	10	0.1	50	30	7.2
M-531.DG	306	29.6:1 [†]	0.033	30.3533827	0.2	6	3	7.1
M-531.PD	306	---	0.5	2	0.5	125	30	7.2
M-531.5S	306	---	0.1	---	0.2	20	5-phase SM	7.1
M-531.2S	306	---	0.1	---	0.2	20	2-phase SM	7.1

* Translation Ratio is the value used by WinMove operating program.

[†] Exact gearhead reduction ratio is $(28/12)4 : 1$, = 29.641975309 : 1, Encoder: 2048 c/rev

1.4 General Mechanical Data

Straightness / Flatness:	1 μm per 100 mm
Origin Repeatability:	1 μm
Max. Load capacity:	100 kg
Max. push/pull force:	80/80 N
Max. lateral force:	200 N
Ballscrew pitch:	2 mm
Material:	Aluminum

1.5 Electrical Data

1.5.1 Type "DD": Stages with Linear Scales and Direct Drives

Motor Type:	DC, 3557 S024
Motor Power:	30 W
Motor Voltage:	24 VDC
PWM amplifier:	LMD 18201, 24.5 kHz
Encoder type:	optical linear scale, integrated in stage
Linear resolution:	0.020 μm
Signals:	A, A/, B, B/
Encoder transmission:	RS-422

Brake Signal:	Active low, normal high (12 V output)
Power supply:	external line-power power supply, order # M-500.PS
Internal current draw:	149 mA (supplied by external P/S)

1.5.2 Type "PD": Stages with Rotary Encoders and Direct Drives

Motor Type:	DC, 3557K024CS
Motor Power:	30 W
Motor Voltage:	24 VDC
PWM amplifier:	LMD 18201, 24.5 kHz
Encoder type:	rotary encoder, HEDM5500B
Encoder resolution:	4000 counts / motor revolution
Linear resolution:	0.5 $\mu\text{m}/\text{count}$
Signals:	A, A/, B, B/
Transmission:	RS-422
Brake Signal:	Active low, normal high (12 V output)
Power supply:	external line-power power supply, order # M-500.PS
Power consumption:	Motor power plus 130 mA (supplied by external P/S)

1.5.3 Type "DG": Stages with Gearhead Drives

Motor Type:	G2224R012S
Motor Power:	3 W
Motor Voltage:	12 V
Encoder Type:	IE2-512 (rotary type)
Encoder resolution:	2048 counts / motor revolution
Signals:	A, A/, B, B/
Encoder transmission:	RS-422
Gearhead type:	backlash free
Gearhead ratio:	29.641975309 : 1
Translation Ratio, (to be used with QMove) :	30.3533827 counts/ μ m
Power supply:	via motor controllers
Internal current draw:	92 mA

1.5.4 Type "xS": Stages with Stepper Motor

See "M-5x1 Stages with Stepper Motors" Section on page 20.

1.6 Recommended Motor Controllers

M-5x1 series stages with DC motor drives can be used with C-842, C-843, C-844, C-848, C-862 Mercury. The M-5x1.2S 2-phase stepper motor versions can be used with C-600 or C-630 stepper-motor controllers.

2 Linear Scale Position Encoder

An optical linear encoder is mounted in the M-5x1 series stages. It features 0.1 μm linear resolution and can be used at velocities up to 50 mm/s.

The optical encoder is mounted in the center of the stage, close to the ballscrew drive to prevent possible cosine error. The linear encoder measures the actual position of the moving carriage directly, thus eliminating drivetrain errors such as non-linearity, backlash or elastic deformations.

The encoder is based on an optical grating and a noncontacting read head with integrated signal conditioner and interpolator.

3 PWM Amplifiers

Stages with a direct DC-motor drive (M-5x1.DD and M-5x1.PD) have the revolving spindle ball connected directly to the 30-watt DC motor by a flexible coupling.

For maximum dynamic performance, the DC servo-motors are driven by high-efficiency PWM power amplifiers integrated into the stages. An external line-power power supply (order number: M-500.PS) is provided to supply the built-in amplifiers directly. This architecture allows high torque and high velocities, while loading the motor controller with control signals only. The actual power is provided by the external supply.

4 Position Sensors

4.1 Limit Switches

M-5x1 series stages are protected against running into the hard stop by double-level magnetic limit sensors (Hall-effect sensors with TTL drivers) at each end of travel.

The **inner limit sensors** (*N1 at the negative-travel end and P1 at the positive-travel end*) work with the controller's limit-sense input lines. The TTL output signal is active-high.

The **outer limit sensors** (*N2 at the negative and P2 at the positive end*) work locally, opening a relay that cuts the motor current. The second-level limit switches provide for fail-safe operation in case the controller fails to stop the motor when the first-level limit sensor is reached.

If the second-level limit switch is reached, the stage can not be operated by the controller until the platform is pushed back manually. Disconnect the motor cable or set the motor into the MOTOR OFF state before pushing the platform back into the current-allowed area.

Limit Switch Sensor Specifications:

Type:	magnetic (Hall-effect) sensors
Power supply.	+5 V / GND, supplied by the motor controller through the motor connector.
Voltage output:	TTL level
Sink / Source capab.	± 48 mA
Logic:	active-high, normal motor operation: low, Limit switch reached: high

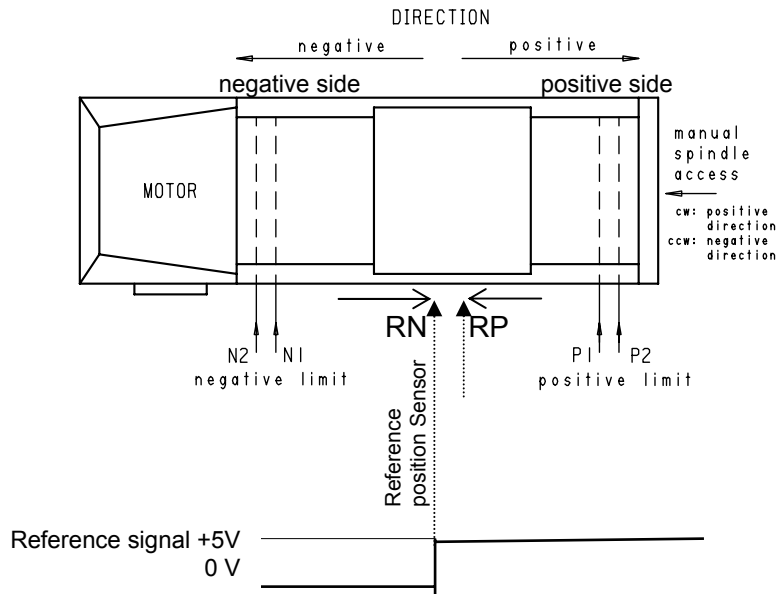


Fig. 2 Location of magnetic limit switch and reference-position sensors

Distances to selected points in mm:

NOTE

All values given may differ by a few percent from stage to stage

Stage	M-511.DD	M-521.DD	M-531.DD
N1 ... P1 (nominal operating range)	107 mm	207 mm	307 mm
RN ... N1	51 mm	104 mm	154 mm
RP ... P1	56 mm	103 mm	153 mm
RN ... RP	0.3 to 0.5 mm		
N2 ... N1	5.3 mm		
P2 ... P1	5.3 mm		

1 mm == 10,000 counts

4.2 Position Reference Signal Sensors

Position Reference Sensors are located approximately in the middle of the operating range and can be used to reference the absolute position of the stage within 0.5 µm accuracy. Always approach the reference sensor from the same side to reach the

same position. The difference in the reference points when approached from the positive side and from the negative side is about 0.2 mm to 0.4 mm.

The reference sensor in M-5x1 series stages provides a static signal level which depends on the platform position. If the platform is on the "positive side" the reference signal is +5 V, while if the platform is on the "negative side", the signal level is 0 V. The C-844 DC-motor controller offers the option of starting a search run for the reference point using the current reference sensor signal to determine the appropriate direction (see MS 52E user manual, command reference for the "TARGET:FIND:REF AUTO" command).

C-842 Motor Controllers offer only the FEP and FEN commands to start a search run for the reference signal. If the stage is initially on the "positive side", the FEN (find edge in negative direction) command must be used, whereas when the stage is in the "negative side" the FEP command must be used to start the search run in the right direction, i.e. toward the reference point.

5 Operating M-5x1 Stages

M-5x1.DD series stages have internal linear scales, PWM amplifiers and optional motor brakes. Individual setting of motion control parameters is required for smooth and optimized movement. Incorrect parameter setting may cause severe spindle vibration (for details see section 5.2 on page 15). If this occurs set the motor off (MF) and modify the parameter settings.

If the motor-brake option is installed, the operators and/or programmers should take measures to ensure that no platform motion occurs or is commanded while the motor brake is clamped (ON state).

5.1 Mechanical Handling

5.1.1 Mounting

M-5x1 series stages can be mounted in any orientation, horizontally or vertically.

To achieve the specified guiding accuracy, the stages have to be mounted on a flat surface to avoid torsion of the basic profile.

5.1.2 Operating Environment

M-5x1 series stages should be operated in clean environments. Although the bearings and ballscrew are covered to protect against dust and liquids falling vertically, the aluminum case is not hermetically sealed. Make sure that metal dust and liquid spray do not enter the case via the gap between the cover and the aluminum body.

5.1.3 Maintenance

When operated in a clean environment, no maintenance is required. If the stages are operated in extremely dusty environments, we recommend cleaning and greasing the ballscrew and linear bearings from time to time. The time interval depends of the degree of contamination and can vary from 100 to 800 operating hours.

Recommended lubricant for ball screws:

KLÜBER Staburags Type NBU 8EP or Beacom 325

5.2 Motor Controller Setup

5.2.1 Using C-843 Motor Controllers with M-5x1 Stages

The C-843 is an add-on card to be installed in a PCI slot of a PC; 2- and 4-axis versions are available, and more than one card can be installed in the same PC. PWM and analog stages can be run off the same card without using a converter box.

See the C-843 user and software manuals for information on this controller and its software interfaces. Suitable control settings are provided in the controller software.

5.2.2 Using C-848 Motor Controllers with M-5x1 Stages

The C-848 is a benchtop/rackmount unit. It is actually an industrial PC with C-842 cards installed. See the C-842 section below and the C-848 manuals for more information. Settings suitable for the M-5x1 are included in the stage database integrated with the *C-848Control* software.

5.2.3 Using C-842 Motor Controllers with M-5x1 Stages

If stages are equipped with the motor-brake option (M-5x1.DDB or M-5x1.PDB) C-842.xx controllers should be used. These controllers offer the appropriate signals for motor brakes, controllable via the digital output channels #7 and #8.

WinMove and WinMoveNT are the standard operating programs for C-842 Motor Controllers being operated from Windows platforms. WinMove allows configuration of the M-5x1 stages by a configuration file.

WinMove software automatically handles amplifier mode setting as a function of the stage model number selected.

The amplifier mode can also be set by command: PWM mode is enabled by the "SOP" command while analog mode is enabled by the "SOH" command.



Example of Configuration File for Use by WinMove :

```
; File: "WINMOVE.CFG"
; WinMove Configuration File for C-842
; -----
BOARDMODE=9
LIMITMODE=autodetect
STAGE1=M-511.DD
STAGE2=M-521.DD
STAGE3=M-511.DD
STAGE4=M-405.PG
```

C-842 Parameter Settings for M-5x1 Stages			
Stage Type: Parameter	".DD"	".PD"	".DG"
p- term	DP35 (30 to 60)	DP120 (80 to 300)	DP250 (150 to 300)
i- term	DI5 (0 to 20)	DI20 (0 to 50)	DI40 (0 to 50)
d- term	DD200 (0 to 500)	DD150 (0 to 400)	DD800 (0 to 1,200)
i- Limit	DL2000	DL2000	DL2000
vff- term	DF0 (0 to 3,000)	DF0 (0 to 3,000)	DF0 (0 to 1,500)
Acceleratio n	SA800 (40 to 1,500)	SA400 (20 to 1,000)	SA800 (20 to 1,200)
Velocity	SV300000 (1 to 500,000)	SV180000 (1 to 270,000)	SV120000 (1 to 200,000)

5.2.4 Using C-844 Motor Controllers with M-5x1 Stages

DCMove is the standard C-844 operating program. This program uses a configuration file to define the motion control parameters. First use the parameter menu to set these values:

PWM mode is enabled by the OUP:SIGN PWM command, while analog mode is enabled by the OUP:SIGN DAC command.



C-844 Parameter Settings for M-5x1 Stages			
Stage Type:	".DD"	".PD"	".DG"
p-i-d terms	PID 35,5,200 p : 30 to 60 i : 0 to 20 d : 0 to 500	PID 120,20,150 p : 80 to 300 i : 0 to 50 d : 0 to 400	PID 250,40,800 p : 150 to 300 i : 0 to 50 d : 0 to 1,200
i- Limit	LIM:IERR 2000	LIM:IERR 2000	LIM:IERR 2000
vff- term	VFF0 (0 to 3,000)	VFF0 (0 to 3,000)	VFF0 (0 to 1,500)
Acceleration	ACC 1800000 (100,000 to 3,500,000)	ACC 1000000 (500000 to 2500000)	ACC 2000000 (500,000 to 3,000,000)
Velocity	MVEL 300000 (1 to 500,000)	MVEL 180000 (1 to 270,000)	MVEL 120000 (1 to 200,000)

5.2.5 Using Mercury Motor Controllers with M-5x1 stages

The Windows operating program for the Mercury controller allows choice of M-5x1 stages as a start option for operation. Mercury always has the PWM mode enabled without any extra command. Ensure that the brake is set off by issuing the "BF" command prior commanding any moves.

Mercury Parameter Settings for M-5x1 Stages			
Stage Type:	".DD"	".PD"	".DG"
p- term	DP35 (30 to 60)	DP120 (80 to 300)	DP250 (150 to 300)
i- term	DI5 (0 to 20)	DI20 (0 to 50)	DI40 (0 to 50)
d- term	DD200 (0 to 500)	DD150 (0 to 400)	DD800 (0 to 1200)
i- Limit	DL2000	DL2000	DL2000
Acceleration	SA2000000 (100,000 to 3,000,000)	SA1000000 (500,000 to 2,500,000)	SA2000000 (500,000 to 3,000,000)
Velocity	SV300000 (1 to 500,000)	SV180000 (1 to 270,000)	SV120000 (1 to 200,000)

5.2.6 Stepper Motor Controller Setup

Controller setup (and multi-axis networking) for the stepper motor versions is fully described in the controller documentation. All PI stepper-motor devices can be networked together and up to 9 axes controlled off of single RS-232 port of a host PC.

6 M-511, M-521, M-531 Dimensions

(decimal places separated by commas in drawings)

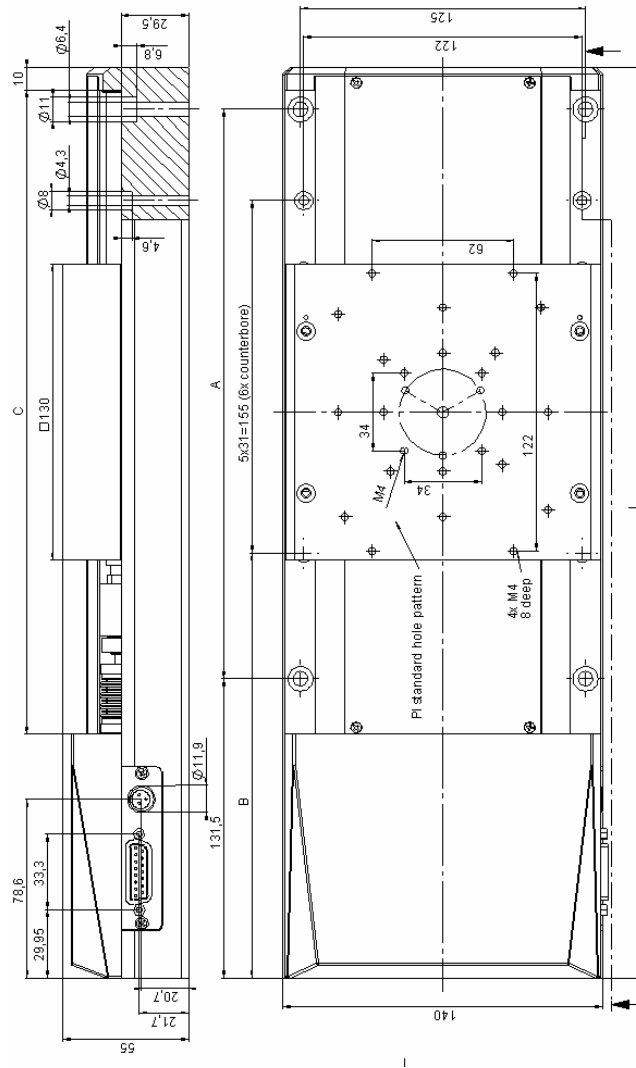


Fig. 3 M-511, M-521, M-531 Dimensions

	L	A	B	C
M-511.xx	400	250	186.5	283
M-521.xx	500	350	236.5	383
M-531.xx	600	450	286.5	483

7 M-5x1 Stages with Stepper Motors

7.1 M-5x1.2S (using 2-phase stepper motors)

M-511.2S, M-521.2S, M-531.2S are equipped with 2-phase stepper motors performing 20,000 steps per revolution in microstepping mode using a C-600 or C-630 Stepper Motor Controller.

Motor Manufacturer:	Nanotec
---------------------	---------

Type:	4H4009-L03-B
-------	--------------

Current per phase:	0.8 A
--------------------	-------

Phase resistance:	3.3 Ohm
-------------------	---------

Torque:	21 Ncm
---------	--------

Connector: at stage	DB25(m)
---------------------	---------

Cable type	C-815.37
------------	----------

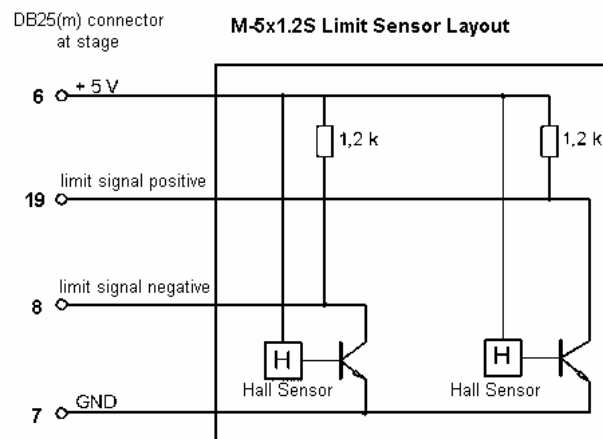


Fig. 4 M-5x1.2S Limit Sensor Layout,
decimal places separated by commas in drawing

Pin	Function
1	Phase 1a
14	Phase 1b
2	Phase 2a
15	Phase 2b
3	n.c.
16	n.c.
4	n.c.
17	n.c.
5	n.c.
18	n.c.
6	+ 5 V Supply from Controller
19	Positive End Limit Signal
7	GND
20	Reference Signal
8	Negative End Limit Signal
21	nc
9	nc
22	nc
10	nc
23	nc
11	nc
24	nc
12	nc
25	nc
13	nc

7.2 M-5x1.5S (using 5-phase stepper motors)

Motor type: 5-Phase stepper motor,
Type RDM 545, LHA, 1 A phase
current, w/o second shaft

Connector type at stage: Sub-D25(m)

Cable type: order # C-815.37,
SubD25(f) to DB15(m)

Pin Assignment:

Pin	Function
1	Phase 1a
14	Phase 1b
2	Phase 2a
15	Phase 2b
3	Phase 3a
16	Phase 3b
4	Phase 4a
17	Phase 4b
5	Phase 5a
18	Phase 5b
6	+ 5 V Supply from Controller
19	Positive End Limit Signal
7	GND
20	Reference Signal
8	Negative End Limit Signal
21	nc
9	nc
22	nc
10	nc
23	nc
11	nc
24	nc
12	nc
25	nc
13	nc

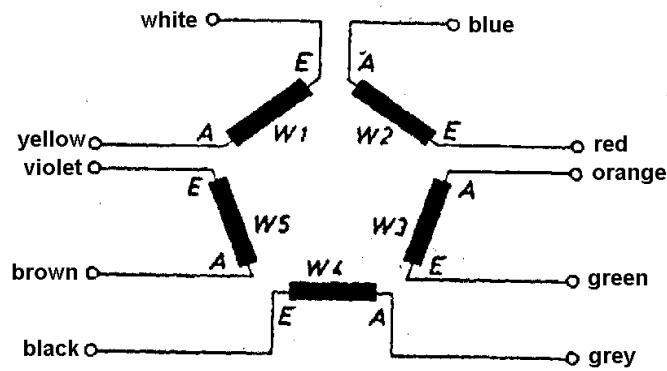


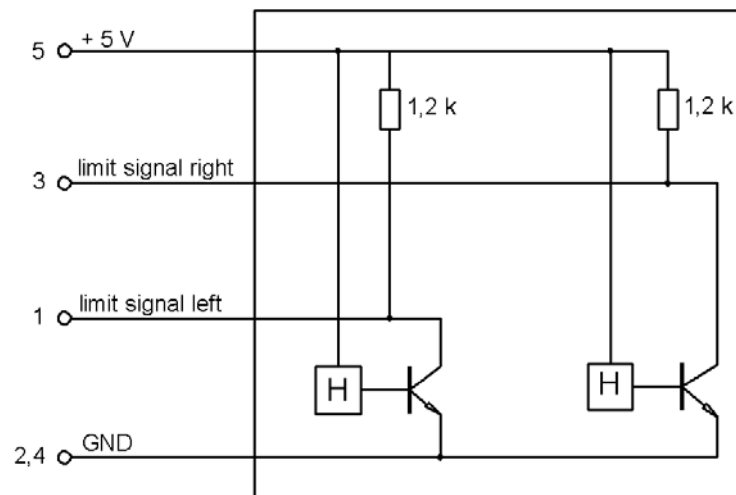
Fig. 5 Phase wiring diagramm

Limit and Position Reference Sensors:

All sensors used are magnetic field triggered (Hall-effect sensors), usable with bipolar or CMOS circuitry.

Sensor Specs:

Supply Voltage Range:	4.5 to 24 volts
Supply Current:	4.5 mA
Sink Capability:	25 mA



M1265S001

*Fig. 6 M-5x1.5S Limit Sensor Layout
decimal places separated by commas in drawing*

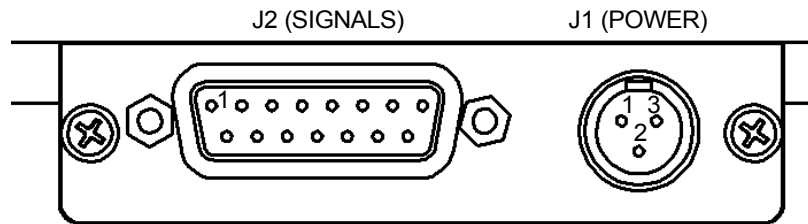
Signal Levels (active low):

Inside allowed travel range:	+ 5 V
Outside allowed travel range:	GND

8 Pin Assignments

M-5x1 series stages are equipped with male DB15 sockets for connecting the motor controller and one 3-pin, round connector for the power supply.

8.1 M-5x1.DD, M-5x1.PD



Connector J1 (Power Supply)

Type: 3-pin, round socket
Reference No: Switchcraft Tini Q-G

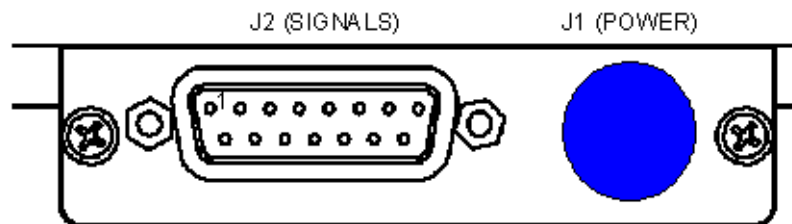
PIN	Signal
1	GND
2	Voltage input
3	n.c.

Connector J2 (Signals, Controller connection)

Type: 15-pin Sub-D connector
Reference No.: AMP #9-215594-1

Pin	Signal
1	Control input for optional motor brake (TTL)
9	n.c.
2	n.c.
10	PGND
3	MAGN
11	SIGN
4	+5 V input
12	NLIMIT (Limit signal of negative side)
5	PLIMIT (Limit signal of positive side)
13	REFS (origin signal)
6	GND (Limit)
14	A(+)
7	A(-)
15	B(+)
8	B(-)

8.2 M-5x1.DG



Connector J1 (Power Supply)

Not installed

Connector J2 (Signals, Controller connection)

Type: 15-pin Sub-D connector
Reference No.: AMP #9-215594-1

Pin	Signal
1	Control input for optional motor brake (TTL, +12 V max)
9	Motor (-)
2	Motor(+)
10	Power GND
3	not used
11	not used
4	+5 V input
12	negative limit (Limit signal for negative side)
5	positive limit (Limit signal for positive side)
13	REFS (position origin signal)
6	GND (Limit)
14	A(+)
7	A(-)
15	B(+)
8	B(-)

