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PHASE MOTION CONTROL

wave

High acceleration linear PM motor

Rare Earth, Linear PM Motors for Automation

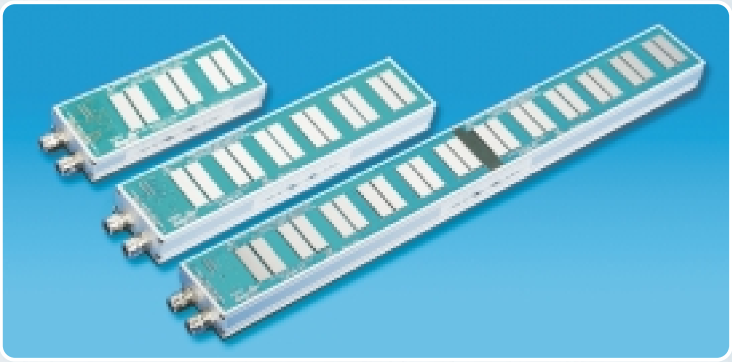
Optimised for:
10-250 kg payloads
replacement of racks – belts – gear motors
high acceleration – speed
travel: 500-6000 mm
positioning time < 100 msec

Beyond rack and pinion, belt, ball screw…

wave Linear Motors

Evolution in positioning

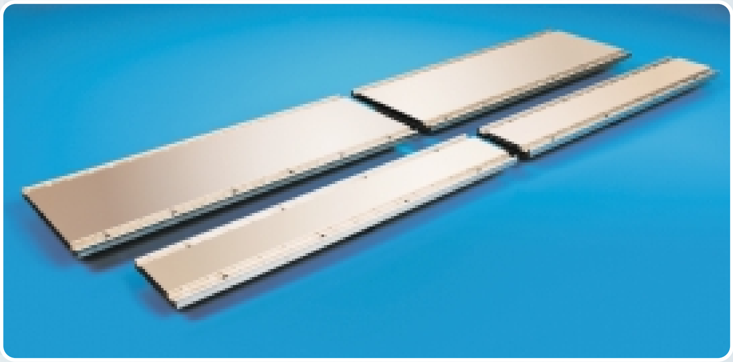
- *Fast positioning and indexing*
- *Suitable for payloads between 10 and 250 kg*
- *Accelerations up to 5 g*
- *Speed up to 6m/sec*
- *Easy mounting with wide mechanical allowances*
- *Conduction/convection natural cooling (IC 0041)*



The *Wave* series, the third generation of linear motors from Phase Motion Control, was designed and produced to replace competitively and with superior performance all linear positioning systems which carry a mostly inertial payload between 10 and 250 kg.

Wave motors are designed to be easily mounted on a machine, they do not require cooling and they match directly with all Phase Motion Control drives. Linear motors replace all the mechanic conversion systems (reducers, pinions, racks, screws, couplings) with a single component with no moving or contact part, and no significant alignment requirements. The resulting positioning systems display the highest level of dynamic performance and control bandwidth available today.

The removal of all mechanical gearing improves the performances and reliability of the applications as all members subject to wear have been suppressed. The novel, patented internal structure of *Wave* motors, which is optimized for mass manufacture on automated equipment, makes the application also extremely competitive when compared to the traditional solution.



Applications

- *Cartesian-coordinate positioning and assembling robots*
- *Plotter and laser cutting machine, waterjet*
- *X-Y sewing machines*
- *Systems to load/unload parts*
- *Fast tool-changers*
- *Flying shears*

What is a Linear Motor?

Linear motors of the *Wave* series are electric units which generate a thrust. They do not have a bearing system of their own and are intended to be carried on the carriage of the driven machine. A typical mounting example is shown in the picture. The motor is composed of:

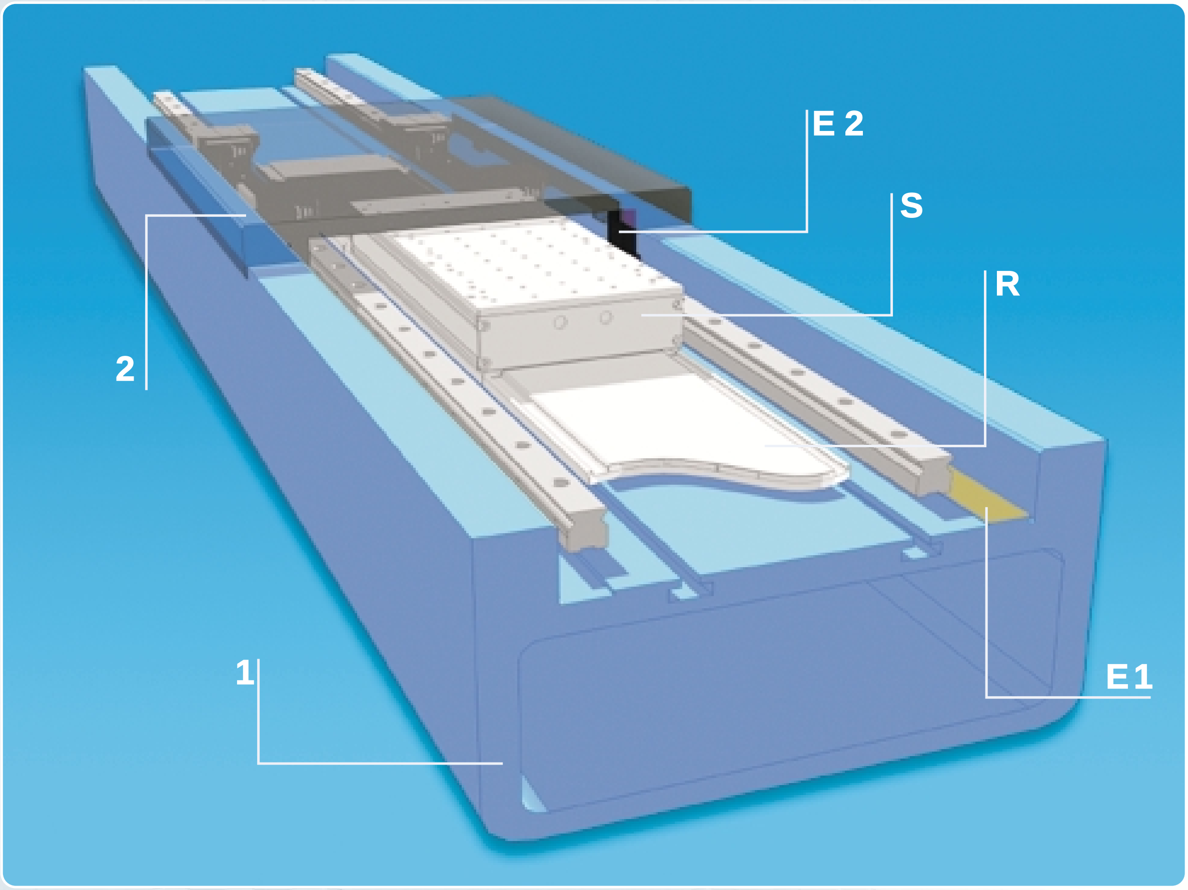
• a stator, or slider, (S) that carries the windings, the probe for thermal protection and monitoring (PTC + KTY 84) and, when necessary, the magnetic position sensor (option S)

• a magnetic rail or Rotor (R) made up of several segments to get the necessary length.

The length of the magnetic rail must be equal to the working stroke plus the magnetic overlap (SM) appropriate to each type of motor (see Technical Data Summary).

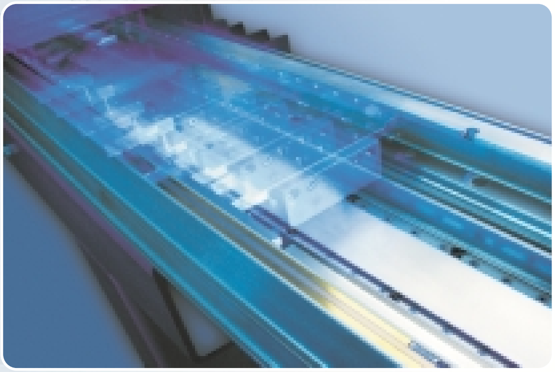
The motor has no supports and is to be mounted on the driven carriage; the drawing shows an example of a machine bench made of a steel or light alloy profile (1) and a carriage (2) with linear ball slider supports; the stator and rotors mounting seats must be shaped to ensure the correct position and distance between the stator and the magnetic rail (see (1) in the Application Notes).

The positioning system must be fitted with a position sensor (E1, E2), usually a magnetic or optical encoder, whose read head must be mounted rigidly on the carriage, as close as possible to the motor:



MAGNETIC ATTRACTION

In all the *Wave* series motors, there is a constant attraction between stator and magnetic rail, even when the motor is de-energized. Such an attraction may be used to preload the bearings or to balance a part of the load when the motor is properly installed. In any case, this attraction must be taken into consideration when sizing the support system that must always be of a rolling type.

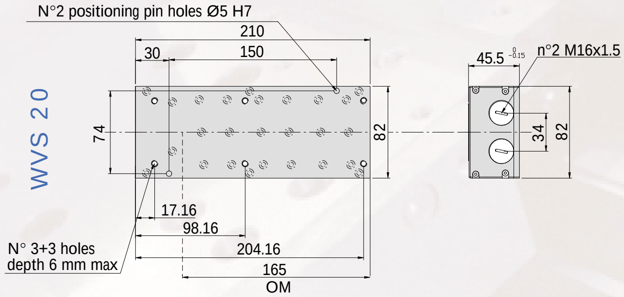


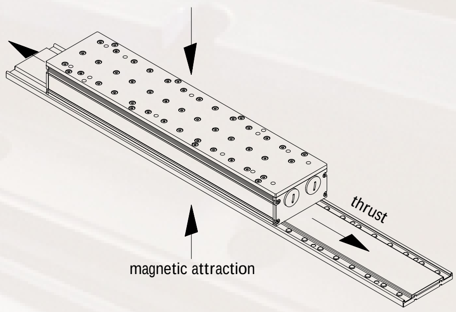
Technical Drawings

Also available in DXF format at http://www.phase.it

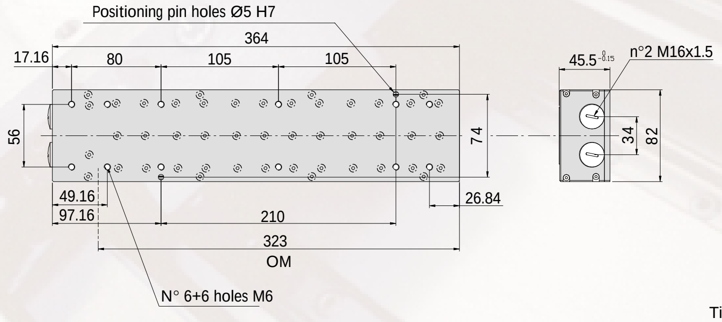
Stator series WVS

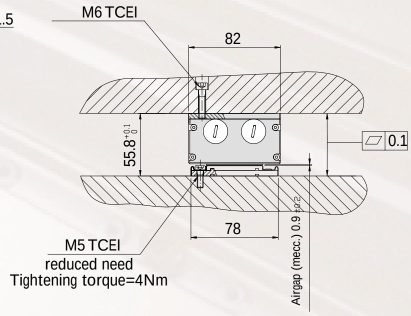
WVS 20



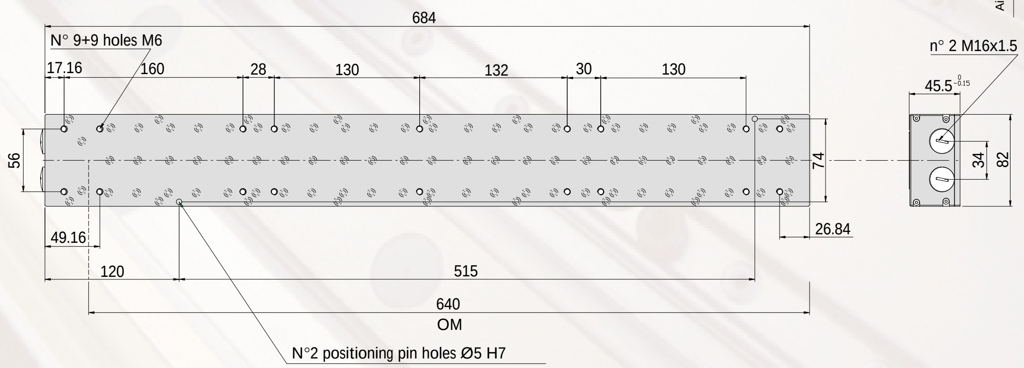


WVS 40



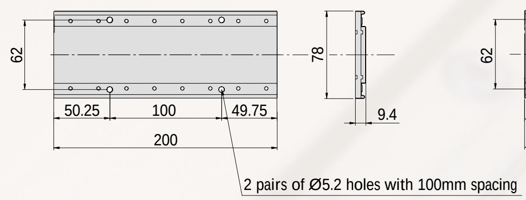


WVS 80

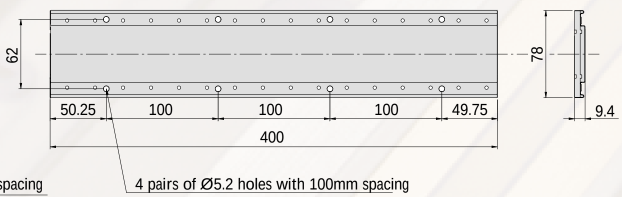


Rotor series WVR

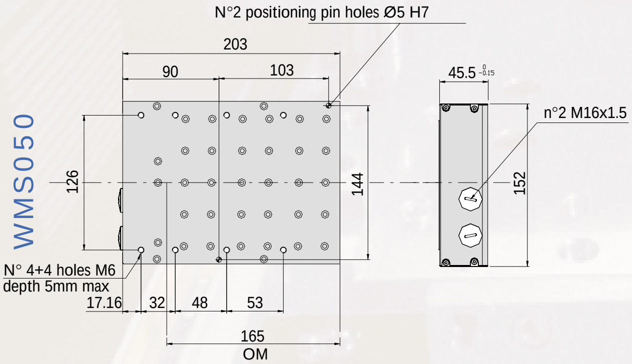
WVR 2

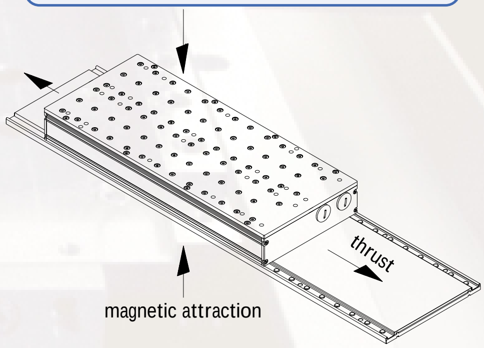


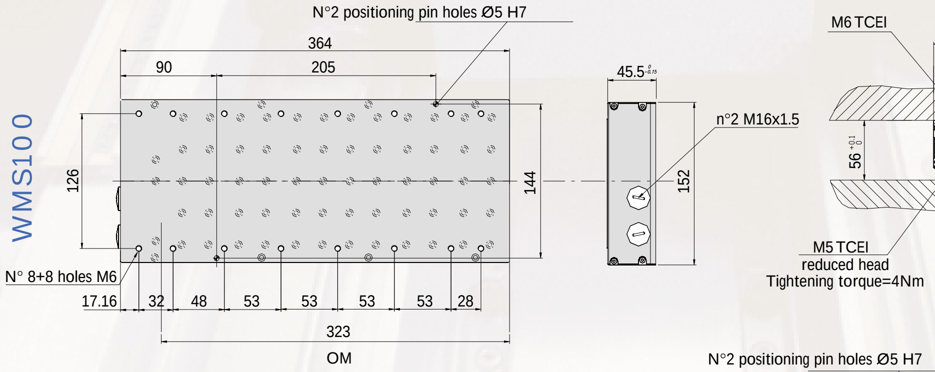
WVR 4

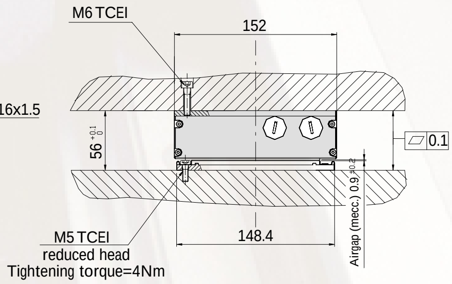


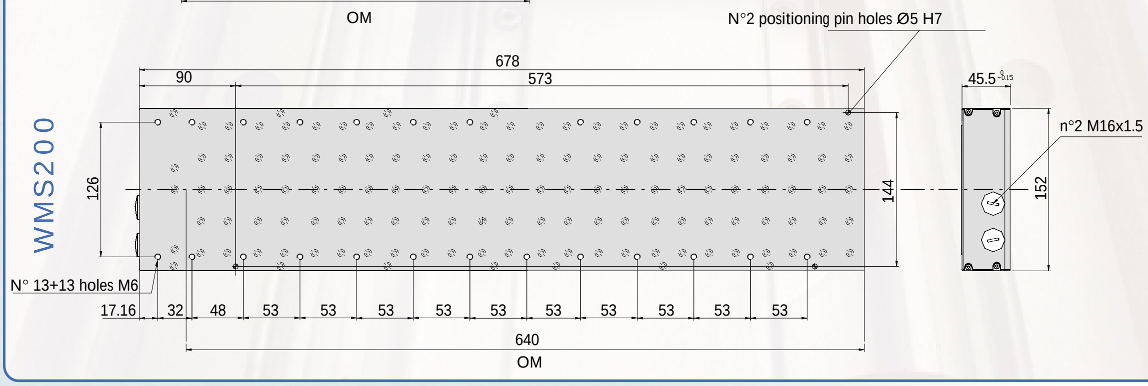
Stator series WMS





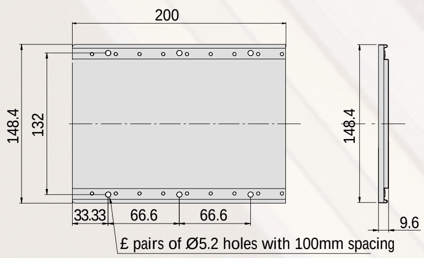




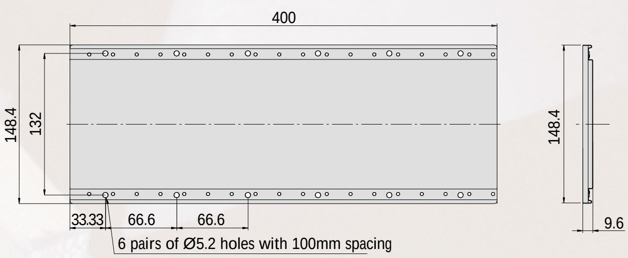


Rotor series WMR

WMR 2



WMR 4



Technical Data Summery, Wave Motors

	Symbol	WVS.20.6.3	WVS.40.6.3	WVS.80.6.3	WMS.050.6.3	WMS.100.3.3	WMS.100.6.3	WMS.200.6.3	Units
Quick Reference data:									
Nominal thrust, c. duty S1, 0 speed, copper 130 C, base 60C [1]	T100	184	368	736	495	985	983	1967	Nrms
Base speed [2]	wn	6	6	6	6	3	6	6	m/s
Nominal power, cont. duty [1]	Pn	1105	2207	4414	2972	2955	5901	11802	W
Peak thrust, 10% duty [3]	Tpk	415	829	1657	1116	2220	2216	4432	Nrms
Physical data:									
Slider mass	Jm	2,95	5,40	10,30	6,25	11,45	11,45	21,84	kg
Acceleration at peak thrust [3]	apk	14,3	15,6	16,4	18,2	19,8	19,8	20,7	g
Rail mass/m	M	3,9	3,9	3,9	7,3	7,3	7,3	7,3	kg/m
Magnetic overlap	OM	165	326	643	165	326	326	643	
Insulation					Class F				
Cooling					Conduction/convection				
Magnetic attraction, slider to rail		1250	2500	5000	3000	6000	6000	12000	N
Protection		IP 20	IP 20	IP 20	IP 20	IP 20	IP 20	IP 20	
Thermal data:									
Motor loss [5] at nominal thrust [1]	Ln	66	132	264	158	317	317	634	W
Thermal imp., copper to base	Rthf	1,06	0,53	0,27	0,44	0,22	0,22	0,11	°C/W
Thermal capacity	Cth	1235	2260	4312	2618	4792	4792	9141	J/°C
Thermal time constant	τa	1309	1198	1143	1156	1058	2019	1009	s
No load loss at base speed	L0	8	16	32	12	24	60	120	W
Treshold of built-in PTC (3x)	PTCt	130	130	130	130	130	130	130	°C
Electrical data:									
Pole pitch	PN	20	20	20	20	20	20	20	mm
Connection		Y	Y	Y	Y	Y	Y	Y	
Back E.M.F, 20 °C [4]	Ke	35	43	43	42	84	51	51	Vs/m
Thrust constant [4]	Kt	58	70	70	70	138	84	84	N/Arms
Temperature coefficient of E.M.F. and Kt	dKe/dT	-0,09	-0,09	-0,09	-0,09	-0,09	-0,09	-0,09	%/°C
Winding resistance, 20°C [4]	Rw	3,2	2,4	1,2	1,6	3,1	1,2	0,6	Ohm
Winding inductance (1000Hz) [5]	Lw	51	38	19	31	61	23	11	mH
Nominal voltage at nom thrust, speed 1,2	Vn	256	312	312	320	324	386	386	Vrms
Max speed at peak thrust with 350 Vac	ωpk	4,50	3,65	3,65	3,38	1,64	2,79	2,79	m/sec
Nominal current, zero speed [1]	In0	3,20	5,23	10,45	7,09	7,13	11,64	23,29	Arms
Peak current [3]	Ipk	9,61	15,70	31,40	21,29	21,41	34,98	69,96	Arms
Frequency at base speed [2]	fn	150	150	150	150	75	150	150	Hz
Min. demag. current, 125°C	Idm	29	47	94	64	64	105	210	Apk
Recommended connection wire size	Wsize	1,0	1,0	2,5	2,5	2,5	2,5	8,0	mmq

Motor specification

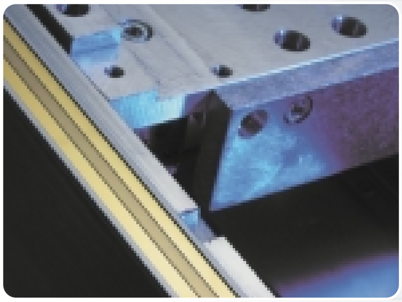
The data reported are nominal and do not take standard manufacturing allowances into consideration. In particular, EMF, Kt and Rw are granted a deviation within +/- 10% of nominal value. All data are referred to a motor correctly mounted with a nominal magnetic gap.

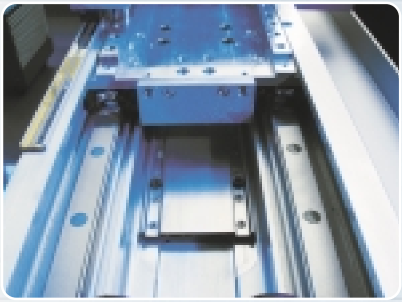
1) The nominal thrust is the thrust which can be output under continuous operating conditions, or an equivalent rms at low speed, at which the copper temperature settles at 120°C provided that the mounting plate can dissipate the nominal heating load 5) settling at a temperature lower than 60°C.

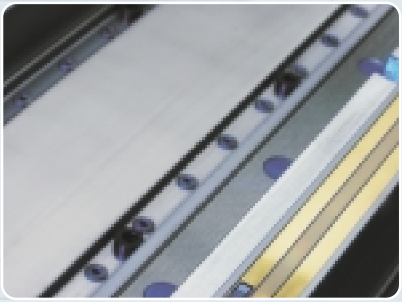
2) The nominal speed is the speed at which the motor voltage at nominal thrust is equal to the supply voltage minus 15% to allow for drive voltage drop. If the operation requires a peak thrust at a high speed, make sure that the voltage compliance of the drive is higher than the vector sum of the EMF plus the voltage drop across the motor impedance at the required operating point.

3) Peak thrust is the thrust above which the saturation of the magnetic circuit makes any additional motor overloading irrelevant. In the *Wave* series, this limit has been coordinated with the system thermal limits and the peak thrust may be sustained at most for an interval equal to the thermal time constant /10 and up to a duty cycle of 10%.

4) Recommended size of the flexible tie cables. Use exclusively highly flexible cables with internal lubrication, as close as possible to the specified size. Route the cables into a crawler suitable for high acceleration leaving them free to flex without constraints or friction.







Application Notes

Seats machining allowances and mounting procedure

The *Wave* series Motors have a nominal airgap of 0,9 mm allowing the motor to be easily mounted.

The total mechanical and motion tolerance may not vary the nominal magnetic gap by more than +0,1 /-0,3 mm not to jeopardize the system performance. A greater than nominal airgap causes a reduction of the effective thrust, and thus may result in motor overheating. A smaller than nominal airgap (with no mechanical contact!) increases the thrust but reduces the maximum possible speed and increases cogging.

The rotor, or magnetic rail, must be assembled on a surface with appropriate length and a recommended flatness within 0,1 mm over 400 mm. On longer spans, flatness error does not influence the operation of the motor unless the structure of the supports leads to changes in the magnetic gap beyond the nominal tolerance. The plane supporting the magnetic rail may be either in ferromagnetic or nonmagnetic material, such as light alloy.

It is better to use a nonmagnetic plane in order to prevent a slight eddy magnetization of the operating machine which might generate eddy currents in the supports.

Rail segments are placed on the mounting plane and are assembled one after the other according to the magnetization direction (when correctly mounted, segments attract one another in the correct position).

Segments are fastened with Torx or socket-head stub screws to a tightening torque of 4 Nm; when the clear length of the screw is more than 20 mm, no locking device is necessary; when the clear length is shorter, make sure that vibrations and thermal stress do not loosen the screws. To do so, use either a lock washer (or self-locking screws) or a thread locking material similar to Loctite 222 or 242.

The linear motor allows a side misalignment (perpendicular to the motion direction) of +/- 0,5 mm; therefore, the mounting requires no side mark nor ledge.

The mounting allowance in the motion direction is +/-0,5 mm taken as the maximum deviation between two segments of the motor. Consequently:
• when the threaded holes of the mounting plane are made within the recommended allowance ⌖ 0,1 , during the mounting, the holes may be taken as reference for any rail length.
• When the mounting plane is made with T slots with no longitudinal binding, the tolerance of the magnetic segments allows the end-to-end mounting up to a length of 2 m.
Greater lengths require a check during the mounting and if necessary, use gauged shims between one segment and another.

The flatness of the stator mounting surface must be < 0,05 mm all over the mounting plane.

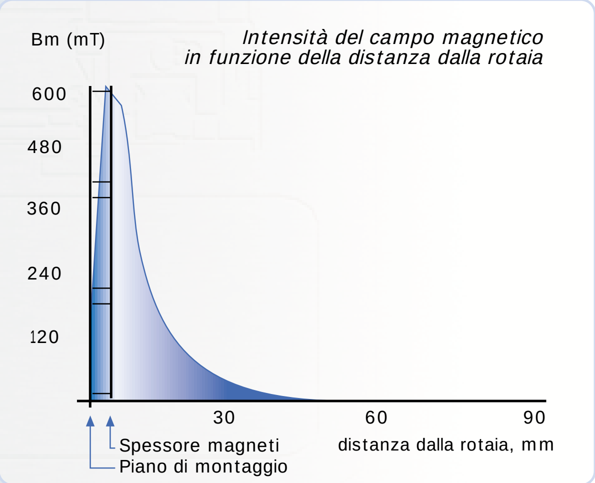
The stator is fastened to the carriage by means of screws that must penetrate the stator 6 mm maximum.
If several stators are mounted in parallel on the same magnetic track, the stators spacing must be exactly n x 40 mm +/- 0,1 mm where n is whatever integer number.
In this case, use the positioning pin holes located on the stators mounting plates.

CAUTION !

Magnetic rail segments are made of powerful rare-earth permanent magnets which attract each other with a very strong force. During the mounting, prevent rotors from contact or vicinity (< 100 mm) of ferromagnetic objects. Do not work on iron benches or tables. Take out from the package only one segment at a time and fix it. When two segments come into contact on the magnetic side, the force of attraction exceeds 15.000 N and it is impossible to separate them without damage.

Linear motor protection, magnetic field leakage

Wave motors have a degree of protection IP 20 adequate for assembly inside the driven machine. The magnetic rail may attract ferromagnetic objects within a distance of about 60 mm.
As a reference, the figure shows the decay with the rail distance of the steady state magnetic field of the rail: the residual field is less than 5 Gauss at 60 mm.
The magnetic field of the motor rail is constant and does not generate any RFI. Typically, it does not interfere with magnetic position sensors and all the differential sensors.
If the environment is characterized by ferromagnetic dust, the magnets may act as a filter attracting the dust. The deposit of dust does not create any trouble until it does not invadee significantly the magnetic gap. This problem, which is common to all linear magnetic encoders, is generally overestimated. In any case, it is generally necessary to protect the magnetic rail, the linear sensor and the linear bearings. If ferromagnetic chips or dust is present, a slight overpressure must be maintained in the cavity of the motor.



Multimotor parallel operation

Several *Wave* motors may be applied on the same payload, connected in parallel to a single drive.
In this kind of configuration, each motor yelds the same **thrust**. Such a solution is particularly recommended for wide and flexible loads that may be moved without exerting any torsional or bending stress.
Note however that in such a configuration, motors do not control the relative **position** but the **thrust**, so they do not increase the structure stiffness.
Would this be required (for example, in a flexible "Gantry" geometry), motors are to be fitted with independent sensors and drives and must to be controlled by the same positioning reference. The AXV drives have a specific Gantry configuration software granting a safe operation even in case of alarm without deforming the structure.
It is also possible to use several independent motors on the same magnetic rail; in this case, each motor requires its own drive and sensor head.

Accuracy and repeatability; choosing a sensor

The linear motor is a faithful and linear generator of thrust; the accuracy and the quality of the movement depends on the linear sensor which is coupled to the motor and which has to be chosen according to the application requirements.
The sensor resolution must be much higher than the required accuracy.
For this reason, it is better to use linear sensors with 1V pk – pk analog output: all Phase Motion Control drives have interpolation capabilities to interpolate. The AXV line enhance the encoder resolution by 214.
Information on certificated linear sensors to be used with *Wave* motors and AX-V drives is available at www.phase.it. Generally, pick and place applications - or where the required accuracy is of 0,1 mm - use a magnetic stripe sensor; whereas, applications requiring an accuracy up to 1 µm use reflection or diffraction optical sensors.

Phasing the motor

In general, linear encoders suitable for linear motors do not provide absolute position information.
Consequently, a start-up or initialization cycle to transform the incremental signal into absolute is usually necessary. This process is included in the Phase Motion Control drives control software.
The typical start-up process consists of two steps:

1. The motor moves by a few encoder increments (it must be free to move) to establish the position of the magnetic field

2. The motor moves slowly until its acquires an external overtravel limit signal; it reverses its motion and acquires the first index of the encoder, thus zeroing the absolute position.

When the start-up process may not be activated, the motor has to be fitted with the option S which provides the drive with an absolute position of the magnetic field, at first start-up.

> IMPORTANT NOTE
>
> The power supply of Phase Motion Control drives as well as the signal and power logic circuits are completely separated. The emergency cycle may thus be executed disconnecting the power supply without cutting the signal input, thus without losing the encoder absolute position.

Identification of the *Wave* series motors

Motors of the *Wave* series consist of a stator and several rotors that have to be ordered separately to compose the necessary stroke length.

The reas rotors coding is as follows:
W■R□
■ Identifier of type of the magnetic rail and motor width: WV = motors width 82, WM = motors width 152.
□ Identifier of the length: available lengths:
- 2= 200 mm
- 4= 400 mm

Example: WVR2

The coding of the stators is as follows:
W■S■.□.□.□
■ Identifier of the stator, identifier of type of the magnetic rail and of motor width: V = motors, width 82, M = motors width 152.
■ Identifier of the thrust in dN, continuous
□ Identifier of the maximum speed at nominal thrust, m/sec: standard = 6 m/sec.
□ Identifier of the supply voltage: standard = 400 Vac = 3
□ Identifier of the sensor: available options:
- 0 = no sensor
- S = sine/cosine magnetic absolute sensor, 1 cycle = 40 mm, accuracy +/-0.5 mm

Example: WVS40.6.3.S

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