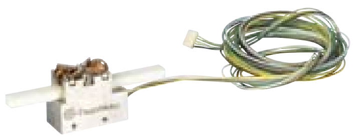
DIFFERENT TYPES OF PIEZO LEGS® MOTORS

Piezo LEGS® motors are available in rotating and linear versions and in different standard sizes . They are also available in standard, vacuum and non-magnetic versions.

We also produce OEM-motors for different applications and customers. If you have a special application or requirement, please do not hesitate to send us your specification for evaluation and recommendation. Our staff of mechanical and electronic designers will assist you in finding the optimal solution to your motion needs.

DIFFERENT DRIVE ELECTRONICS

There are standard drive electronics available for Piezo LEGS® motors both from PiezoMotor and from independent suppliers. They range from very simple and low cost to highly advanced. For guidance see our web page or contact us for recommendations. We will also be happy to assist you in designing your own drive and control electronics.

SENSORS

If your mechanical system requires position sensors, we will be glad to help you make a proper choice. Sensors that fit our motors are available in standard as well as custom solutions from several independent suppliers. Should you need to have the sensors integrated at the factory, please contact us for further assistance.

DEMO KIT

To fully appreciate what our piezo technology can do for you and your customers, contact us for application-specific information or order a demo kit online for direct evaluation. Demo kits for our standard motors are available online on www.piezomotor.com. We also have a team of engineers who have extensive experience both of piezo electric technology and of integrating our motors into existing systems as well as designing complete systems tailored to customer specifications. Let us show you how we can make your products smaller, easier to control and adjust, more reliable and durable.

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Piezo LEGS®

PiezoMotor
Simplicity in motion

GENERAL TECHNOLOGY

The Piezo LEGS® motor is designed for “move and hold” applications where precision, minimal space, low energy consumption and simple mechanical design are important factors. The motor is available in either linear or rotating versions. As the motor is of a non-resonant type it is also very easy to scale up and down in size. Today we have designed motors from a few N in force up to close to 500 N (See figure 1 for the possible design range for Piezo LEGS® motors).

Unlike resonant piezoelectric motors, which only operate at a given resonant frequency and therefore at fixed speeds, Piezo LEGS® motors offer extraordinary speed dynamics and can be operated at extremely low speed in the range of a few nanometres per second up to 20 – 30 mm/second and any speed in between at full control. What also makes the motor unique is its ability to take extremely small steps (in the single nanometer range) in combination with long strokes. This means that one Piezo LEGS® motor often can replace two motion systems, such as a DC-motor and a piezo actuator – without sacrificing performance.

The fact of the matter is that the Piezo LEGS motor has enabled significant simplification of the mechanical design in most motion systems that use it today. For our customers this has not only contributed to the reduced size and complexity of the end product, but more importantly – to reduced cost.

So what do you need to integrate and design your motion system based on Piezo LEGS®?

For a start we offer standard Piezo LEGS® motors in various sizes as well as drivers/controllers. (see figure 2)

We can also offer help with the selection of suitable position sensors as well as guidance and/or design of the mechanical interface of the motor. Our experienced mechanical and electronic designers are here to help you throughout the process.

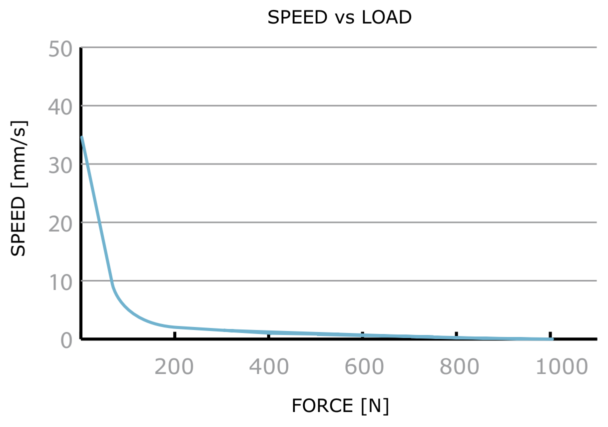


Figure 1. *Design range of linear Piezo LEGS® motor*

PIEZO LEGS MOTORS	**DRIVERS**
LEGS® 10N	PMC 2.1
LEGS R ® 80 Nmm	PDA 3.1
LEGS® 20N	PMD90
LEGS® 25N	3-AXIS DRIVER
LEGS® 50N	
LEGS® 150N	**ENCODERS**
LEGS® 300N	MAGNETIC
LEGS® 450N	GLASS SCALE
LEGS® OEM	CAPACITIVE
	OPTOREFLECTIVE
	OPTICAL
	PSD

Figure 2

PRINCIPLE OF MOTION

The Piezo LEGS® motor element consists of a number of drive legs. The number of legs on a motor element can vary, depending on the application and motor type.

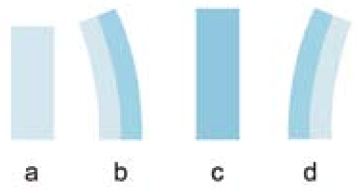
One drive leg can be seen as a piezoceramic bimorph. This means that each side of the drive leg is electrically independent and separated from the other side.

By applying a voltage to only one of the sides, this side will expand, while the other side will maintain its shape, causing the whole drive leg to expand and bend.

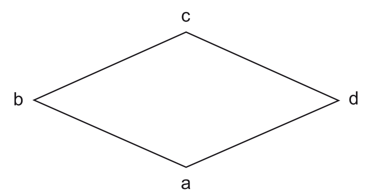
If equal voltage is applied to both sides of the drive leg, the drive leg will expand – move straight up.

Figure 3 describes a complete motion cycle of one drive leg (at the extreme positions; a, b, c and d). Thus the tip of the drive leg will describe a rhombic clockwise or anti-clock wise motion, i.e. forward or backwards.

Figure 3. *The two modes of motion, extension/ contraction and bending of a drive leg. The blue shaded parts illustrate an applied voltage*



The rhombic area within which the tip of the drive leg can move arbitrarily



THE WALKING DRIVE PRINCIPLE

The drive principle of the Piezo LEGS® motor is of the non-resonant type, i.e. the position of the drive legs is known at any given moment and at least two drive legs are in contact with the driven object (e.g. the drive rod or rotor disc) at all times. In short this assures very good control of the motion over the whole speed range.

The basic idea creating the motion in the motor is a walking action. Operating the drive legs in pairs so that one pair is moving forward, in contact with the drive surface, while the other pair of legs is repositioning in free space, getting ready for the next step, creates a step-by-step, synchronized movement – a walking motion.

Figure 4 illustrates the walking drive principle. The darker blue represents a higher applied voltage.

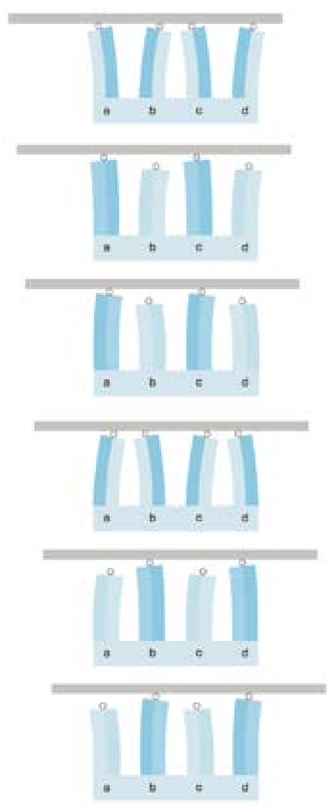


Figure 4. *Schematic illustration of the walking drive principle*

DRIVE CONTROL ELECTRONICS

From the description of the drive leg, it can be seen that two phases are needed to achieve motion in the drive leg. To get a walking action, two further phases are needed as two independent pairs of legs have to be used to create the motion in the motor. The same wave form can be used for all phases, phase-shifted 90° between each side of the drive leg and 180° between each pair of drive legs. Figure 5 illustrates the phase-shift between drive voltages, in this case with a sinusoidal voltage. The solid line corresponds to one pair of drive legs and the broken line to the other pair.

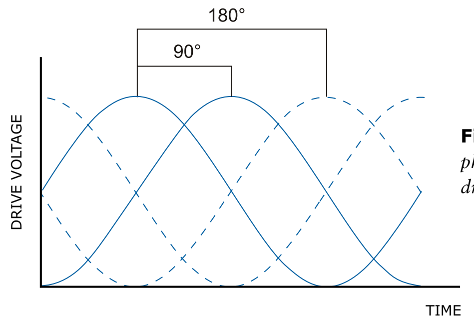


Figure 5. *Normal phase shifts between drive voltage signals*

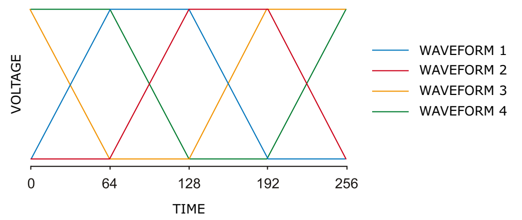


Figure 6. *Waveform to make the drive legs move along a rhombic trajectory*

WAVEFORMS AND RESOLUTION

Different analogue drive signals can be used to drive the motor, lending the motor different characteristics .
The voltage signals are always positive, normally between 0 and +46 V. For high speeds a rhombic waveform phase shifted 90° is ideal , as in figure 6. This means that the motor moves taking maximum steps all the time. However, better resolution is often preferable to speed. A way to achieve this is to take reduced steps. This can be done by reducing the phase shift from the 90°. In figure 7 a reduced step length of just 10% is achieved in this way. However, if a resolution better than 5% of the maximum step length is required, another method is preferable.

Micro-stepping is achieved by dividing the waveforms into points. The resolution will then be the combination of the resolution of the D/A converter and the number of points in the wave form. Example: 256 points in a waveform will give a resolution of 20nm for a 5μm complete step length, and this can be achieved with an eight-bit D/A converter.
Another way of fine-positioning in the single nanometer range is to bend the drive legs with an analogue voltage signal. This is referred to as bending mode.

If a very linear and even speed is required, thus minimizing the reversed motion that may occur during the releasing and gripping of the drive legs in a rhombic or sinusoidal waveform, a so-called Omega waveform can be used. See figure 8.

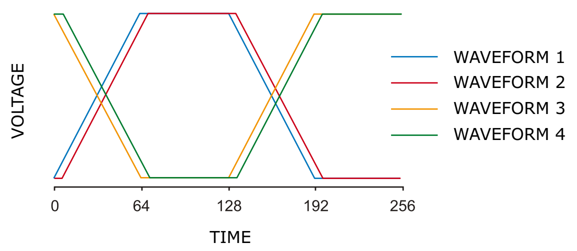


Figure 7. *Waveform giving a reduced step length*

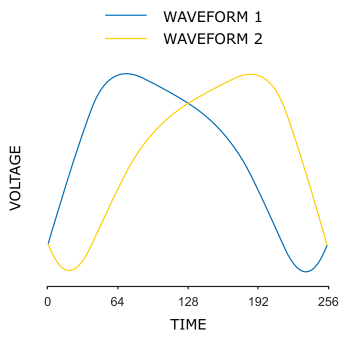


Figure 8. *Waveform giving a linear and smooth, even motion to the drive rod*

PERFORMANCE OF A PIEZO LEGS® MOTOR

The performance of a Piezo LEGS® motor is different from that of a DC or stepper motor in several aspects.

First of all a Piezo LEGS® motor is friction based, meaning the motion is transferred through contact friction between the drive legs and the drive rod or drive disc. You cannot rely on each step being equal to the next. This is especially true if the motor is operated under varying loads, as the step length will be affected by the loads. Figure 9 offers an example of the performance of a Piezo LEGS® motor, showing the speed/force relation.

Because the motor is friction based, it also has the advantage that there is no need to keep the motor electrically activated in order to hold a position. Nor will the motor be damaged if the drive rod is subjected to an impact force – the drive rod will simply slide. Another difference from conventional motors is that there is no inertia in a Piezo LEGS® motor, so it is ideal for move-and-hold applications as well as applications requiring very fast response times or low energy consumption, or a combination of the two.

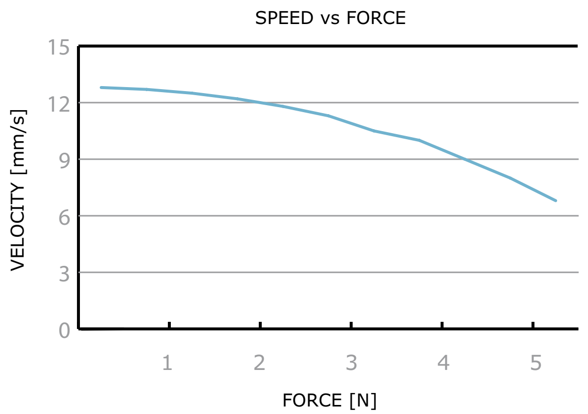


Figure 9. *Motor performance for a drive frequency of 2100 Hz.*