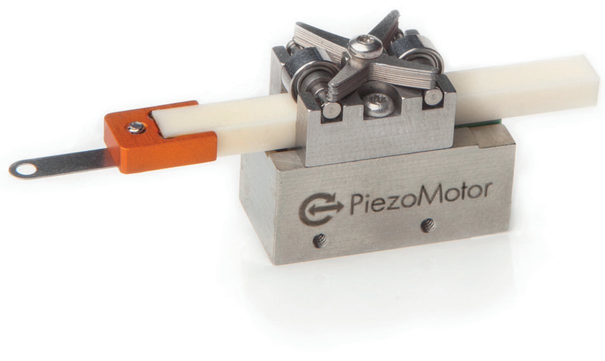
Piezo LEGS® Linear 6N



- **Direct drive – backlash free**
- **Nanometer resolution**
- **Simple drive electronics**
- **No power draw in hold position**
- **Quick response and high speed dynamics**

The LL10 linear motor is intended for a large range of OEM applications. Design focus has been for ease of integration. The very high speed dynamics and nanometer resolution makes it ideal for numerous applications.

The Piezo LEGS technology is characterized by its outstanding precision. Fast speed and quick response time, as well as long service life are other benefits. In combination with the nanometer resolution the technology is quite unique.

The motor is ideally suited for move and hold applications or for automatic adjustments. When in hold position it does not consume any power. The drive technology is direct, meaning no gears or lead screws are needed to create linear motion. The motor has no mechanical play or backlash. The LL10 linear motor is available in a standard version, and in a non-magnetic vacuum version.

Mechanical connection

The motor is easily integrated in your application using the drive rod mechanical adapter. Drive rods are supplied in different lengths (30, 40, 50, 60, 70 and 101.8 mm).

Operating modes

The motor can move in full steps (waveform-steps), or partial steps (microsteps) giving positioning resolution in the nanometer range. Speed is adjustable from single microsteps per second up to max specified.

Controlling the motor

PiezoMotor offers a range of drivers and controllers. The most basic one is a handheld push button driver. Another option is an analogue driver that regulates the motor speed by means of an ±10 V analog interface. More advanced alternatives are microstep drivers/controllers in the 100- and 200-series. These products allow for closed loop control and precise positioning. The microstepping feature divides the wfm-step into thousands of small increments which results in microsteps in the nanometer range. The PMD units are straight forward to use, supports quadrature and serial sensors, and have multiple I/O ports.

PMD101

PMD206

Design your own driver

Some customers prefer to design their own driver for ease of integration. PiezoMotor provides information to assist in the design.

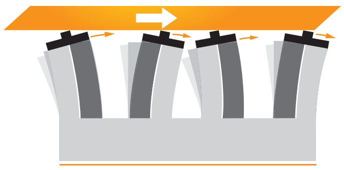
Ordering information	
Motors	
LL1011A-	Stainless Steel
LL1011D-	Non-Magnetic Vacuum
Drivers and Controllers	
PMCM21	Handheld push button driver
PMCM31	Analogue driver
PMD101	1-axis microstepping driver
PMD206	6-axis microstepping driver
PMD236	36-axis microstepping driver
Linear Encoders	
See separerate data sheet	

Operating Principle

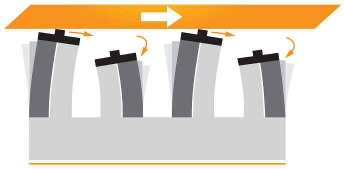
The Piezo LEGS walking principle is of the non-resonant type, i.e. the position of the drive legs is known at any given moment. This assures very good control of the motion over the whole speed range.

The performance of a Piezo LEGS motor is different from that of a DC or stepper motor in several aspects. A Piezo LEGS motor is friction based, meaning the motion is transferred through contact friction between the drive leg and the drive rod. You cannot rely on each step being equal to the next. This is especially true if the motor is operated under varying loads, as shown in the diagram below. For each waveform cycle the Piezo LEGS motor will take one full step, referred to as one *wfm-step* (~7.5 µm at no load with waveform *Rhomb*). In the schematic illustrations to the right, you can see one step being completed. The velocity of the drive rod is wfm-step length multiplied with waveform frequency (7.5 µm x 2 kHz = 15 mm/s).

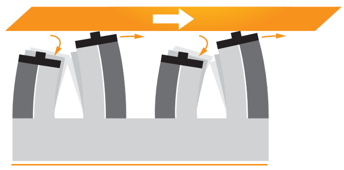
Microstepping is achieved by dividing the *wfm-step* into discrete points. The resolution will be a combination of the number of points in the waveform, and the load. Example: at 3 N load the typical wfm-step length with waveform *Delta* is ~4 µm, and with 8192 discrete points in the waveform the microstep resolution will be ~0.5 nm.



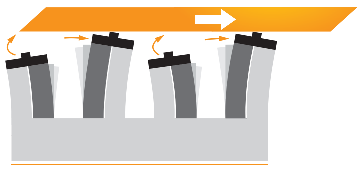
***1** When all four legs are electrically activated they are elongated and bending. As we shall see below, alternate legs move as pairs. Arrows show the direction of motion of the tip of each leg.*



***2** The first pair of legs maintains contact with the rod and moves towards the right. The second pair retracts and their tips begin to move left.*



***3** The second pair of legs has now extended and repositioned in contact with the rod. Their tips begin moving right. The first pair retracts and their tips begin to move left.*



***4** The second pair of legs has moved right. The first pair begins to elongate and move up towards the rod.*

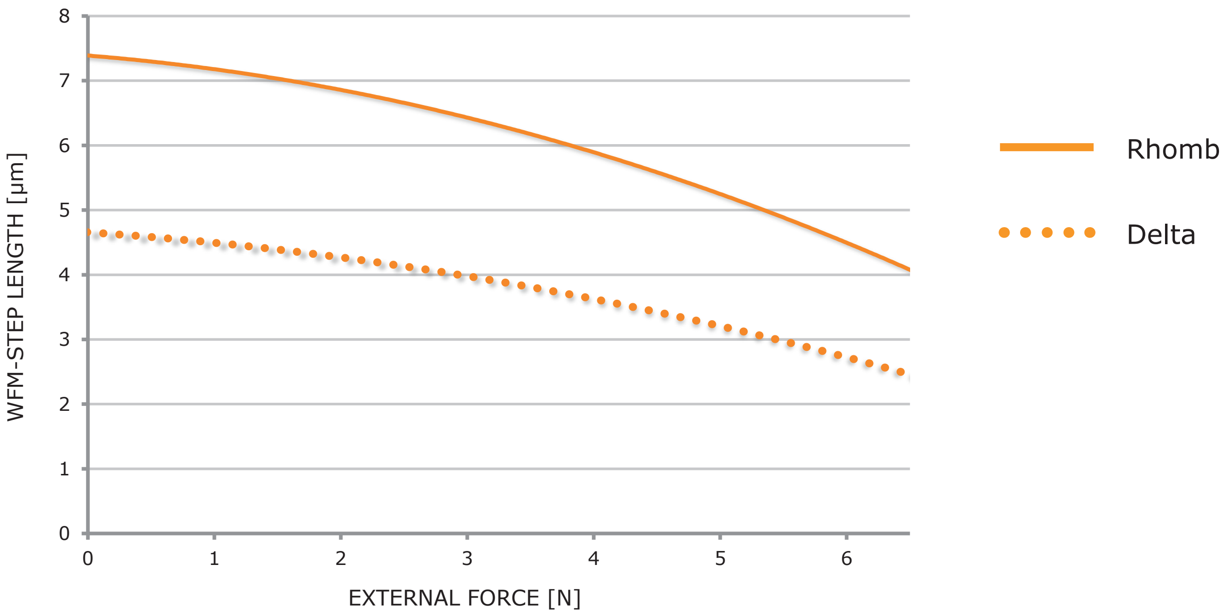
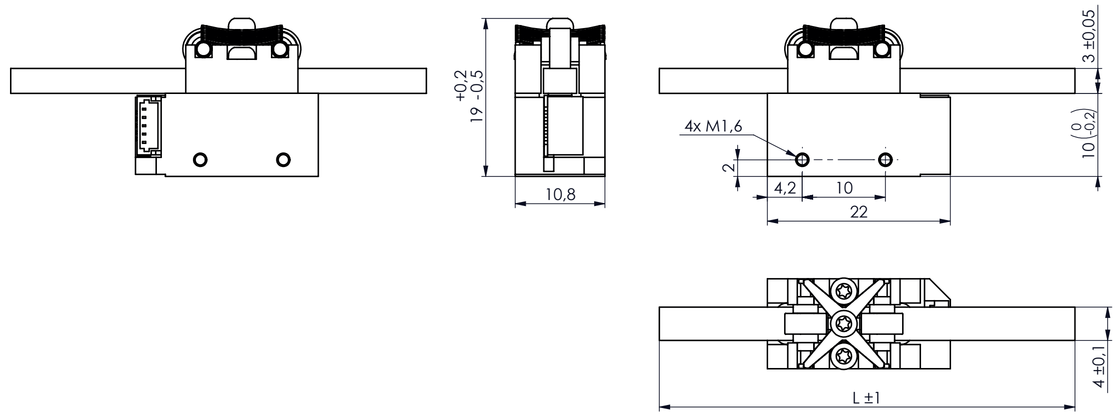
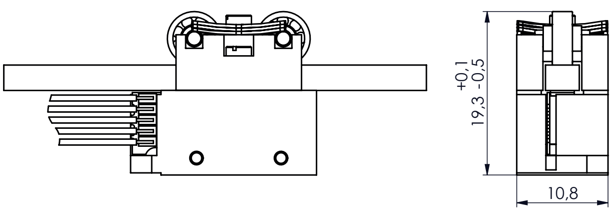


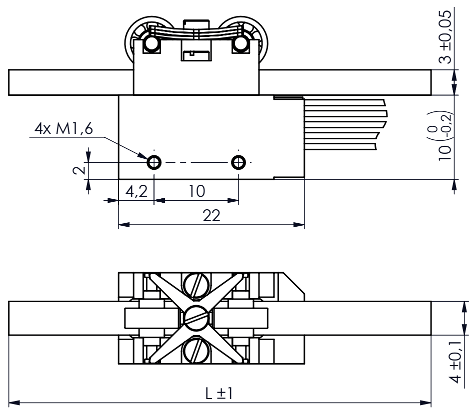
Figure 1 *Motor performance with waveform Rhomb (filled) and waveform Delta (dotted). Wfm-step length is the average distance the drive rod moves when the legs take one wfm-step (i.e. for one waveform cycle). Note: Standard deviation σ of 0.5 µm should be taken into account. Typical values are given for 20ºC.*

Main Dimensions LL1011A
Stainless Steel



Main Dimensions LL1011D
Non-Magnetic Vacuum

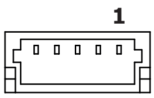




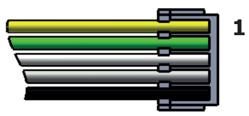
Note: Refer to drawings for details.
Read *Installation Guidelines* carefully.

Electrical Connector Type

On motor type A (standard version) the connector is JST BM05B-SRSS-TB.



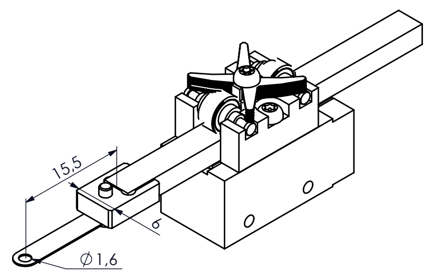
Motor type D (non-magnetic ,vacuum version) has a soldered cable with connector of type JST 05SR-3S.

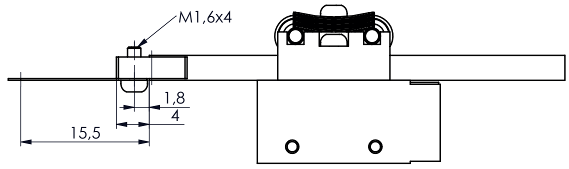


Pin Assignment		
Pin	**Terminal**	**Cable Color**
1	Phase 1	Yellow
2	Phase 2	Green
3	Phase 3	White
4	Phase 4	Grey
5	Ground (GND)	Black or brown

Mechanical Connector Type

The drive rod can be fastened using a mechanical adapter with sheet metal extender. Please read *Installation Guidelines* carefully for notes on how to properly connect the Piezo LEGS motor. Disregarding the instructions given in the guideline document may impair both motor performance as well as life time.





150010-05

Technical Specification

Type	LL1011A- stainless steel	LL1011D- n-m vacuum	Unit	Note
Maximum Stroke	80 (L−20.8)	80 (L−20.8)	mm	100.8 mm rod, no mechanical adapter
Speed Range [a]	0-15	0-15	mm/s	recommended, no load
Step Length [b]	4	4	µm	one wfm-step
	0.0005 [c]	0.0005 [c]	µm	one microstep [c]
Resolution	< 1	< 1	nm	driver dependent
Recommended Operating Range	0-3	0-3	N	for best microstepping performance and life time
Stall Force	6.5	6.5	N	
Holding Force	7	7	N	
Vacuum	-	10^{-7}	torr	
Maximum Voltage	48	48	V	
Power Consumption [d]	5	5	mW/Hz	=0.5 W at 100 Hz wfm-step frequency
Connector	JST BM05B-SRSS-TB	soldered cable w. JST 05SR-3S		
Mechanical Size	22 x 19 x 10.8	22 x 19.3 x 10.8	mm	see drawing for details
Material in Motor Housing	Stainless Steel	Non-Magnetic		
Weight	23	23	gram	approximate
Operating Temp.	−20 to +70	−20 to +70	ºC	

a. Max value is typical for waveform *Rhomb* at 2 kHz, no load, temperature 20ºC.
b. Typical values for waveform *Delta*, 3 N load, temperature 20ºC.
c. Driver dependent; 8192 microsteps per wfm-step for driver in the PMD200-series.
d. At temperature 20ºC, intermittent runs.

Note: *All specifications are subject to change without notice.*

Item no. LL1011_-_____

Family name
LEGS Linear

Stall force
10 = 6.5 N

Version

Motor type
A = SS / Stainless Steel
D = NMV / Non-Magnetic Vacuum

Drive rod (standard lengths)
030 = 30 mm
040 = 40 mm
050 = 50 mm
060 = 60 mm
070 = 70 mm
101 = 100.8 mm

Mechanical adapter
A0 = No adapter
D1 = One adapter - Front

Connector/Cable

Motor type A

A00 = JST connector, no cable
A05 = Same as K05
A15 = Same as K15
K05 = 0.5 m cable for driver PMD101 and PMCM31
K15 = 1.5 m cable for driver PMD101 and PMCM31
L05 = 0.5 m cable-kit for driver PMD206 and PMD236
L15 = 1.5 m cable-kit for driver PMD206 and PMD236

Motor type D

B10 = 1.0 m Teflon flying wires PTFE AWG28 for connection to driver PMD101 and PMCM31

For connection to driver PMD206 or PMD236 you need a D-sub adapter, p/n CK6280.

Note: All combinations are **not** possible!

Visit our website for application examples, CAD files, videos and more...

www.piezomotor.com

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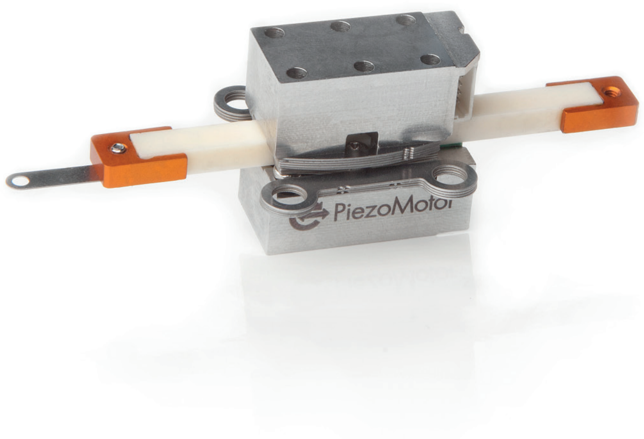


- **Direct drive – backlash free**
- **Nanometer resolution**
- **Simple drive electronics**
- **No power draw in hold position**
- **Quick response and high speed dynamics**

The LT20 linear motor is intended for a large range of OEM applications. Design focus has been for ease of integration. The very high speed dynamics and nanometer resolution makes it ideal for numerous applications.

The Piezo LEGS technology is characterized by its outstanding precision. Fast speed and quick response time, as well as long service life are other benefits. In combination with the nanometer resolution the technology is quite unique.

The motor is ideally suited for move and hold applications or for automatic adjustments. When in hold position it does not consume any power. The drive technology is direct, meaning no gears or lead screws are needed to create linear motion. The motor has no mechanical play or backlash. The LT20 linear motor is available in standard version, vacuum version, and non-magnetic vacuum version.

Mechanical and electrical connection

The motor is easily integrated in your application using the drive rod mechanical adapter. Drive rods are supplied in different lengths (30, 40, 50, 60, 70 and 100.8 mm).

The motor has two electrical connectors which are connected in parallel to the driver.

Operating modes

The motor can move in full steps (waveform-steps), or partial steps (microsteps) giving positioning resolution in the nanometer range. Speed is adjustable from single microsteps per second up to max specified.

Controlling the motor

PiezoMotor offers a range of drivers and controllers. The most basic one is a handheld push button driver. Another option is an analogue driver that regulates the motor speed by means of an ±10 V analog interface. More advanced alternatives are microstep drivers/controllers in the 100- and 200-series. These products allow for closed loop control and precise positioning. The microstepping feature divides the wfm-step into thousands of small increments which results in microsteps in the nanometer range. The PMD units are straight forward to use, supports quadrature and serial sensors, and have multiple I/O ports.

PMD101

PMD206

Design your own driver

Some customers prefer to design their own driver for ease of integration. PiezoMotor provides information to assist in the design.

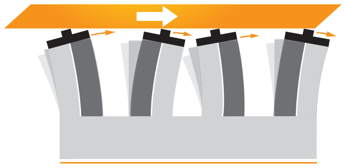
Ordering information	
Motor Types	
LT2010A-/20A-	Stainless steel
LT2010B-/20B-	Stainless steel vacuum
LT2010D-/20D-	Non-magnetic vacuum
Drivers and Controllers	
PMCM21	Handheld push button driver
PMCM31	Analogue driver
PMD101	1-axis microstepping driver
PMD206	6-axis microstepping driver
PMD236	36-axis microstepping driver
Linear Encoders	
See separerate data sheet	

Operating Principle

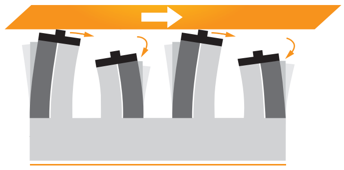
The Piezo LEGS walking principle is of the non-resonant type, i.e. the position of the drive legs is known at any given moment. This assures very good control of the motion over the whole speed range.

The performance of a Piezo LEGS motor is different from that of a DC or stepper motor in several aspects. A Piezo LEGS motor is friction based, meaning the motion is transferred through contact friction between the drive leg and the drive rod. You cannot rely on each step being equal to the next. This is especially true if the motor is operated under varying loads, as shown in the diagram below. For each waveform cycle the Piezo LEGS motor will take one full step, referred to as one *wfm-step* (~5 µm at no load with waveform *Rhomb*). In the schematic illustrations to the right, you can see one step being completed. The velocity of the drive rod is wfm-step length multiplied with waveform frequency (5 µm x 2 kHz = 10 mm/s).

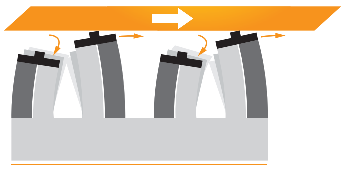
Microstepping is achieved by dividing the *wfm-step* into discrete points. The resolution will be a combination of the the number of points in the waveform, and the load. Example: at 10 N load the typical wfm-step length with waveform *Delta* is ~2.5 µm, and with 8192 discrete points in the waveform the microstep resolution will be ~0.3 nm.



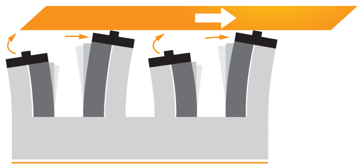
1 *When all four legs are electrically activated they are elongated and bending. As we shall see below, alternate legs move as pairs. Arrows show the direction of motion of the tip of each leg.*



2 *The first pair of legs maintains contact with the rod and moves towards the right. The second pair retracts and their tips begin to move left.*



3 *The second pair of legs has now extended and repositioned in contact with the rod. Their tips begin moving right. The first pair retracts and their tips begin to move left.*



4 *The second pair of legs has moved right. The first pair begins to elongate and move up towards the rod.*

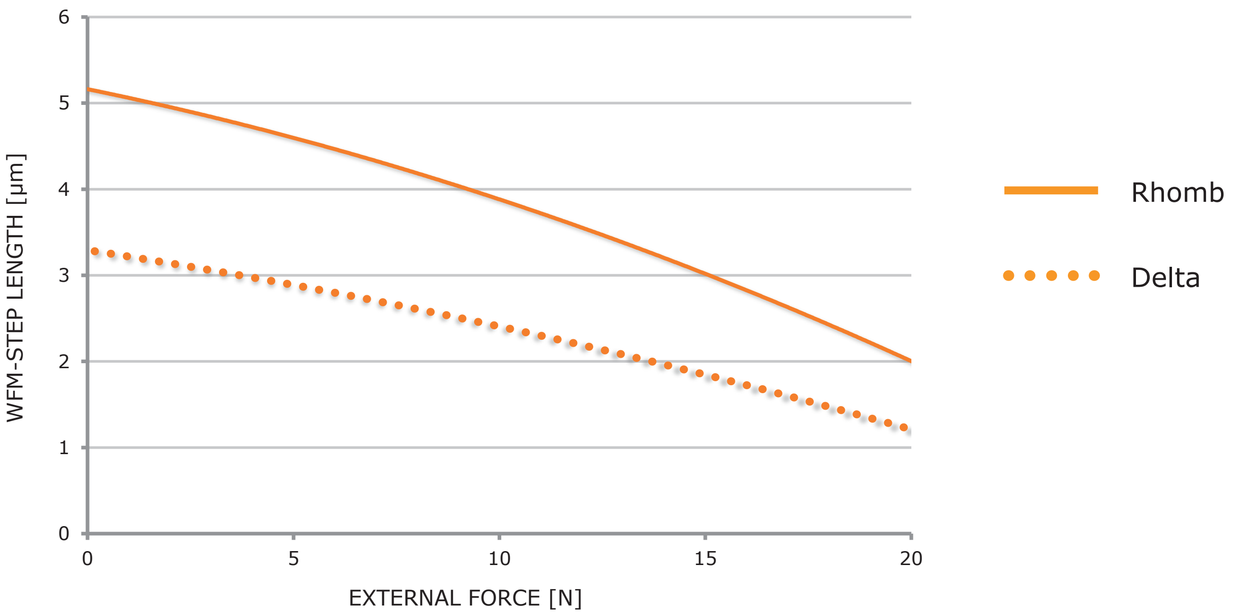
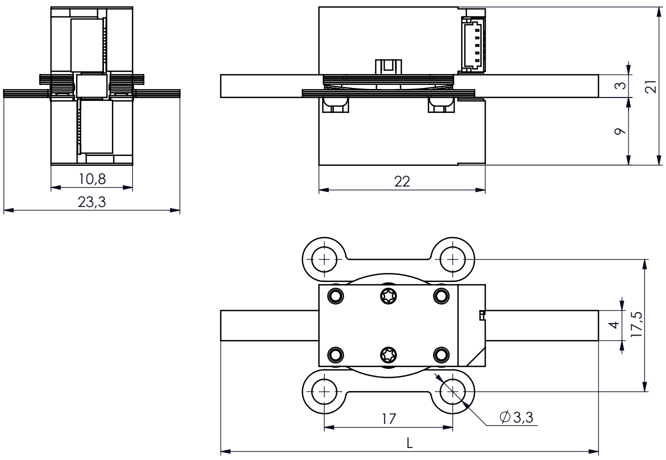


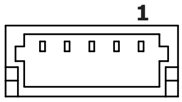
Figure 1 *Motor performance with waveform Rhomb (filled) and waveform Delta (dotted). Wfm-step length is the average distance the drive rod moves when the legs take one wfm-step (i.e. for one waveform cycle). Note: Standard deviation σ of 0.5 µm should be taken into account. Typical values are given for 20ºC.*

Main Dimensions LT2010 A
Stainless Steel

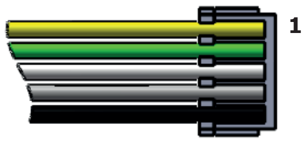


Electrical Connector Types

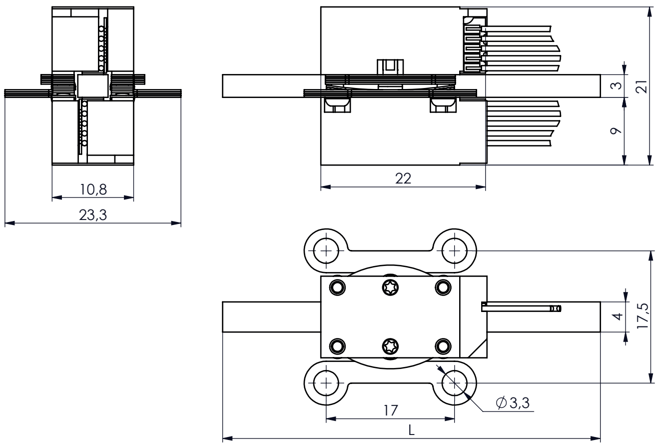
On motor type LT2010A (standard version) there are two connectors of type JST BM05B-SRSS-TB.



Motor type LT2010B (vacuum version) has soldered cables with two connectors of type JST 05SR-3S.



Main Dimensions LT2010 B/D
Stainless Steel Vacuum / Non-Magnetic Vacuum



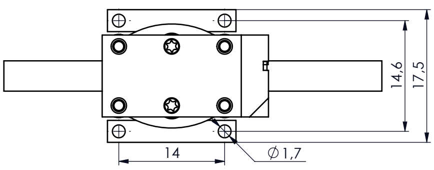
Note: Refer to drawings for details. Read *Installation Guidelines* carefully.

Pin Assignment

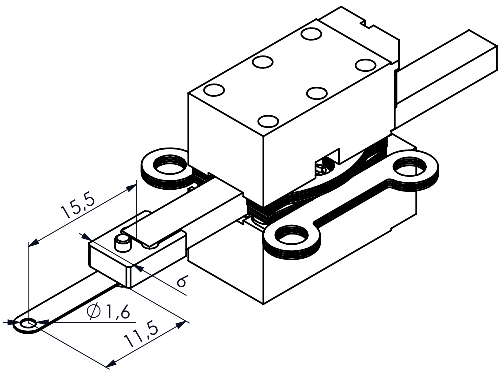
Pin	Terminal	Cable Color
1	Phase 1	Yellow
2	Phase 2	Green
3	Phase 3	White
4	Phase 4	Grey
5	Ground (GND)	Black or brown

Mounting Options

There are two mounting options available, either for M3 screws (Ø3.3 mm holes), as seen above, or a slim version for M1.6 screws (Ø1.7 mm holes), see below.



Mechanical Adapter



The drive rod can be fastened using a mechanical adapter with sheet metal extender. In this figure the adapter is mounted in front end of drive rod. Please read *Installation Guidelines* carefully for notes on how to properly connect the Piezo LEGS motor. Disregarding the instructions given in the guideline document may impair both motor performance as well as life time.

150020-05

Technical Specification LT20					
Type	**10A/20A** stainless steel	**10B/20B** vacuum	**10D/20D** non-magnetic vac.	**Unit**	**Note**
Maximum Stroke	80 (L−20.8)	80 (L−20.8)	80 (L−20.8)	mm	100.8 mm drive rod, no mechanical adapter
Speed Range [a]	0-10	0-10	0-10	mm/s	recommended
Step Length [b]	2.5	2.5	2.5	µm	one wfm-step
	0.0003 [c]	0.0003 [c]	0.0003 [c]	µm	one microstep [c]
Resolution	< 1	< 1	< 1	nm	driver dependent
Recommended Operating Range	0-10	0-10	0-10	N	for best microstepping performance and life time
Stall Force	20	20	20	N	
Holding Force	22	22	22	N	
Vacuum	-	10^{-7}	10^{-7}	torr	
Maximum Voltage	48	48	48	V	
Power Consumption [d]	10	10	10	mW/Hz	=1 W at 100 Hz wfm-step frequency
Connector	2 x JST BM05B-SRSS-TB	soldered cable w. 2 x JST 05SR-3S	soldered cable w. 2 x JST 05SR-3S		
Mechanical Size	22 x 21 x 10.8	22 x 21 x 10.8	22 x 21 x 10.8	mm	see drawing for details
Material in Motor Housing	Stainless Steel	Stainless Steel	Non-magnetic		
Weight	29	29	29	gram	approximate
Operating Temp.	−20 to +70	−20 to +70	−20 to +70	ºC	

a. Max value is typical for waveform *Rhomb* at 2 kHz, no load, temperature 20ºC.
b. Typical values for waveform *Delta*, 10 N load, temperature 20ºC.
c. Driver dependent; 8192 microsteps per wfm-step for driver in the PMD200-series.
d. At temperature 20ºC, intermittent runs.

Note: *All specifications are subject to change without notice.*

Item no. LT20___-________

Family name
LEGS Linear Twin

Stall force
20 = 20 N

Version
10 = mounts with M3 screws
20 = mounts with M1.6 screws

Motor type
A = SS / Stainless Steel
B = SSV / Stainless Steel Vacuum
D = NMV / Non-Magnetic Vacuum

Drive rod (standard lengths)
030 = 30 mm
040 = 40 mm
050 = 50 mm
060 = 60 mm
070 = 70 mm
101 = 100.8 mm

Mechanical adapter
A0 = No adapter
D1 = One adapter - Front
D2 = One adapter - Back
E1 = Two adapters - Front and back

Connector/Cable

Motor type A

A00 = JST connectors, no cables
A05 = 0.5 m cables *
A15 = 1.5 m cables *
K05 = 0.5 m cable-kit for driver PMD101 and PMCM31
K15 = 1.5 m cable-kit for driver PMD101 and PMCM31
L05 = 0.5 m cable-kit for driver PMD206 and PMD236
L15 = 1.5 m cable-kit for driver PMD206 and PMD236

* = does not connect directly to either PM driver

Motor type B and D

B10 = 1.0 m Teflon flying wires PTFE AWG28

For connection to driver PMD101 or PMCM31 you need an additional cable-kit, p/n CK6281.

For connection to driver PMD206 or PMD236 you need a D-sub adapter, p/n CK6280.

Note: All combinations are **not** possible!

PiezoMotor

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- **Direct drive – backlash free**
- **Nanometer resolution**
- **Optical mount interface**
- **Quick response and high speed dynamics**

The LTC20 enclosed linear motor is intended for use in a large range of applications; laser and optics applications, moving mirror mounts, replacement for micrometer screws etc. The very high speed dynamics and nanometer resolution makes it ideal for numerous applications.

The Piezo LEGS technology is characterized by its outstanding precision. Fast speed and quick response time, as well as long service life are other benefits. In combination with the nanometer resolution the technology is quite unique.

The motor is ideally suited for move and hold applications or for automatic adjustments. When in hold position it does not consume any power. The drive technology is direct, meaning no gears or lead screws are needed to create linear motion. The motor has no mechanical play or backlash. The LTC20 linear motor is available in two different mounting versions.

Operating modes

The motor can move in full steps (waveform-steps), or partial steps (microsteps) giving positioning resolution in the nanometer range. Speed is adjustable from single microsteps per second up to max specified.

Controlling the motor

PiezoMotor offers a range of drivers and controllers. The most basic one is a handheld push button driver. Another option is an analogue driver that regulates the motor speed by means of an ±10 V analog interface. More advanced alternatives are microstep drivers/ controllers in the 100- and 200-series. These products allow for closed loop control and precise positioning. The microstepping feature divides the wfm-step into thousands of small increments which results in microsteps in the nanometer range. The PMD units are straight forward to use, supports quadrature and serial sensors, and have multiple I/O ports.

PMD101

PMD206

Design your own driver

Some customers prefer to design their own driver for ease of integration. PiezoMotor provides information to assist in the design.

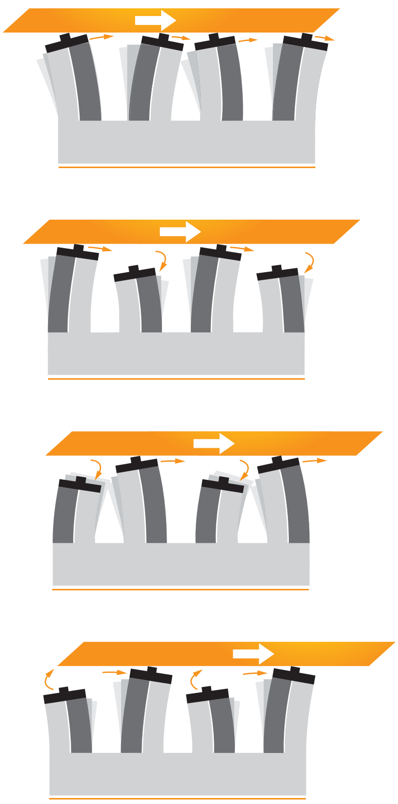
Ordering information	
Motors	
LTC2013-013	Clamp mount, shaft w. M2.5
LTC2014-013	Nut mount, shaft w. M2.5
Drivers and Controllers	
PMCM21	Handheld push button driver
PMCM31	Analogue driver
PMD101	1-axis microstepping driver
PMD206	6-axis microstepping driver
PMD236	36-axis microstepping driver
Linear Encoders	
See separerate data sheet	

Operating Principle

The Piezo LEGS walking principle is of the non-resonant type, i.e. the position of the drive legs is known at any given moment. This assures very good control of the motion over the whole speed range.

The performance of a Piezo LEGS motor is different from that of a DC or stepper motor in several aspects. A Piezo LEGS motor is friction based, meaning the motion is transferred through contact friction between the drive leg and the drive rod. You cannot rely on each step being equal to the next. This is especially true if the motor is operated under varying loads, as shown in the diagram below. For each waveform cycle the Piezo LEGS motor will take one full step, referred to as one *wfm-step* (~5 µm at no load with waveform *Rhomb*). In the schematic illustrations to the right, you can see one step being completed. The velocity of the drive rod is wfm-step length multiplied with waveform frequency (5 µm x 2 kHz = 10 mm/s).

Microstepping is achieved by dividing the *wfm-step* into discrete points. The resolution will be a combination of the the number of points in the waveform, and the load. Example: at 10 N load the typical wfm-step length with waveform *Delta* is ~2.5 µm, and with 8192 discrete points in the waveform the microstep resolution will be ~0.3 nm.



1 *When all four legs are electrically activated they are elongated and bending. As we shall see below, alternate legs move as pairs. Arrows show the direction of motion of the tip of each leg.*

2 *The first pair of legs maintains contact with the rod and moves towards the right. The second pair retracts and their tips begin to move left.*

3 *The second pair of legs has now extended and repositioned in contact with the rod. Their tips begin moving right. The first pair retracts and their tips begin to move left.*

4 *The second pair of legs has moved right. The first pair begins to elongate and move up towards the rod.*

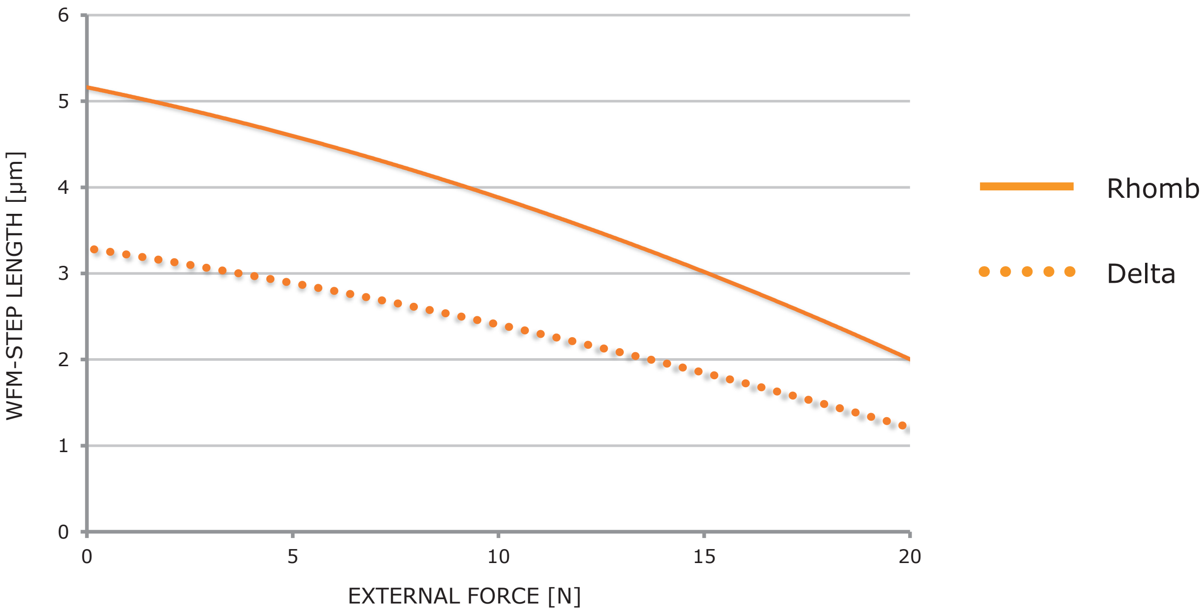
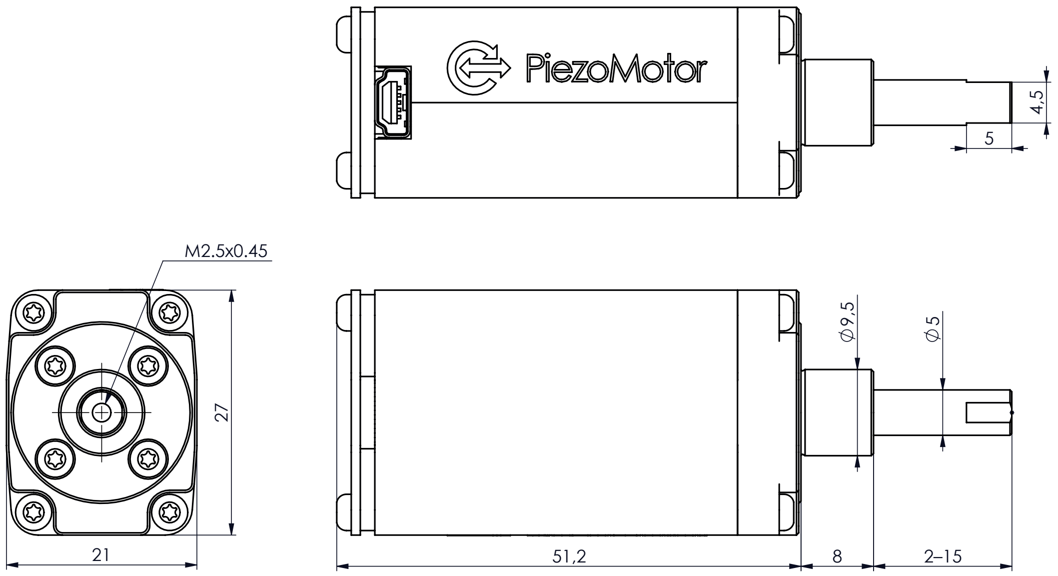
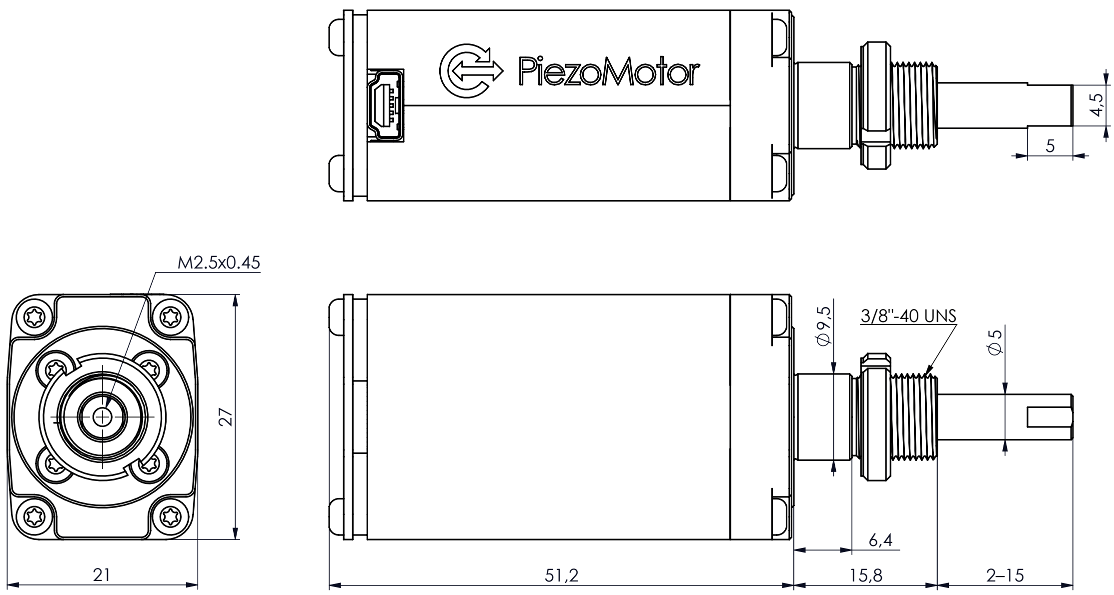


Figure 1 *Motor performance with waveform Rhomb (filled) and waveform Delta (dotted). Wfm-step length is the average distance the drive rod moves when the legs take one wfm-step (i.e. for one waveform cycle). Note: Standard deviation σ of 0.5 µm should be taken into account. Typical values are given for 20ºC.*

Main Dimensions LTC2013-013

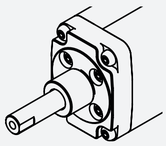
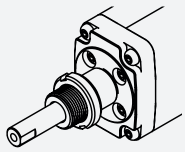


Main Dimensions LTC2014-013



Note:
Refer to drawings for details. Drive shaft has only limited bending moment capability, and absolutely no rotational torque is allowed. In order to safely mount an endpiece in the threaded hole, you must first release the motor completely (it must not be fixed in position). Thereafter, hold on only to the flat part of the shaft and fasten endpiece tightly.

150030-05

Technical Specification				
Type	**LTC2013-013 (clamp mount)**	**LTC2014-013 (nut mount)**	**Unit**	**Note**
Stroke	12.8	12.8	mm	
Speed Range [a]	0-10	0-10	mm/s	recommended, no load
Step Length [b]	2.5	2.5	µm	one wfm-step
	0.0003 [c]	0.0003 [c]	µm	one microstep [c]
Resolution	< 1	< 1	nm	driver dependent
Recommended Operating Range	0-10	0-10	N	for best microstepping performance and life time
Stall Force	20	20	N	
Holding Force	22	22	N	
Maximum Voltage	48	48	V	
Power Consumption [d]	10	10	mW/Hz	=1 W at 100 Hz wfm-step frequency
Connector	USB mini-B	USB mini-B		
Mechanical Size	51.2 x 27 x 21	51.2 x 27 x 21	mm	see drawing for details
Material in Motor Housing	Stainless Steel, Aluminum	Stainless Steel, Aluminum		
Mounting	Clamp 	Nut 		
Weight	95	95	gram	approximate
Operating Temp.	0 to +50	0 to +50	ºC	

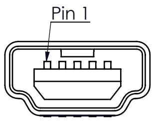
a. Max value is typical for waveform *Rhomb* at 2 kHz, no load, temperature 20ºC.
b. Typical values for waveform *Delta*, 10 N load, temperature 20ºC.
c. Driver dependent; 8192 microsteps per wfm-step for driver in the PMD200-series.
d. At temperature 20ºC, intermittent runs.

Note: *All specifications are subject to change without notice.*

Connector Type

The motor connector is USB mini-B. Motor cable is included (2 m with USB mini-B to JST 05SR-3S). Cable connects directly to driver PMD101 and PMCM31. For connection to driver PMD206 and PMD236 you also need a D-sub adapter (p/n CK6280).

Pin Assignment		
Pin	**Terminal**	**Cable Color**
1	Ground (GND)	Black or brown
2	Phase 4	Grey
3	Phase 3	White
4	Phase 2	Green
5	Phase 1	Yellow



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www.piezomotor.com

- **For stage integration**
- **Direct drive – backlash free**
- **Nanometer resolution**
- **Simple drive electronics**
- **Quick response and high speed dynamics**

The LC20 motor is intended for motorizing linear stages or goniometer stages. It is miniaturized to such a degree it will fit within the stage block. Manufacturers can with the Caliper motor reach new degrees of miniaturization in stage motorization. The very high speed dynamics and nanometer resolution makes it ideal for motorized stages.

The Piezo LEGS technology is characterized by its outstanding precision. Fast speed and quick response time, as well as long service life are other benefits. In combination with the nanometer resolution the technology is quite unique.

When the motor is in hold position it does not consume any power. The drive technology is direct, meaning no gears or lead screws are needed to create linear motion. The motor has no mechanical play or backlash.

Operating modes

The motor can move in full steps (waveform-steps), or partial steps (microsteps) giving positioning resolution in the nanometer range. Speed is adjustable from single microsteps per second up to max specified.

Controlling the motor

PiezoMotor offers a range of drivers and controllers. The most basic one is a handheld push button driver. Another option is an analogue driver that regulates the motor speed by means of an ±10 V analog interface. More advanced alternatives are microstep drivers/ controllers in the 100- and 200-series. These products allow for closed loop control and precise positioning. The microstepping feature divides the wfm-step into thousands of small increments which results in microsteps in the nanometer range. The PMD units are straight forward to use, supports quadrature and serial sensors, and have multiple I/O ports.

PMD101

PMD206

Design your own driver

Some customers prefer to design their own driver for ease of integration. PiezoMotor provides information to assist in the design.

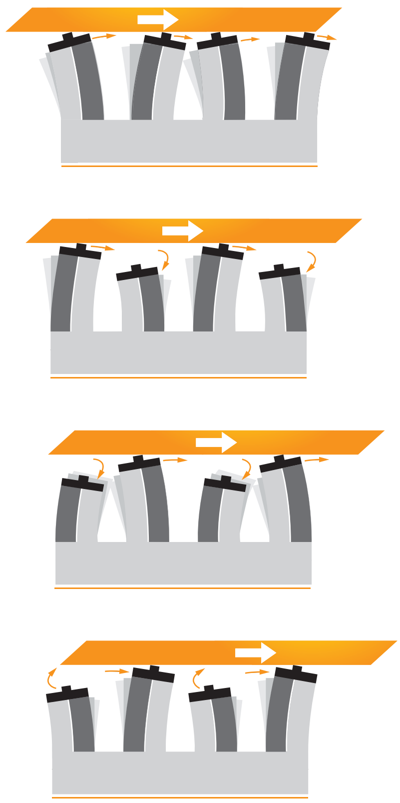
Ordering information	
Motors	
LC2010	Motor for goniometer stage
LC2020	Motor for linear stage
Drivers and Controllers	
PMCM21	Handheld push button driver
PMCM31	Analogue driver
PMD101	1-axis microstepping driver
PMD206	6-axis microstepping driver
PMD236	36-axis microstepping driver
Linear Encoders	
See separerate data sheet	

Operating Principle

The Piezo LEGS walking principle is of the non-resonant type, i.e. the position of the drive legs is known at any given moment. This assures very good control of the motion over the whole speed range.

The performance of a Piezo LEGS motor is different from that of a DC or stepper motor in several aspects. A Piezo LEGS motor is friction based, meaning the motion is transferred through contact friction between the drive leg and the drive rod. You cannot rely on each step being equal to the next. This is especially true if the motor is operated under varying loads, as shown in the diagram below. For each waveform cycle the Piezo LEGS motor will take one full step, referred to as one *wfm-step* (~5 µm at no load with waveform *Rhomb*). In the schematic illustrations to the right, you can see one step being completed. The velocity of the drive rod is wfm-step length multiplied with waveform frequency (5 µm x 2 kHz = 10 mm/s).

Microstepping is achieved by dividing the *wfm-step* into discrete points. The resolution will be a combination of the number of points in the waveform, and the load. Example: at 10 N load the typical wfm-step length with waveform *Delta* is ~2.5 µm, and with 8192 discrete points in the waveform the microstep resolution will be ~0.3 nm.



__1__ When all four legs are electrically activated they are elongated and bending. As we shall see below, alternate legs move as pairs. Arrows show the direction of motion of the tip of each leg.

__2__ The first pair of legs maintains contact with the rod and moves towards the right. The second pair retracts and their tips begin to move left.

__3__ The second pair of legs has now extended and repositioned in contact with the rod. Their tips begin moving right. The first pair retracts and their tips begin to move left.

__4__ The second pair of legs has moved right. The first pair begins to elongate and move up towards the rod.

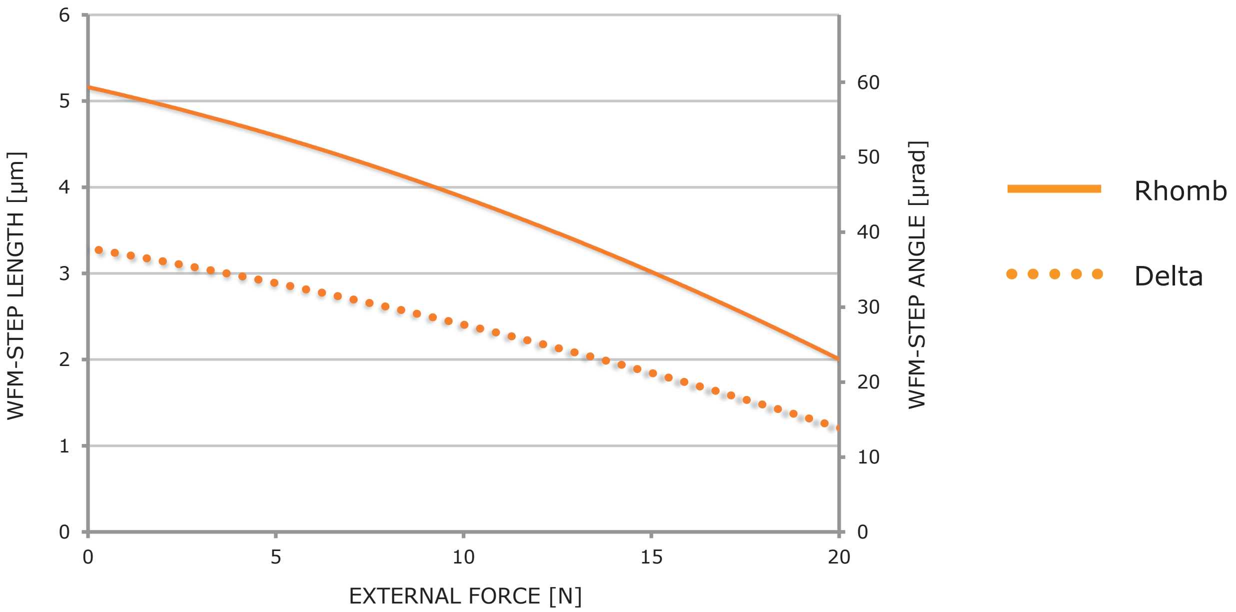
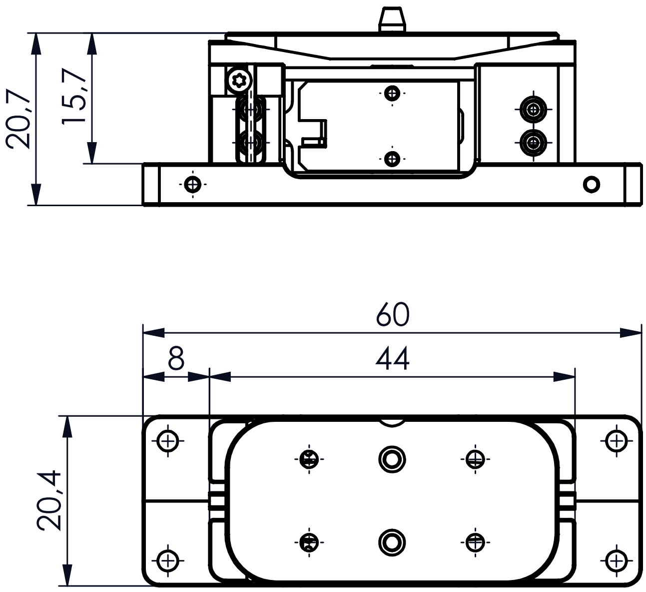
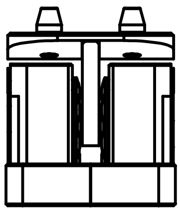


Figure 1 *Motor performance with waveform Rhomb (filled) and waveform Delta (dotted). Wfm-step length/angle is the average distance the drive rod moves when the legs take one wfm-step (i.e. for one waveform cycle). Note: Standard deviation σ of 0.5 µm should be taken into account. Typical values are given for 20ºC.*

Main Dimensions LC20





Note: All specifications are subject to change without notice. Detailed drawings can be found in the document *Installation Guidelines for the Piezo LEGS Caliper.*

Installation

The Piezo LEGS Caliper is designed for stage integration. It is miniaturized to a degree where it will fit inside a linear stage or a goniometer stage (figure 2). The motor is easily mounted in the stage blocks using eight screws. No further adjustments have to be made. Please look at the document *Installation Guidelines for the Piezo LEGS Caliper* for information on how to design the stage blocks and how to correctly mount the motor. The guideline document also has more detailed drawings of the motor.

The PiezoMotor staff will be happy to assist you with details on system integration and can provide mechanical engineering expertise. On our webpage you can find CAD files for download (motor units and mock-up stages).

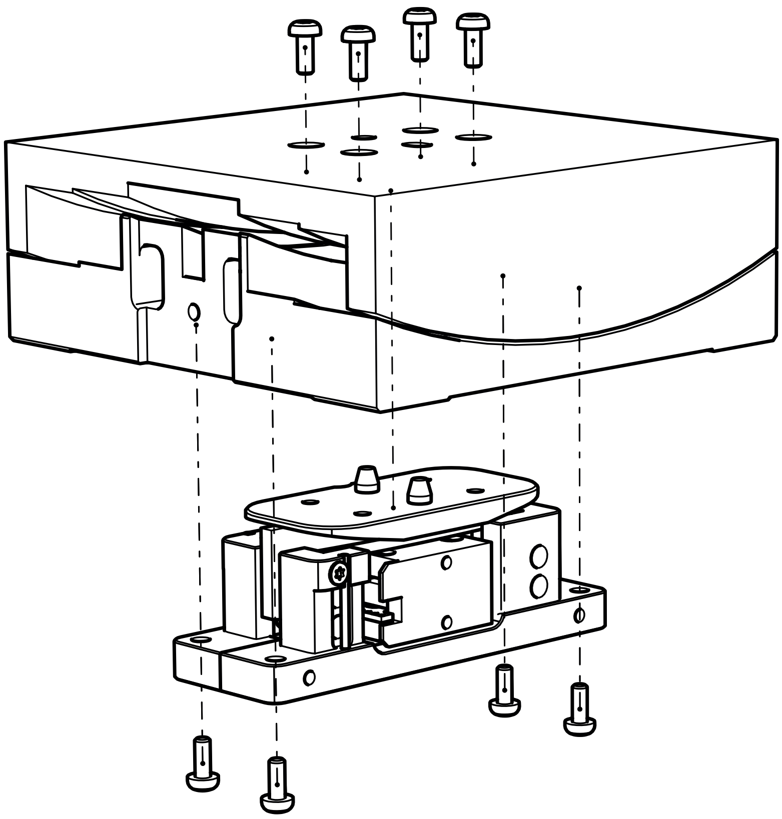


Figure 2 Example of Caliper motor integration in a 70x70 mm goniometer stage.

150052-06

Technical Specification

Type	LC2010 (for gonio stage)	LC2020 (for linear stage)	Note
Stroke	±10º [a]	29 mm	
Minimum Radius	86 mm	-	see installation guidelines
Speed Range [b]	0-7 º/s [a]	0-10 mm/s	recommended, no load
Step Angle/Length [c]	30 µrad [a]	2.5 µm	one wfm-step
	0.004 µrad [a d]	0.0003 µm [d]	one microstep [d]
Resolution	< 10 nrad [a]	< 1 nm	driver dependent
Recommended Operating Range	0-10 N	0-10 N	for best microstepping performance and life time
Stall Force	20 N	20 N	
Holding Force	22 N	22 N	
Maximum Voltage	48 V	48 V	
Power Consumption [e]	10 mW/Hz	10 mW/Hz	=1 W at 100 Hz wfm-step frequency
Connector	2 x soldered cable with JST 05SR-3S	2 x soldered cable with JST 05SR-3S	
Mechanical Size	60 x 20.7 x 20.4 mm	60 x 20.7 x 20.4 mm	see drawing for details
Material in Motor Housing	Stainless Steel, Aluminum	Stainless Steel, Aluminum	
Weight	110 grams	110 grams	
Operating Temp.	0 to +50 ºC	0 to +50 ºC	

a. Value is valid for minimum radius 86 mm.
b. Max value is typical for waveform *Rhomb* at 2 kHz, no load, temperature 20ºC.
c. Typical values for waveform *Delta*, 10 N load, temperature 20ºC.
d. Driver dependent; 8192 microsteps per wfm-step for driver in the PMD200-series.
e. At temperature 20ºC, intermittent runs.

Note: *All specifications are subject to change without notice.*

Item no. LC20__A-044___

Family name
LEGS Caliper

Stall force
20 = 20 N

Version
10 = for goniometer stage mount
20 = for linear stage mount

Motor type
A = SS / Stainless Steel

Drive rod (standard lengths)
044 = 44 mm (will give stroke according to specifications)

Connector/Cable
A15 = 1.5 m cables - does not connect directly to either PM driver
K15 = 1.5 m cable-kit for driver PMD101 and PMCM31
L15 = 1.5 m cable-kit for driver PMD206 and PMD236

Electrical Connector Type

The motor is fitted with two cables with JST 05SR-3S connectors on the end. The cables need to be connected in parallell to the driver.

Pin Assignment

Pin	Terminal	Cable Color
1	Phase 1	Yellow
2	Phase 2	Green
3	Phase 3	White
4	Phase 4	Grey
5	Ground (GND)	Black or brown

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PiezoMotor

Piezo LEGS® Linear Twin-C 40N

- **Direct drive – backlash free**
- **Nanometer resolution**
- **Quick response**
- **Optical mount interface**

The LTC40 linear motor is intended for use in a large range of applications; laser and optics applications, moving mirror mounts, replacement for micrometer screws etc. The very high speed dynamics and nanometer resolution makes it ideal for numerous applications.

The Piezo LEGS technology is characterized by its outstanding precision. Fast speed and quick response time, as well as long service life are other benefits. In combination with the nanometer resolution the technology is quite unique.

The motor is ideally suited for move and hold applications or for automatic adjustments. When in hold position it does not consume any power. The drive technology is direct, meaning no gears or lead screws are needed to create linear motion. The motor has no mechanical play or backlash. The LTC40 linear motor is available with a few different mounting options - clamp, nut, or flange.

Operating modes

The motor can move in full steps (waveform-steps), or partial steps (microsteps) giving positioning resolution in the nanometer range. Speed is adjustable from single microsteps per second up to max specified.

Controlling the motor

PiezoMotor offers a range of drivers and controllers. The most basic one is a handheld push button driver. Another option is an analogue driver that regulates the motor speed by means of an ±10 V analog interface. More advanced alternatives are microstep drivers/ controllers in the 100- and 200-series. These products allow for closed loop control and precise positioning. The microstepping feature divides the wfm-step into thousands of small increments which results in microsteps in the nanometer range. The PMD units are straight forward to use, supports quadrature and serial sensors, and have multiple I/O ports.

PMD101

PMD206

Design your own driver

Some customers prefer to design their own driver for ease of integration. PiezoMotor provides information to assist in the design.

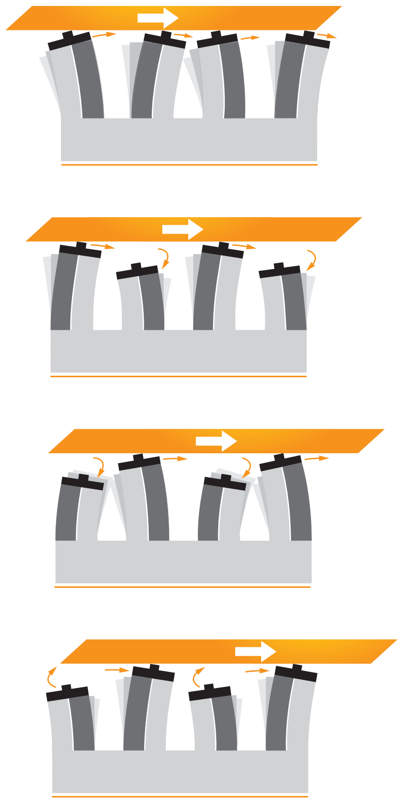
Ordering information	
Motors	
LTC4012-013	Clamp mount, shaft with ball tip
LTC4013-013	Clamp mount, shaft with M2.5
LTC4014-013	Nut mount, shaft with M2.5
LTC4016-013	Flange mount, shaft with M2.5
Drivers and Controllers	
PMCM21	Handheld push button driver
PMCM31	Analogue driver
PMD101	1-axis microstepping driver
PMD206	6-axis microstepping driver
PMD236	36-axis microstepping driver
Linear Encoders	
See separerate data sheet	

Operating Principle

The Piezo LEGS walking principle is of the non-resonant type, i.e. the position of the drive legs is known at any given moment. This assures very good control of the motion over the whole speed range.

The performance of a Piezo LEGS motor is different from that of a DC or stepper motor in several aspects. A Piezo LEGS motor is friction based, meaning the motion is transferred through contact friction between the drive leg and the drive rod. You cannot rely on each step being equal to the next. This is especially true if the motor is operated under varying loads, as shown in the diagram below. For each waveform cycle the Piezo LEGS motor will take one full step, referred to as one *wfm-step* (~8 µm at no load with waveform *Rhomb*). In the schematic illustrations to the right, you can see one step being completed. The velocity of the drive rod is wfm-step length multiplied with waveform frequency (8 µm x 2 kHz = 16 mm/s).

Microstepping is achieved by dividing the *wfm-step* into discrete points. The resolution will be a combination of the the number of points in the waveform, and the load. Example: at 20 N load the typical wfm-step length with waveform *Delta* is ~4.5 µm, and with 8192 discrete points in the waveform the microstep resolution will be ~0.5 nm.



1 *When all four legs are electrically activated they are elongated and bending. As we shall see below, alternate legs move as pairs. Arrows show the direction of motion of the tip of each leg.*

2 *The first pair of legs maintains contact with the rod and moves towards the right. The second pair retracts and their tips begin to move left.*

3 *The second pair of legs has now extended and repositioned in contact with the rod. Their tips begin moving right. The first pair retracts and their tips begin to move left.*

4 *The second pair of legs has moved right. The first pair begins to elongate and move up towards the rod.*

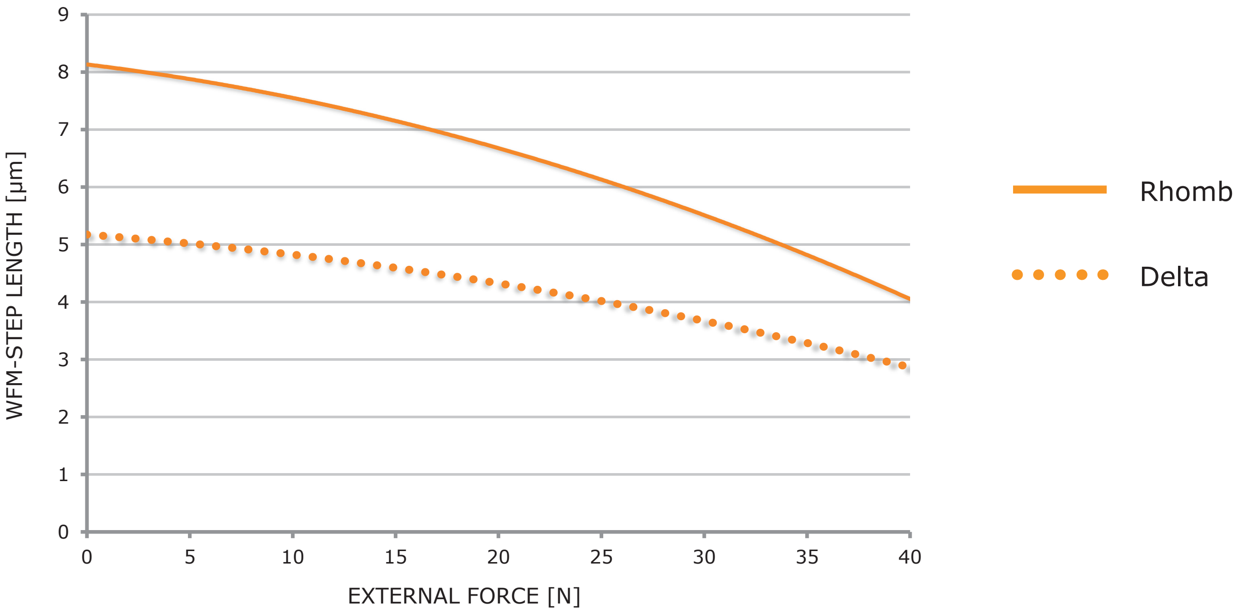
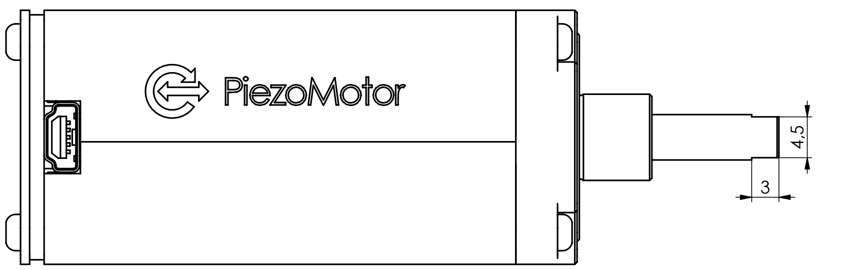
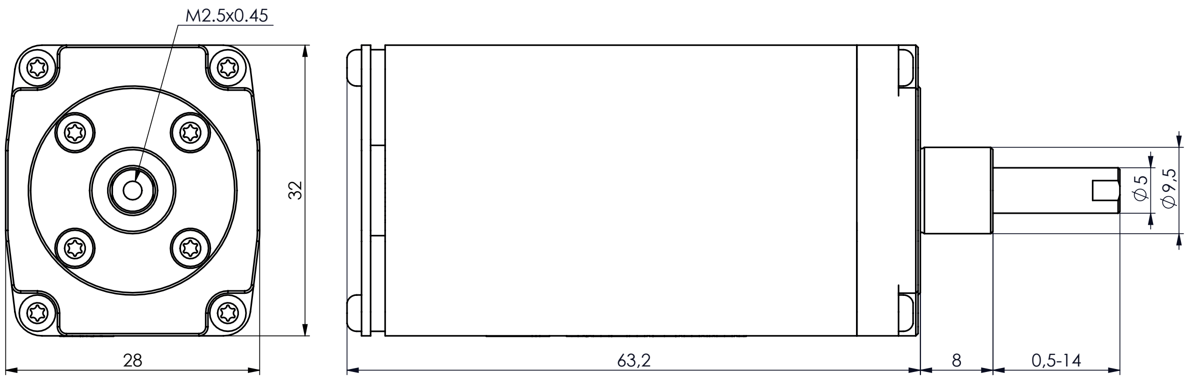


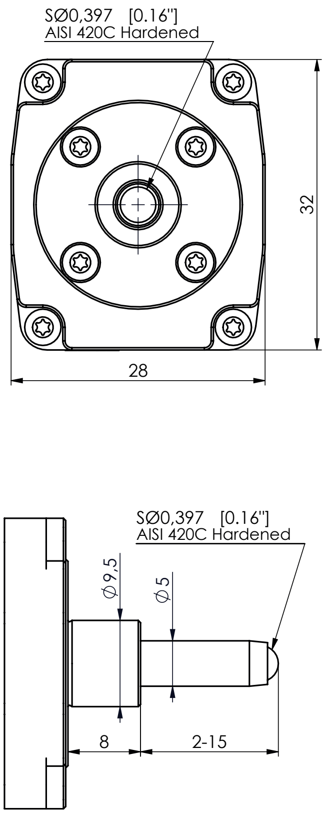
Figure 1 *Motor performance with waveform Rhomb (filled) and waveform Delta (dotted). Wfm-step length is the average distance the drive rod moves when the legs take one wfm-step (i.e. for one waveform cycle). Note: Standard deviation σ of 0.5 µm should be taken into account. Typical values are given for 20ºC.*

Main Dimensions LTC4013-013

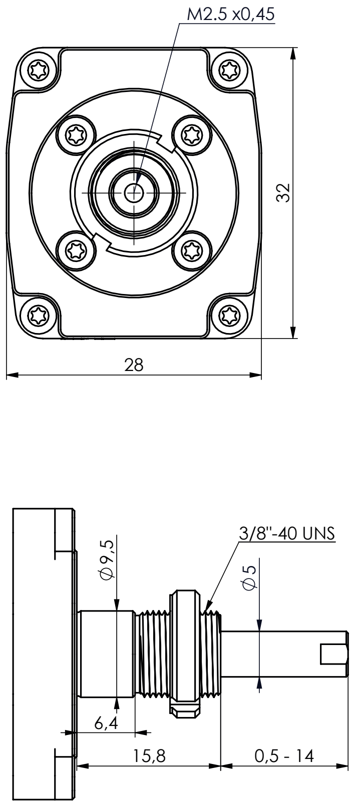




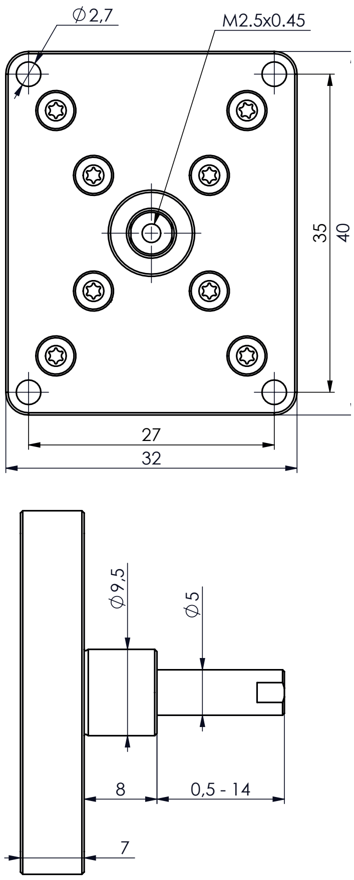
Main Dimensions LTC4012-013



Main Dimensions LTC4014-013



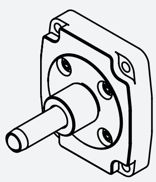
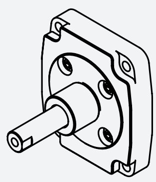
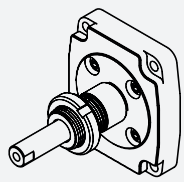
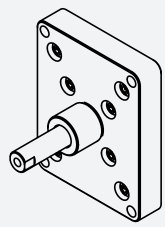
Main Dimensions LTC4016-013



Note:
Refer to drawings for details. Drive shaft has only limited bending moment capability, and absolutely no rotational torque is allowed. In order to safely mount an endpiece in the threaded hole, you must first release the motor completely (it must not be fixed in position). Thereafter, hold on only to the flat part of the shaft and fasten endpiece tightly.

150031-03

Technical Specification			
Type	**LTC40**	**Unit**	**Note**
Minimum Stroke	12.8	mm	
Speed Range [a]	0-16	mm/s	recommended, no load
Step Length [b]	4.5	µm	one wfm-step
	0.0005 [c]	µm	one microstep [c]
Resolution	< 1	nm	driver dependent
Recommended Operating Range	0-20	N	for best microstepping performance and life time
Stall Force	40	N	
Holding Force	44	N	
Maximum Voltage	48	V	
Power Consumption [d]	10	mW/Hz	=2 W at 100 Hz wfm-step frequency
Connector	USB mini-B		
Mechanical Size	63.2 x 32 x 28	mm	see drawing for details
Material in Motor Housing	Stainless Steel, Aluminum		
Weight	165	gram	approximate
Operating Temp.	0 to +50	ºC	

Versions	**LTC4012-013**	**LTC4013-013**	**LTC4014-013**	**LTC4016-013**
				

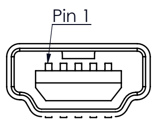
a. Max value is typical for waveform *Rhomb* at 2 kHz, no load, temperature 20ºC.
b. Typical value for waveform *Delta*, 20 N load, temperature 20ºC.
c. Driver dependent; 8192 microsteps per wfm-step for driver in the PMD200-series.
d. At temperature 20ºC, intermittent runs.

Note: *All specifications are subject to change without notice.*

Connector Type

The motor connector is USB mini-B. Motor cable is included (2 m with USB mini-B to JST 05SR-3S). Cable connects directly to driver PMD101 and PMCM31. For connection to driver PMD206 and PMD236 you also need a D-sub adapter (p/n CK6280).

Pin Assignment		
Pin	**Terminal**	**Cable Color**
1	Ground (GND)	Black or brown
2	Phase 4	Grey
3	Phase 3	White
4	Phase 2	Green
5	Phase 1	Yellow



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PiezoMotor

Piezo LEGS® Linear Twin-C 300N

- **Direct drive – backlash free**
- **Nanometer resolution**
- **No power draw in hold position**
- **Quick response**
- **Heavy loads**

The LTC300 motor is intended for high force and precision applications. This includes applications in vacuum for the semiconductor industry. The advantage of using the Piezo LEGS technology is the very precise positioning resolution, as well as automatic locking giving true set-and-forget performance. The technology is based on direct drive without any backlash.

The Piezo LEGS technology is characterized by its outstanding precision. Quick response time, as well as long service life are other benefits. In combination with the nanometer or even sub-nanometer resolution the technology is quite unique.

Operating modes

The motor can move in full steps (waveform-steps), or partial steps (microsteps) giving positioning resolution in the nanometer range. Speed is adjustable from single microsteps per second up to max specified.

Controlling the motor

PiezoMotor offers a range of drivers and controllers. The more advanced alternatives are the microstep drivers/controllers in the 100- and 200-series. These products allow for closed loop control and precise positioning. The microstepping feature divides the wfm-step into thousands of small increments which results in microsteps in the nanometer range. The PMD units are straight forward to use, supports quadrature and serial sensors, and have multiple I/O ports.

PMD101

PMD206

Design your own driver

Some customers prefer to design their own driver for ease of integration. PiezoMotor provides information to assist in the design.

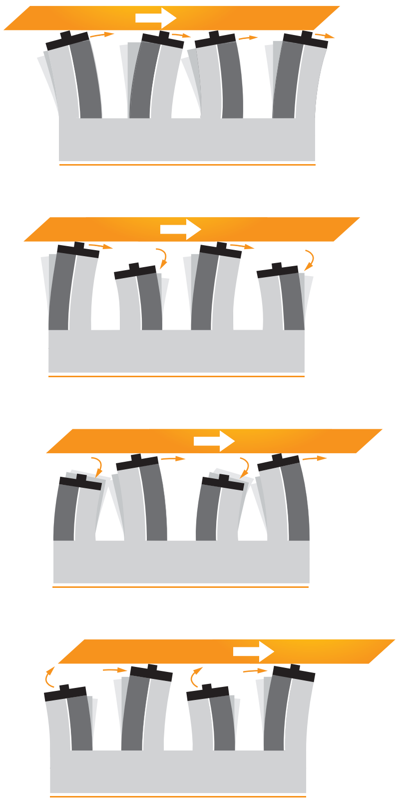
Ordering information	
Motor	
LTC30011-020	Standard version
Drivers and Controllers	
PMD101	1-axis microstepping driver
PMD206	6-axis microstepping driver
PMD236	36-axis microstepping driver
Linear Encoders	
See separerate data sheet	

Operating Principle

The Piezo LEGS walking principle is of the non-resonant type, i.e. the position of the drive legs is known at any given moment. This assures very good control of the motion over the whole speed range.

The performance of a Piezo LEGS motor is different from that of a DC or stepper motor in several aspects. A Piezo LEGS motor is friction based, meaning the motion is transferred through contact friction between the drive leg and the drive rod. You cannot rely on each step being equal to the next. This is especially true if the motor is operated under varying loads, as shown in the diagram below. For each waveform cycle the Piezo LEGS motor will take one full step, referred to as one *wfm-step* (~6.5 µm at no load with waveform *Rhomb*). In the schematic illustrations to the right, you can see one step being completed. The velocity of the drive rod is wfm-step length multiplied with waveform frequency (6.5 µm x 50 Hz = 0.3 mm/s).

Microstepping is achieved by dividing the *wfm-step* into discrete points. The resolution will be a combination of the resolution of the D/A converter, the number of points in the waveform, and the load. Example: at 150 N load the wfm-step length with waveform *Delta* is ~3 µm, and with 8192 discrete points in the waveform the microstep resolution will be ~0.4 nm.



1 *When all four legs are electrically activated they are elongated and bending. As we shall see below, alternate legs move as pairs. Arrows show the direction of motion of the tip of each leg.*

2 *The first pair of legs maintains contact with the rod and moves towards the right. The second pair retracts and their tips begin to move left.*

3 *The second pair of legs has now extended and repositioned in contact with the rod. Their tips begin moving right. The first pair retracts and their tips begin to move left.*

4 *The second pair of legs has moved right. The first pair begins to elongate and move up towards the rod.*

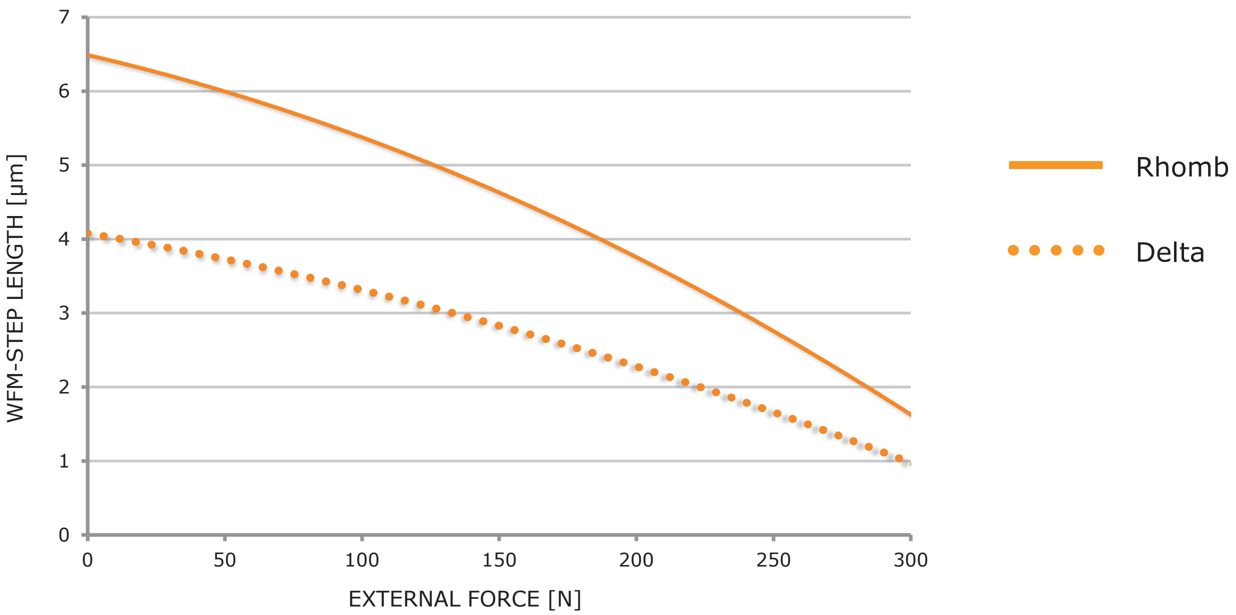
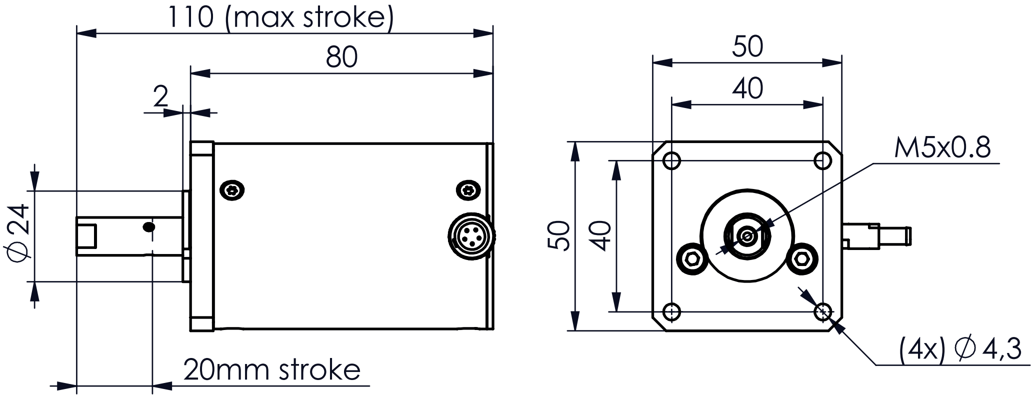
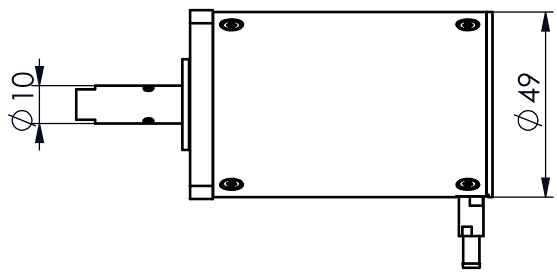
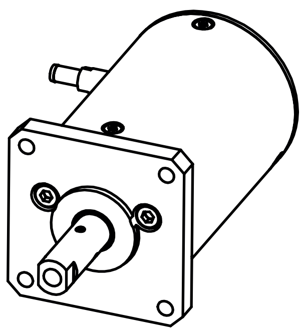


Figure 1 *Motor performance with waveform Rhomb (filled) and waveform Delta (dotted). Wfm-step length is the average distance the drive rod moves when the legs take one wfm-step (i.e. for one waveform cycle). Note: Standard deviation σ of 0.5 µm should be taken into account. Typical values are given for 20ºC.*

Main Dimensions LTC30011-020
Standard version







Note: Refer to drawings for details.

Electrical Connector Type
Motor has multiple options for connectors depending on customer requirements. Options include LEMO connector, JST connector, or conventional D-sub type connector.

150046-04

Technical Specification			
Type	**LTC30011-020 (standard version)**	**Unit**	**Note**
Maximum Stroke	20	mm	
Speed Range [a]	0-0.3	mm/s	recommended, no load
Step Length [b]	3	µm	one wfm-step
	0.0004 [c]	µm	one microstep [c]
Resolution	< 1	nm	driver dependent
Recommended Operating Range	0-150	N	for best microstepping performance and life time
Stall Force	300	N	
Holding Force	> 300	N	
Maximum Voltage	48	V	
Power Consumption [d]	0.2	W/Hz	= 10 W at 50 Hz wfm-step frequency
Connector	On request		
Mechanical Size	80 x 50 x 50	mm	see drawing for details
Material in Motor Housing	Stainless Steel		
Weight	955	gram	approximate
Operating Temperature	+10 to +70	ºC	

a. Max value is typical for waveform *Rhomb* at 50 Hz, no load, temperature 20ºC.
b. Typical value for waveform *Delta*, 150 N load, temperature 20ºC.
c. Driver dependent; 8192 microsteps per wfm-step for driver in the PMD200-series.
d. At temperature 20ºC, intermittent runs.

Note: *All specifications are subject to change without notice.*

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www.piezomotor.com

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PiezoMotor

Piezo LEGS® Linear Twin-C 450N

- **Direct drive – backlash free**
- **Nanometer resolution**
- **No power draw in hold position**
- **Quick response**
- **Heavy loads**

The LTC450 motor is intended for high force and precision applications. This includes applications in vacuum for the semiconductor industry. The advantage of using the Piezo LEGS technology is the very precise positioning resolution, as well as automatic locking giving true set-and-forget performance. The technology is based on direct drive without any backlash.

The Piezo LEGS technology is characterized by its outstanding precision. Quick response time, as well as long service life are other benefits. In combination with the nanometer or even sub-nanometer resolution the technology is quite unique.

Operating modes

The motor can move in full steps (waveform-steps), or partial steps (microsteps) giving positioning resolution in the nanometer range. Speed is adjustable from single microsteps per second up to max specified.

Controlling the motor

PiezoMotor offers a range of drivers and controllers. The more advanced alternatives are the microstep drivers/ controllers in the 100- and 200-series. These products allow for closed loop control and precise positioning. The microstepping feature divides the wfm-step into thousands of small increments which results in microsteps in the nanometer range. The PMD units are straight forward to use, supports quadrature and serial sensors, and have multiple I/O ports.

PMD101

PMD206

Design your own driver

Some customers prefer to design their own driver for ease of integration. In this case PiezoMotor can provide information to assist in the design.

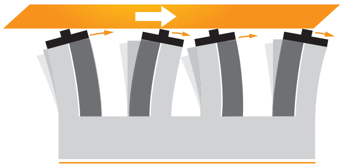
Ordering information	
Motor	
LTC45011-020	Standard version
Drivers and Controllers	
PMD101	1-axis microstepping driver
PMD206	6-axis microstepping driver
PMD236	36-axis microstepping driver
Linear Encoders	
See separerate data sheet	

Operating Principle

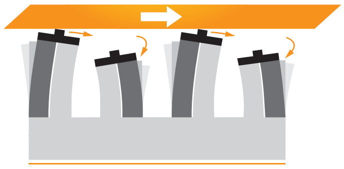
The Piezo LEGS walking principle is of the non-resonant type, i.e. the position of the drive legs is known at any given moment. This assures very good control of the motion over the whole speed range.

The performance of a Piezo LEGS motor is different from that of a DC or stepper motor in several aspects. A Piezo LEGS motor is friction based, meaning the motion is transferred through contact friction between the drive leg and the drive rod. You cannot rely on each step being equal to the next. This is especially true if the motor is operated under varying loads, as shown in the diagram below. For each waveform cycle the Piezo LEGS motor will take one full step, referred to as one *wfm-step* (~6.5 µm at no load with waveform *Rhomb*). In the schematic illustrations to the right, you can see one step being completed. The velocity of the drive rod is wfm-step length multiplied with waveform frequency (6.5 µm x 50 Hz = 0.3 mm/s).

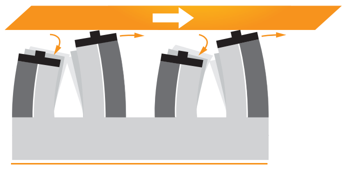
Microstepping is achieved by dividing the *wfm-step* into discrete points. The resolution will be a combination of the resolution of the D/A converter, the number of points in the waveform, and the load. Example: at 225 N load the wfm-step length with waveform *Delta* is ~2 µm, and with 8192 discrete points in the waveform the microstep resolution will be ~0.2 nm.



***1** When all four legs are electrically activated they are elongated and bending. As we shall see below, alternate legs move as pairs. Arrows show the direction of motion of the tip of each leg.*



***2** The first pair of legs maintains contact with the rod and moves towards the right. The second pair retracts and their tips begin to move left.*



***3** The second pair of legs has now extended and repositioned in contact with the rod. Their tips begin moving right. The first pair retracts and their tips begin to move left.*

***4** The second pair of legs has moved right. The first pair begins to elongate and move up towards the rod.*

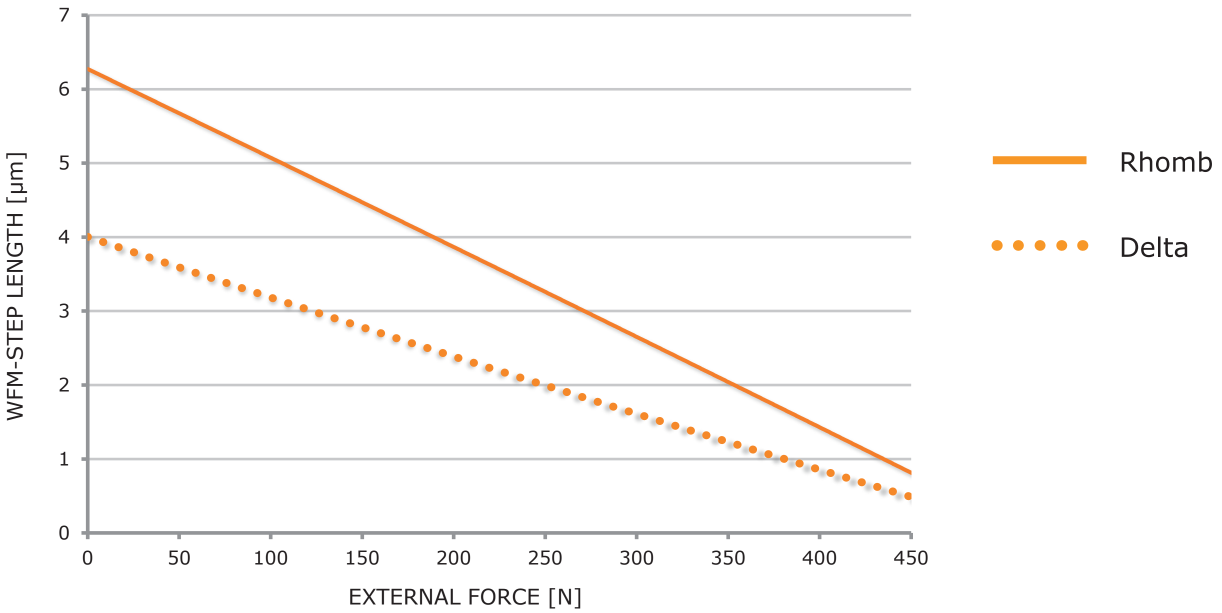
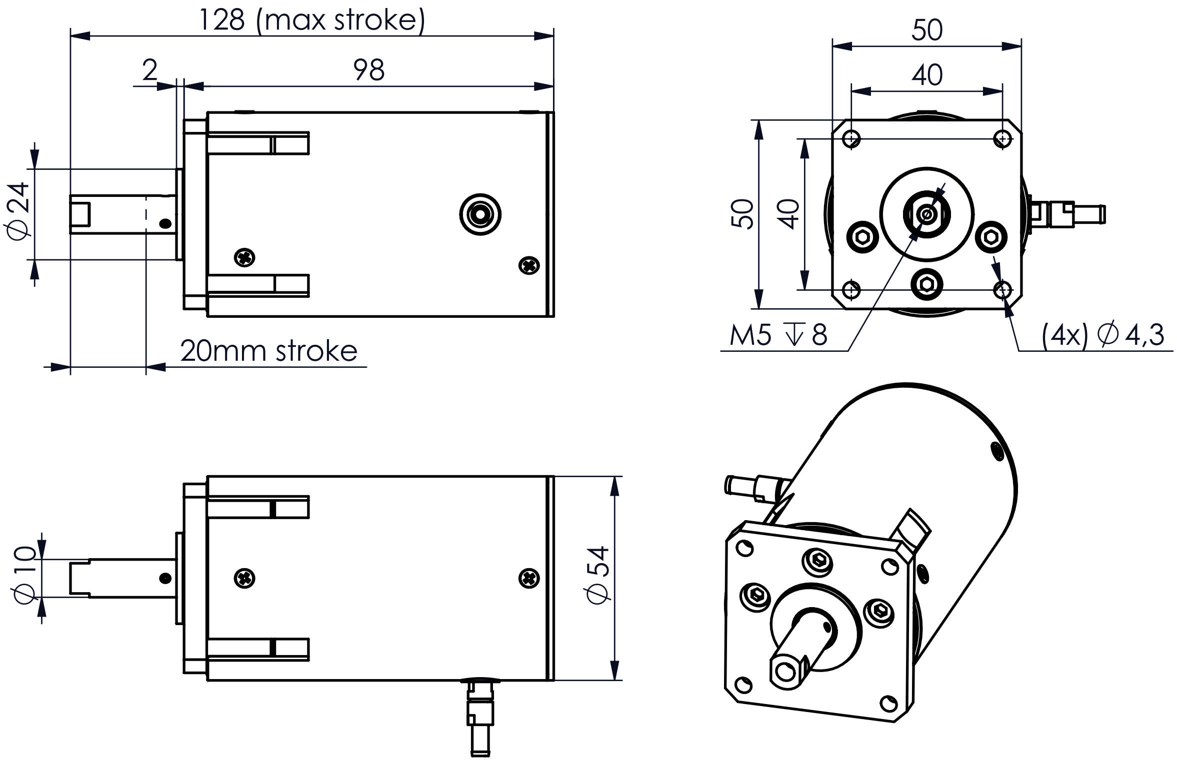


Figure 1 *Motor performance with waveform Rhomb (filled) and waveform Delta (dotted). Wfm-step length is the average distance the drive rod moves when the legs take one wfm-step (i.e. for one waveform cycle). Note: Standard deviation σ of 0.5 µm should be taken into account. Typical values are given for 20ºC.*

Main Dimensions LTC45011-020
Standard version



Note: Refer to drawings for details.

Electrical Connector Type

Motor has multiple options for connectors depending on customer requirements. Options include LEMO connector, JST connector, or conventional D-sub type connector.

150047-03

Technical Specification			
Type	**LTC45011-020 (standard version)**	**Unit**	**Note**
Maximum Stroke	20	mm	
Speed Range [a]	0-0.3	mm/s	recommended, no load
Step Length [b]	2	µm	one wfm-step
	0.0002 [c]	µm	one microstep [c]
Resolution	< 1	nm	driver dependent
Recommended Operating Range	0-225	N	for best microstepping performance and life time
Stall Force	450	N	
Holding Force	> 450	N	
Maximum Voltage	48	V	
Power Consumption [d]	0.3	W/Hz	= 15 W at 50 Hz wfm-step frequency
Connector	On request		
Mechanical Size	98 x 50 x 50	mm	see drawing for details
Material in Motor Housing	Stainless Steel		
Weight	1060	gram	approximate
Operating Temperature	+10 to +70	ºC	

a. Max value is typical for waveform *Rhomb* at 50 Hz, no load, temperature 20ºC.
b. Typical value for waveform *Delta*, 225 N load, temperature 20ºC.
c. Driver dependent; 8192 microsteps per wfm-step for driver in the PMD200-series.
d. At temperature 20ºC, intermittent runs.

Note: *All specifications are subject to change without notice.*

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