

marco provides piezoceramic stack actuators according to customer specifications.

The designs rely on our in-house manufacturing of *piezoceramic materials* and our knowledge and experience in all the manufacturing techniques: surface-finishing, plate cutting, structurized vapour metallization and melting of metallized ceramics.

The function of a stack actuator is determined by the following parameters:

- Relative extension at a maximum operating field strength of 2 kV/mm**
 The choice of a suitable material is critical, for example, piezoelectric or electrostrictive. The mechanical prestress also influences the relative length extension.
 The material also determines the temperature behaviour, hysteresis and linearity characteristics of the actuator.
- Extension of the stack**
 The extension depends on the relative extension of the material and on the length of the stack. It is typically about 0.11 ... 0.18 %. The length of a stack should not exceed approximately 10x its diameter for circular stacks, and 10x its smaller side length for rectangular stacks.
- Blocking Force**
 The blocking force of a stack element is proportional to the surface of its cross section. marco offers a range of disks with 10 mm, 15 mm, 25 mm, 30 mm and 35 mm diameter. Other diameters are available upon request.
 The range of rectangular stacks is much more varied, offering greater design possibilities.
 The smallest possible sections are 3 mm x 3 mm, the largest 50 mm x 50 mm. The choice of section size and shape is determined by the loads/forces and the conditions of installation.
- Operating Voltage**
 With the given maximum operating field strength of 2 kV/mm, the operating voltage is determined by the thickness of the individual plates. marco manufactures actuator stacks with plate thicknesses from 0.15 mm, which allows operating voltages from 300 V to 1000 V.
- Electrical Capacity**
 The capacity of a stack element is determined by the material, the plate thickness, the section and the length of the element. The actuator capacity is of great importance for the dynamic operation of a system. The capacity and the operating voltage can be freely adjusted by varying the plate thickness.
 Capacity values are low-signal measured values. Under operating conditions (operating field strength and mechanical load), they can increase up to twice the measured value.

□ **Permissible Load**

We differentiate between mechanical compression load and tensile load.

The compression load depends on the surface of the section and leads to a compression of the stack as an elastic system, depending on the stack's mechanical stiffness. The zero point of the piezo actuator displacement is thus shifted.

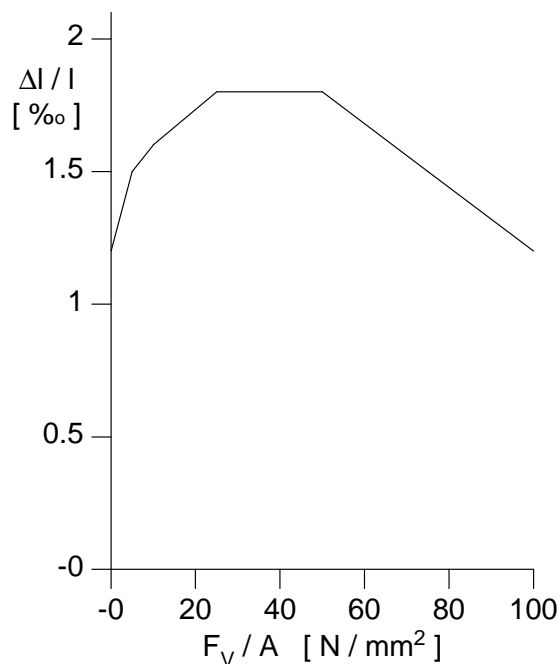
The maximum permissible compression load is calculated from the maximum permissible compressive stress of 40 N/mm^2 and the section surface of the actuator. The actual compression load in an application consists of the prestress load and the static and dynamic loads. It should not exceed the maximum value.

The tensile load should not exceed 80 % of the prestress load.

□ **Prestress**

Prestressing stack actuators has a positive effect on many properties, particularly in dynamic operation:

- increased external tensile load of 80% of the prestress load
- increased intrinsic stiffness
- inertia compensation in dynamic operation
- increase in extension of the materials FPM231 and FPM203



Specific extension as function of mechanical compressive stress

We recommend a prestress load (F_v) with 25 N/mm^2 actuator cross sectional area or 62.5 % of permitted compression load ($F_{zul.}$).

The stiffness of the prestress spring should not exceed 10 % of the actuator stiffness.

□ **Resonance Frequency**

Resonance frequency is determined by low-signal control and free-body conditions.

Part Number Information:

pa/ps<A>/<C>x<D>x<E>/<F>

pa =	Piezo Actuator
ps =	Stack
<A> =	Maximum operating voltage and polarization voltage in 100V 3 = 300 V 5 = 500 V 10 = 1000 V
 =	Material Description 1 = FPM 220* 2 = FPM 202 3 = FPM 231 4 = FPM 110 5 = FPM 225 Elektrostriktor RT 6 = FPM 226 Elektrostriktor 50°C 7 = FPM 203 * replaced by FPM 231!
<C>x<D>x<E> =	Dimensions Height x Width x Depth for round parts: Height x Diameter
<F> =	Version a, b, c, ... specifies the wire length, cable type, end-piece design, etc., specified in the drawing of the particular product.

Stack actuators

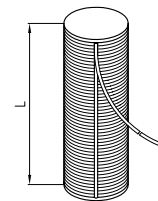
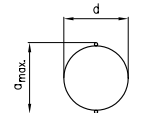
marco offers complete system solutions based on customers' specific requirements:

- Stack inside a housing with mechanical pre-stress and integrated position measurement system for position-regulated operation
- Highly integrated regulated positioning systems for 12 V drive voltage
- Position translated systems
- Drive electronics for analog and switching operation, for static to high dynamic displacements, for controlled and regulated positioning tasks.

For high dynamic applications, the Torque-Block® is used. Its advantage over stack actuators is its longer life expectancy due to stress minimization on the tracks and the possibility of building temperature compensated systems.

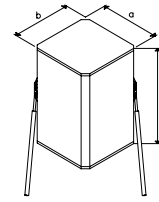
On request, the soldered tracks on stack actuators can be strengthened, thus permitting higher currents; inlays can be used to improve the mechanical stability of the brittle soldering material.

The following table lists the characteristic values of several circular stacks made of the material FPM 220 with diameters 10 mm, 15 mm, 25 mm and 35 mm:



Type	Dimensions			Stroke at $U_{\max} = 1000V$ [μm]	Operating Stiffness [N/ μm]	Permissible Load [kN]	Resonance Frequency [kHz]	Capacity (Typical) [nF]
	$d^{+0,5}$ [mm]	a_{\max} [mm]	l [mm]					
<i>pa/ps101/16x10/a</i>	10	12	16	20	79	2.4	78	75
<i>pa/ps101/31x10/a</i>	10	12	31	40	41	2.4	41	150
<i>pa/ps101/46x10/a</i>	10	12	46	60	27	2.4	26	225
<i>pa/ps101/16x15/a</i>	15	17	16	20	177	5.4	73	165
<i>pa/ps101/31x15/a</i>	15	17	31	40	91	5.4	38	330
<i>pa/ps101/46x15/a</i>	15	17	46	60	62	5.4	24	495
<i>pa/ps101/16x25/a</i>	25	27	16	20	491	15.0	65	460
<i>pa/ps101/31x25/a</i>	25	27	31	40	253	15.0	34	930
<i>pa/ps101/46x25/a</i>	25	27	46	60	171	15.0	21	1395
<i>pa/ps101/16x35/a</i>	35	37	16	20	962	30.0	49	915
<i>pa/ps101/31x35/a</i>	35	37	31	40	497	30.0	25	1830
<i>pa/ps101/46x35/a</i>	35	37	46	60	335	30.0	16	2745

The following characteristic values apply for a choice of rectangular stacks with dimensions 3 mm x 3 mm, 4 mm x 5 mm and 8 mm x 8 mm made of the material FPM 231:



	Stroke Δl at F_v and $U=300V$ [μm]	Stroke Δl_{nom} at $F=0$ and $U=300V$ [μm]	Height l [mm]	Stiffness [N/ μm]	Permissible Load $F_{perm.}$ [kN]	Pre- stress F_v [kN]	Capacity [μF]	Resonance Frequency [kHz]
<i>pa/ps33/5x8x8/a</i>	7	5	5	225	2.5	1.56	0.26	178
<i>pa/ps33/9x8x8/a</i>	14	10	9	125	2.5	1.56	0.52	117
<i>pa/ps33/18x8x8/a</i>	28	20	18	62	2.5	1.56	1.03	63
<i>pa/ps33/26x8x8/a</i>	42	30	26	43	2.5	1.56	1.50	45
<i>pa/ps33/5x4x5/a</i>	7	5	5	80	0.8	0.5	0.10	253
<i>pa/ps33/9x4x5/a</i>	14	10	9	45	0.8	0.5	0.19	125
<i>pa/ps33/18x4x5/a</i>	28	20	18	22	0.8	0.5	0.38	68
<i>pa/ps33/26x4x5/a</i>	42	30	26	15	0.8	0.5	0.52	47
<i>pa/ps33/5x3x3/a</i>	7	5	5	40	0.4	0.25	0.05	260
<i>pa/ps33/9x3x3/a</i>	14	10	9	22	0.4	0.25	0.10	130
<i>pa/ps33/18x3x3/a</i>	28	20	18	11	0.4	0.25	0.19	70

Order Number	Release	Description
<i>pa/ps</i>		Piezoceramic Stack Actuators