Bimorph Type Vibrators

Bimorph type vibrators consist of two piezoelectric elements bonded lengthwise so that when one expands, the other contracts, producing bending vibrations. Conversely, applying bending force generates an AC electric field. Often having natural frequencies in the audible range, they are widely used as high-sensitivity acoustic sensors or on/off bending actuators.

For Actuators

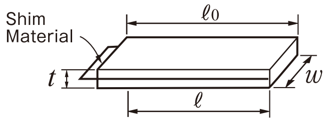
For Sensors

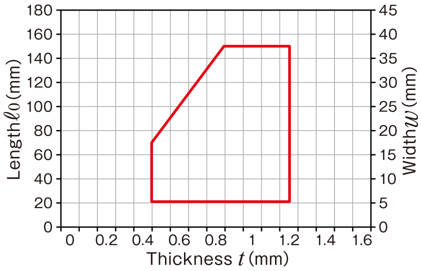
Typical Application

- Diaphragm micro pumps
- Passage flapper valve
- Bone conduction microphones
- Vibration switch
- Sound pickups
- Various actuators

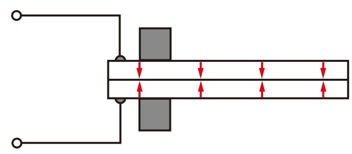
Maximum Production Range

The thickness t_s of the shim material (elastic reinforcement plate) is standardized at 0.05 mm and 0.1 mm. The free length ℓ is standardized at approximately 85% of the total length ℓ_0.

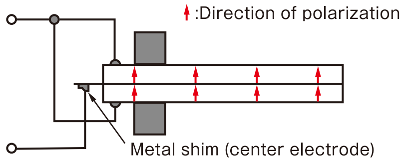




Basic Structures

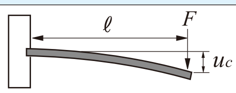
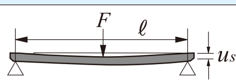


Series type



Parallel type

Bimorph type vibrator's relational expression

Conditions	One end fixed		Supporting both ends	
				
	Series type	Parallel type	Series type	Parallel type
Generating charge amounts	$Q_{cs}=\frac{3}{2}d_{31}\left(\frac{\ell}{t}\right)^2F$	$Q_{cp}=3d_{31}\left(\frac{\ell}{t}\right)^2F$	$Q_{ss}=\frac{3}{8}d_{31}\left(\frac{\ell}{t}\right)^2F$	$Q_{sp}=\frac{3}{4}d_{31}\left(\frac{\ell}{t}\right)^2F$
Output voltage versus forces F	$V_s=\frac{3}{2}g_{31}\frac{\ell}{tw}F$	$V_p=\frac{3}{4}g_{31}\frac{\ell}{tw}F$	$V_s=\frac{3}{8}g_{31}\frac{\ell}{tw}F$	$V_p=\frac{3}{16}g_{31}\frac{\ell}{tw}F$
Output voltage versus displacement u	$V_s=\frac{3}{8}g_{31}Y\left(\frac{t}{\ell}\right)^2u$	$V_p=\frac{3}{16}g_{31}Y\left(\frac{t}{\ell}\right)^2u$	$V_s=\frac{3}{2}g_{31}Y\left(\frac{t}{\ell}\right)^2u$	$V_p=\frac{3}{4}g_{31}Y\left(\frac{t}{\ell}\right)^2u$
Capacitance	$C_{ds}=\varepsilon_{33}{}^T\frac{\ell w}{t}$	$C_{dp}=4\varepsilon_{33}{}^T\frac{\ell w}{t}$	$C_{ds}=\varepsilon_{33}{}^T\frac{\ell w}{t}$	$C_{dp}=4\varepsilon_{33}{}^T\frac{\ell w}{t}$
Compliance	$S_{nc}=\frac{1}{Y}\cdot\frac{4\ell^3}{wt^3}$		$S_{ns}=\frac{1}{4}\cdot\frac{1}{Y}\cdot\frac{\ell^3}{wt^3}$	
Displacement	$u_c=F\cdot S_{nc}$		$u_s=F\cdot S_{ns}$	
Resonant frequency	$f_{rn}=\frac{\alpha_n{}^2}{4\sqrt{3}\,\pi}\,\frac{t}{\ell^2}\sqrt{\frac{Y}{\rho}}$ $\alpha_1=1.875$, $\alpha_2=4.69$, $\alpha_3=7.85$		$f_{rn}=\frac{\alpha_n{}^2}{4\sqrt{3}\,\pi}\,\frac{t}{\ell^2}\sqrt{\frac{Y}{\rho}}$ $\alpha_1=\pi$, $\alpha_3=3\pi$	

Parallel type bimorph vibrators, when used with one end fixed, relationship between the displacement u_0 and the generated force F_b or compliance S_n and the resonant frequency f_{rm} is shown in the following formula.

$$u_0=3\cdot d_{31}\left(\frac{\ell}{t}\right)^2\cdot\left(1+\frac{t_s}{t}\right)\cdot V\cdot\alpha\ [\mathrm{m}]$$

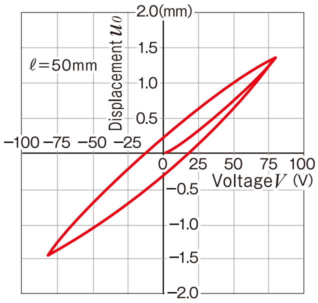
$$F_b=\frac{u_0}{S_n}\ [\mathrm{N}]$$

$$S_n=s_{11}{}^E\cdot\frac{4\cdot\ell^3}{w\cdot t^3}\ [\mathrm{m/N}]$$

$$f_{rm}=\frac{1.875^2}{4\sqrt{3}\,\pi}\cdot\frac{t}{\ell^2}\sqrt{\frac{Y_{11}{}^E}{\rho}}\ [\mathrm{Hz}]$$

α : Nonlinearly correction coefficient (≅2)
d_{31} : Piezoelectric constant (C−82 ; −266×10⁻¹² [m/V])
V : Applied voltage
$s_{11}{}^E$: Elastic compliance of piezo $\left\{\frac{1}{Y_{11}{}^E}\right\}$
$Y_{11}{}^E$: Young's modules of piezo $\left\{\frac{1}{s_{11}{}^E}\right\}$
t_s : Shim thickness (elastic reinforcing plate)
ρ : Density of piezo (C-82 ; 7.5×10³ [kg/m³])

Typical characteristics



PM60−5−0.5 (C−82) 0.05P
Displacement u_0 is proportional to the applied voltage V proportional to the square of the length ℓ.
Generated force F is proportional to the applied voltage V proportional to the width w.
Maximum applied DC voltage level V_{max} of the normal temperature, please use within the range of the following formula.

$$V_{max}=E_r\times\frac{t-t_s}{2}\ [\mathrm{V}]$$

E_r : Endurance electric field C−6 ; 400 [V/mm], C−82 ; 300 [V/mm], C−91 ; 250 [V/mm]

Usage Notes Bimorph transducers are classified as series or parallel types by wiring, with most actuators using the parallel type. Actuators aim for large displacement at low voltage. Since displacement is proportional to voltage per unit thickness, the parallel type yields greater displacement due to higher internal electric field. Compared to stacked actuators, bimorphs produce less force but larger displacement, ideal for compact fine-motion actuators. Their electrical and mechanical symmetry results in symmetric hysteresis curves of displacement and force versus applied voltage.