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# Parallel Cantilever Biaxial Micro-Positioner

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## Abstract

The Parallel Cantilever Biaxial Micro-Positioner (PCBMP) has a novel configuration and design in that it has two parallel sets of cantilever beam flexures. This design reduces crosstalk in the X and Y translations and creates motions that are more linear and independent from each other in the X and Y directions. The PCBMP comes in two flavors, which are explained in this brief paper.

## Brief Description of the Device

*1 Straight Cantilever*

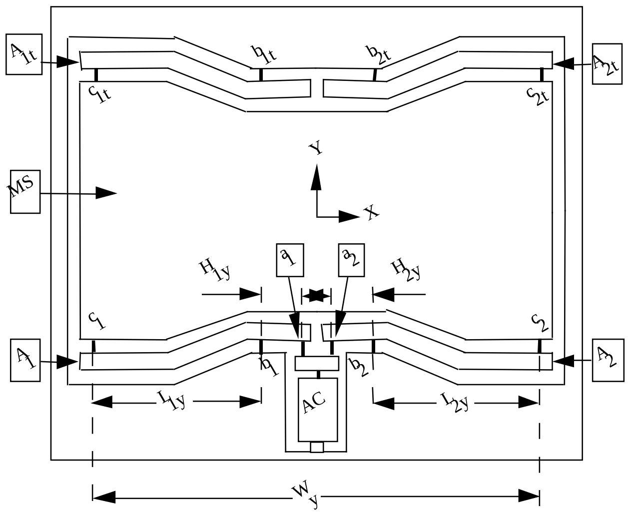


**Figure 1.** Schematic drawing of the PCBMP Y-axis motion mechanism.

Fig. 1 shows a schematic drawing of the micro-positioner mechanism. Only the Y-axis motion mechanism is shown for clarity. The input displacement is generated by the actuator (AC) and transmitted to the moving stage (MS) through flexures $a_1$ and $a_2$ of levers $A_1$ and $A_2$, respectively. These levers pivot about flexures $b_1$ and $b_2$, transmitting the actuator force to the moving stage through flexures $c_1$ and $c_2$. If not further constrained, due to the pivoting action, the attachment points of flexures $c_1$ and $c_2$ would generate arcuate motion. However, these arcs operate symmetrically on a rigid body. We therefore expect balanced elastic deformation, finally resulting in the approximate cancellation of the parasitic cross-axis motion. Levers $A_{1t}$ and $A_{2t}$ similarly constrain the other end of this stage of motion.

*2 Folding Cantilever*

Figure 2 shows an alternative design of the PCBMP. Again only the Y axis motion mechanism is shown for clarity. In the new design the levers are broken into two segments, lever "$A_i$" and lever "$B_i$" (see Fig. 2), where i = 1 or 2. Lever "$A_i$" pivots about flexure "$a_i$" and lever "$B_i$" about flexure "$b_i$". If the gain of lever "$A_i$" is $G_{Ai}$ and the gain of lever "$B_i$" is $G_{Bi}$ and since lever "$A_i$" and "$B_i$" are connected in series the total lever gain should be $G_i = G_{Ai} \times G_{Bi}$. The total lever gain can be the same as that of the straight lever micro-positioner design, but the lever "$A_i$" length is now only $N_i = (G_{Ai}+1)H_i$ instead of $(G_i+1)\ H_i$ of the straight cantilever design. The schematic of Fig. 2 shows the case of $G_{Ai} = 4$ and $G_{Bi} = 2.5$, which results in a total gain of 10 and a lever "$A_i$" length reduction of 54 %, compared with the corresponding straight lever micro-positioner design.

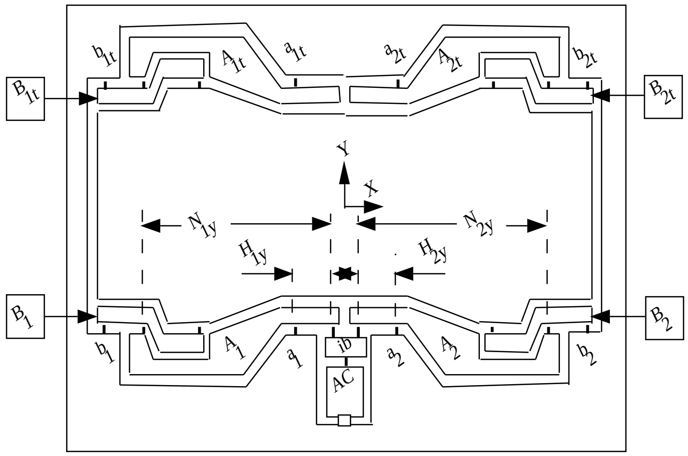


**Figure 2.** Schematic drawing of the PCBMP Y-axis motion mechanism with a folding cantilever.

*3 Experimental Prototype*

**Figure 3.** Parallel Cantilever 2D Micropositioning Stage

A macro scale size prototype of the Parallel Cantilever Biaxial Micropositioning Stage was constructed. Figure 3 shows a picture of this prototype, which is composed of two piezo-electric translators (PZTs) with internal capacitance sensors, two flexure joint couplings, a monolithic mechanical flexure baseplate, two capacitance sensors measuring the inner stage motions, control software and supporting commercial electronics. The sensors are located on the axis of the corresponding actuator of the system. This is designed to reduce Abbe offset errors for precision measurement and control of the stage.

*4 Static Performance*

The PCBMP design has the potential to reduce the error caused by the rotation of the cantilever and also provide room for on-axis sensing of the moving x-y stage. One of the more important performance characteristics of any planar micro-positioner is its angular cross talk error. All other errors can be compensated with the use of sensors and closed-loop feedback control. Correcting angular error cross talk can often require the use of expensive sensors and additional micro-positioners, which would then have to be connected in series with the planar micro-positioner to induce equal and opposite sign angular displacements. Our second macro scale size prototype micro-positioner has an unqualified (uncertainties yet to be determined) angular error of 0.1” to 0.15” (1/24000)º.

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**Key Words:** Planar Micro-positioner, Performance.