# A multichannel piezo driver for active mirrors in X-ray telescopes

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X-ray astronomy is gaining importance for studying X-ray space sources such as single and binary stars, neutron stars, supernovae and black holes. Due to atmospheric absorption, X-ray telescopes must operate in space on satellites. Among the causes limiting the resolution of modern telescopes are distortions in mirrors shape. An innovative approach for X-ray mirrors aims at correcting the shape errors by means of piezo-ceramic actuators glued to the back of the mirrors, thus creating an "active mirror". In order to test the viability of shape correction, we fabricated [1] a prototype of a thin glass active mirror, sized 20 cm x 20 cm with a 400 um thickness (Fig. 1). The mirror can allocate up to 25 piezo actuators connected to the external driving electronics by means of conductive paths, created on the back of the mirror by metal evaporation followed by a microlithographic process for selectively etching the metal.

We also designed and built [2] a modular multichannel voltage amplifier (Fig. 2), driving up to 16 piezo actuators. At beginning we considered several high voltage monolithic operational amplifiers (OP AMP), capable of managing the specified output voltages (±70 V). However all of them had to be ruled out due to their high quiescent currents, giving around 0.35 W power dissipation per channel. So we used a different approach. Each channel consists of two stages (Fig. 3). The first stage is a conventional OP AMP, powered by a ± 12 V dual supply. It drives in push-pull the control LED's of two high voltage optocouplers (TLP627 by Toshiba), whose output transistors are connected in series between the ± 70 V dual supply. It recalls a "totem pole" configuration, where the two optocouplers act as pull-up and pull-down devices. As the OP AMP driving stage operates at low voltages, its power consumption is quite low. Moreover, the output stage, based on optocouplers, has a very low bias current (around 0.1 mA), giving a power consumption of about 15 mW per channel. The voltage feedback, derived from the output voltage, guarantees the desired signal amplification and linearity. The amplifier has an overall voltage amplification of 11 and a bandwidth limited to 100 Hz, adequate to the typical control signals used to drive the piezo actuators, which are generated by an external 16 channels, 16 bit resolution, USB digital to analog converter. The amplifier also includes a "high voltage" power supply, based on a micropower isolated flyback converter (LT8300 by Linear Technology). Using a dual output transformer with a 1:5:5 winding ratio, it produces a ± 70 V dual voltage output starting from a single 12 V supply, with a nominal maximum output current of 4 mA. The whole 16 channels piezo driver thus only needs a ±12 V supply. Thanks to the adopted strategies, the total power consumption for the 16 channel voltage amplifier has been measured to be within 0.5 W.

**References**

[1] D.Spiga et al., "Manufacturing an active X-ray mirror prototype in thin glass", J. Synchrotron Rad., vol.23, 2016, pp. 59–66.
[2] D. Spiga et al., "Manufacturing and testing a thin glass mirror shell with piezoelectric active control", Proc. of SPIE Vol. 9603, 2015, pp. 96031N1-9.

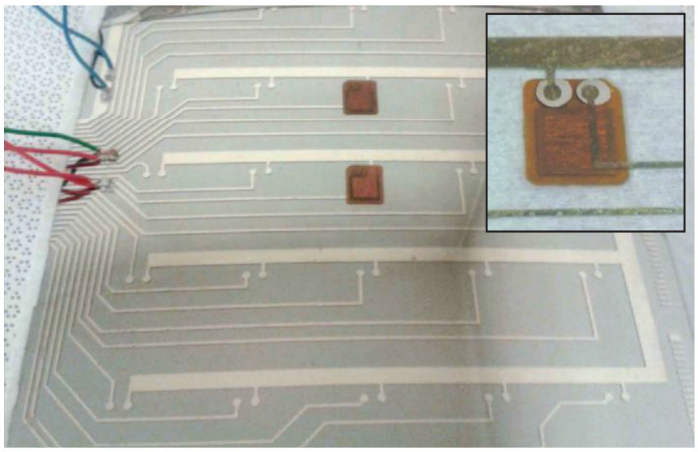

Figure 1: The thin glass active mirror, sized 20 cm x 20 cm, seen from the back side. Two piezo actuators are glued to the mirror at this stage. The inset shows a detail of one actuator connected to the conductive paths using a conductive epoxy, seen in transparency from the front side.

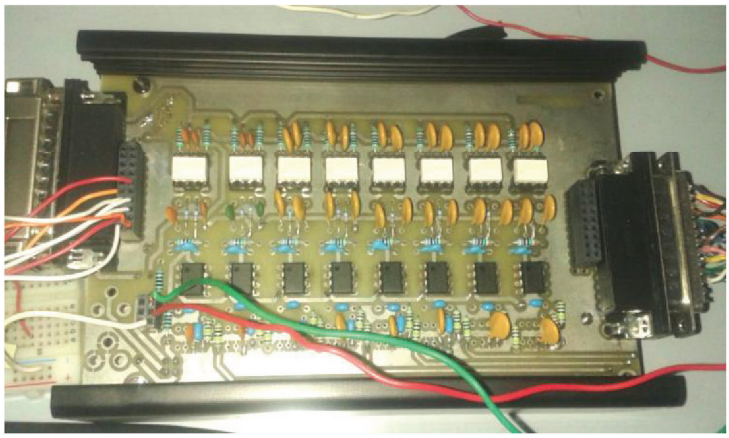

Figure 2: The multichannel piezo driver. It consists of two identical boards, each capable of driving eight piezoelectric elements, stacked together to reach the number of sixteen channels. The white IC's are the dual high voltage optocouplers used for each amplifier.

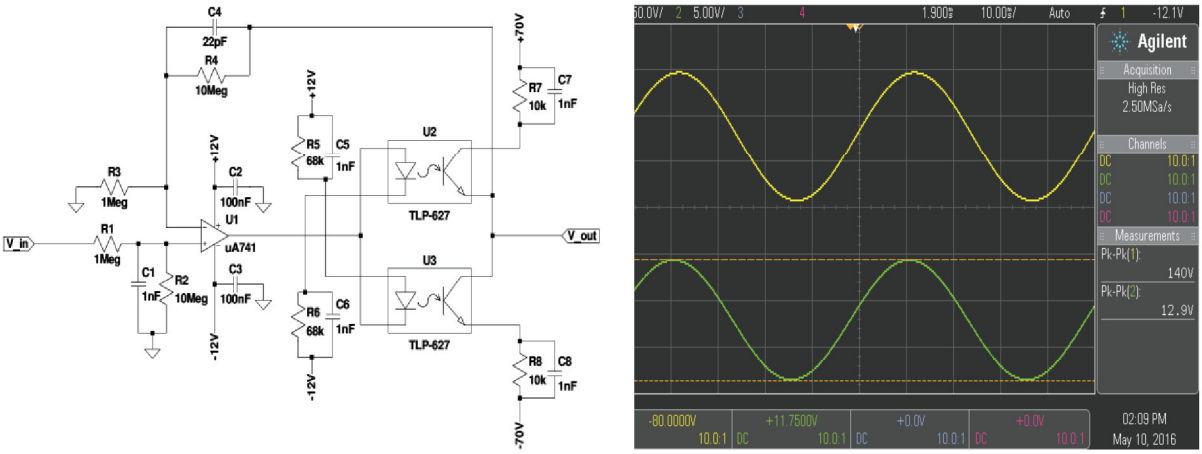


Figure 3: Schematic diagram (left) of a single channel voltage amplifier. Sixteen identical amplifiers are included in the driver. A comparison between input and output voltages is shown for a 20 Hz sinusoidal signal (right). The output voltage reaches a peak-to-peak value of 140 V.