AO@SW with Vrala: Simulations and Tests

Ciro Del Vecchio[1], Guido Agapito[1], Luca Carbonaro[1], Fabrizio Marignetti[2], Enzo De Santis[2], Yuri Coia[2]

[1]National Institute for Astrophysics, Arcetri Astrophysical Observatory, Firenze, Italy
[2]University of Cassino and Southern Latium, Cassino, Italy

Abstract

Designed to actuate large correction forces on small spatial scales for the next-generation Adaptive Secondary Mirrors, VRALA is the ideal candidate for the Adaptive Optics actuators at visible wavelengths. Feeding the device with targeted current commands and using its electric characteristics variations as feedback signal, VRALA can be operated at a bandwidth as high as 2 kHz. As its geometry allows separations as small as 25 mm, VRALA matches the very demanding requirements when correcting the visible wavefront: higher spatial resolutions and greater correction bandwidth. With a soft magnetic composite core, a dual-stator and a single-mover, VRALA (Figure 1) attains unprecedented performances with a negligible thermal impact. Its cylindrical, hollow shaped soft iron stators accommodate the coils. The flux lines of the magnetic field produced by the current flowing in the coils are conveyed into a mover, a disk also built of soft iron and facing the stator, through an air gap. As the magnetic pressure in that gap works as a pull-only force on the mover, a second stator, placed symmetrically with respect to the mover, is needed to produce the push force. This force, applied to the deformable mirror by a shaft fixed to the mover, is delivered applying relatively small currents, as the actuator geometry focuses the magnetic flux density with a great effectiveness, so decreasing by one order of magnitude the power dissipated to actuate the correction force. Pre-shaping the current required to deliver a given stroke greatly simplifies the control system, whose output supplies the current generator (Figure 2). As the inductance depends on the mover position, the electronics of this generator, provided with an inductance measure circuit, works also as a displacement sensor, providing the control system with an accurate feed-back signal. The COMSOL model of VRALA allows to define the optimized geometry, considering the non linearity of the chosen materials, to compute the relationship between force, current, and mover position, to precisely compute, adding the Ordinary Differential Equation governing the overall mechanics and using the Arbitrary Lagrangian-Eulerian method to define the actual motion, the dynamic response to the closed-loop control system (Figure 3), and to calculate the circuit inductance. The temperature variations induced by the Joule heating are also multiphysically considered in all those static and dynamic runs, in order to evaluate the thermal impact onto the very delicate optical environment. A preliminary prototype (Figure 4), built according to the model optimization run in COMSOL with a cheap soft iron, has undergone some preliminary laboratory tests. The magnetostatic results of these checks, matching the design results in terms of power and force, show that the the magnetic design addresses the severe specifications. A complete Somaloy prototype and the electronic driving and sensing board are currently under construction, in order to verify the actual dynamic response of the actuator with respect to the numerical design.

Reference

1. Ciro Del Vecchio et al., Modeling VRALA, the next-generation actuator for high-density, tick secondary mirrors for astronomy, Proceeding of COMSOL Conference (2010) .

Figures used in the abstract

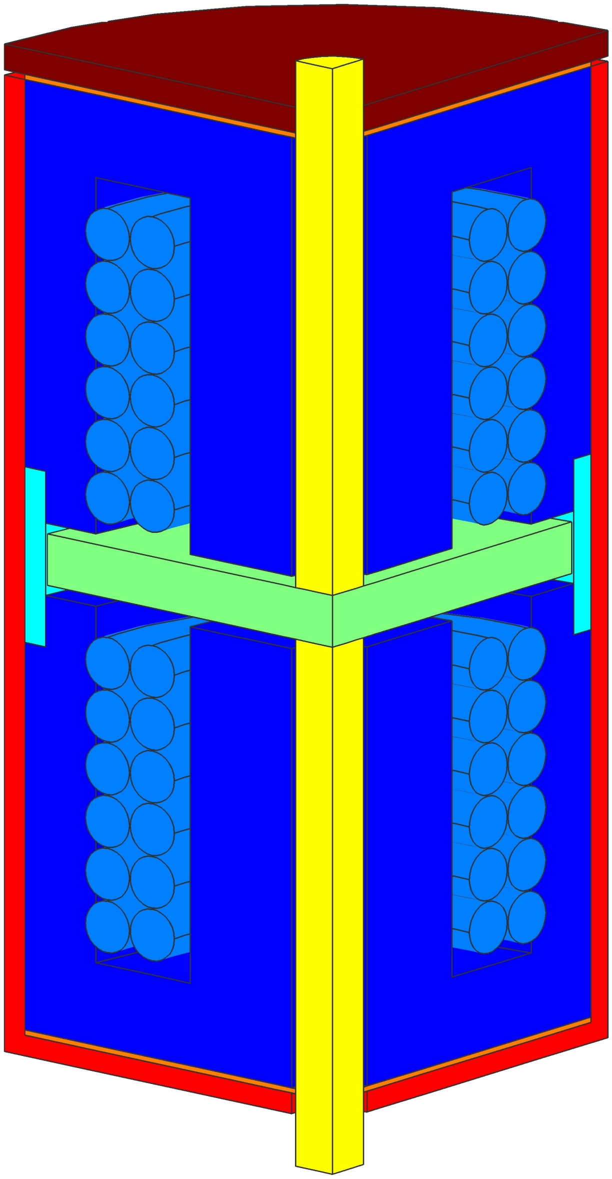

Figure 1: Overall scheme of the actuator.

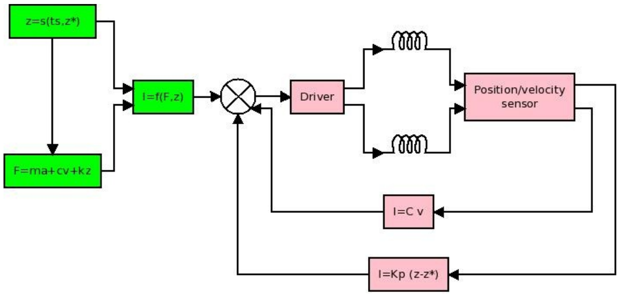

Figure 2: Control system overview.

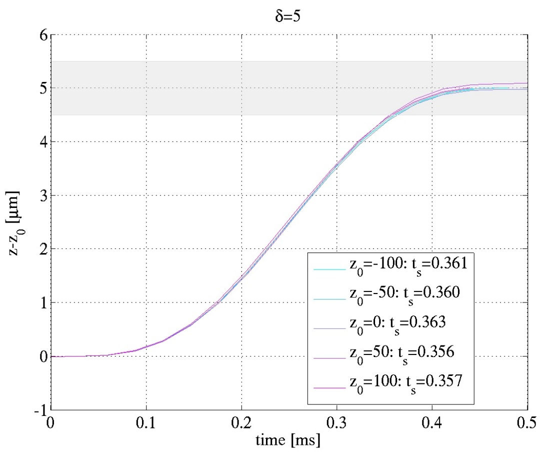

Figure 3: Step response example.

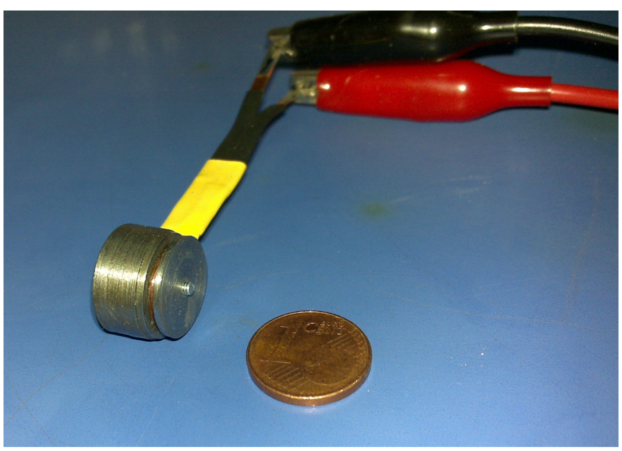

Figure 4: The preliminary actuator prototype.