DEVELOPMENT OF A STANDARDIZED METHOD FOR ACTUATOR CHARACTERIZATION USING ACTIVE CONTROL OF IMPEDANCE

by

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Presently, there is no standard testing procedure for piezoelectric actuators. It is then very difficult for a very specific given application to design the most efficient actuator in terms of blocked force, displacement, power consumption, weight, cost, etc. Piezoelectric actuator suppliers would like to have the possibility to fully characterize their actuators to be able to guide their customers on selection of the most suitable actuator based on their utilization. However, this is not an easy goal to reach since performance of a given actuator depends on the specific dynamic conditions under which it is applied. In order to characterize an actuator, it is therefore necessary to recreate similar conditions to those experienced in the real application. Because of the infinite variety of possible applications for piezoelectric actuators, physically recreating those conditions could take an enormous amount of time, means and money.

The aim of the research is then to develop the technology required in order to test an actuator under a various range of dynamic load conditions using a single automated test set-up. To do so, a second actuator will be used with a suitable sensing apparatus (impedance head) and an active control system. Using data from the sensing apparatus (force and velocity signals), the active control system will drive the second actuator to recreate any load condition the first actuator would be supposed to experience in a real application.
A test rig has then been conceived where the tested actuator is clamped on a rigid structure that has high impedance (supposed infinite for our concern) on one side, and a second actuator, also called control actuator, is fixed on the other side. The force output (F) and the velocity (V) of the test actuator can be monitored by the way of the impedance head. Finally, while driving the test actuator with a test signal, an adaptive controller, using the filtered-X LMS algorithm, can drive the control actuator so that the measured impedance (Z=\(F/V\)) matches the desired load impedance (\(Z_d\)), which characterizes the experimental load condition that is to be reproduced.

In principle this system can recreate any possible load condition. However we faced some limitations due to the sensitivity of the sensor device (lack of precision for small values of the force and the velocity for small and high impedance, respectively) but also from the test rig itself (due to resonance in the range of frequencies tested). The assumption of infinite impedance on the base of the actuator may become a limitation factor too in the case of high impedance. To get rid of this limiting high impedance condition, the solution proposed is to include a second control actuator so that impedance on both sides of the test actuator could be varied simultaneously.

To counteract these limitations, in order to have a really robust tool, the use of a two-port network model for the actuator is interesting since we will then be able to predict of the actuator behavior in the range where the test rig encounters its limitations. Derivation and validation of this two-port network model has therefore been done using the automated set-up inside the operating range of the actuator used.
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