A single piezoelectric element can be simultaneously used as a sensor and actuator, forming a concept of self-sensing actuation. A specially designed electric circuit, referred to as a bridge circuit, is required to realize the concept. Combined with feedback algorithms, the self-sensing actuator could be applied directly to a structure, creating a smart structure capable of controlling the vibration and detecting damage in the system. In this project, the dynamic characteristics of the self-sensing actuator will be established in terms of an electrically equivalent model of a piezoelectric material. Then, the effects of the unbalanced bridge circuit will be numerically and experimentally evaluated and, to some extent, quantified in an attempt to make the self-sensing more robust. The model will also be used to address the issues of vibration control and structural health monitoring by tracking the information from the sensing signal. Finally, the feasibility of using the same hardware to concurrently perform both control and monitoring will be explored.