Noise and vibration are ubiquitous in the human environment and belong to the most significant threats to the human well-being. Noise of high intensity or prolonged exposure can lead to hearing damage. It often causes exasperation, negatively affects the nervous system, and it affects even vision acuity. In industrial environments, noise is frequently a cause of difficulties in communication between staff, thereby reducing the efficiency of the work being performed. The inability to hear alarms or sounds associated with the operation of other devices significantly increases the risk of an accident. The exceeding of current noise limits defined in respective regulations results in the necessity to reduce working time, thereby increasing the costs. Even household appliances such as a washing machine, fridge, vacuum cleaner, coffee maker, etc. can generate noise that causes annoyance and significantly obstructs work or leisure. Sound-absorbing materials are commonly applied to reduce the excessive device noise. However, they are ineffective for low frequencies and often are inapplicable due to unaccepted increase of size and weight of the device and its potential overheating. However, rapid development of microelectronics, smart materials, manufacturing, signal processing, numerical methods and automatic control algorithms in recent decades allow for alternative solutions.

The applicants conducted recently a research project entitled “Active reduction of device acoustic noise by controlling vibration of the device casing”, no. DEC-2012/07/B/ST7/01408, which was finished on 1 July 2016. The objective of the project was to develop the theoretical basis for developing active device casings. The general concept was to enclose devices that generate noise in thin-wall casings (for certain kinds of devices use their own enclosures), and accordingly control their walls. The purpose of the control is to modify or generate vibrations of the walls of the enclosure so as to acoustically isolate the device ("block" sound escaping outside the enclosure). The advantage of such approach is global noise reduction, in an entire room, what is unfeasible to achieve using active control methods widely presented in the literature using loudspeakers. During laboratory experiments, global reduction of over 10 dB was achieved in the entire environment (at some zones it was even over 20 dB) for tonal or multi-tonal noises generated inside the casing, what was appreciated by the international community of researchers and practitioners. As a result, a thesis stated in the project was validated, confirming that “by controlling vibration of the case of an industrial device or a home appliance, it is possible to effectively reduce its noise, to which users are exposed”. Therefore, a new research area in the field of active noise and vibration control was opened. Within that project *a number of new topics were encountered, important mainly from the scientific point of view*, what motivated the authors to submit this application for a new research project, explore the problem further and establish the theory of device noise control. Based on the gained experience the applicants responsibly claim that the main objective of the proposed project is to further develop the theoretical basis for the noise reducing casing approach (passive, semi-active and active) and formulate a thorough theory, which can be used in the future for successful commercialisation.

Three types of active casings will be considered in the project. First of them is a rigid casing, in which each wall is made as a separate panel / panels mounted to a frame. The second type is a frame-less lightweight casing, where metal plates are bolted together, forming a self-supporting structure. The third type is a casing of a real device, with its different irregularities (e.g. embossing, bendings, internal mountings) that complicate the mathematical modelling and control of the structure.

A new group of models will be developed, representing different types of considered casings. The obtained models will be thoroughly analysed to provide a basis for optimization of the arrangement of sensors and actuators, and for frequency response shaping. The models will be respectively generalised, so their parameters could be tuned basing on specified experimental measurements procedure.

Passive methods will be further developed, using optimally arranged additional masses and ribs of suitable size, stiffness, weight and any required shape, what will allow to freely accommodate frequency response of the casing in order to improve the passive sound insulation or control susceptibility. They do not employ any control systems and do not consume any energy during operation, what constitutes a very attractive solution in many applications. A design of new casings according the frequency response demands will also be considered.

Semi-active methods will also be investigated. They will be based on the shunt technology, where by using piezoelectric elements mounted to the casing walls, mechanical energy is transformed into electrical energy, and then it is dissipated in switched multiple passive circuits. The automatic control is responsible there only to assure appropriate switching in the circuit, and thus the energy consumption is very low.

The problem of lowering the computational burden of active control algorithms will be undertaken, by employment of sophisticated control algorithms, which were not utilized in such applications, yet. Other objectives will be to ensure stability and enhance convergence rate of adaptive control algorithms, especially important for real non-stationary disturbances, generated, e.g. during acceleration of the washing machine drum. The research will be theoretical and supported by a number of simulation and experiments with different casings, including those of real devices.