Piezoelectric transducer for low frequency sound generation on surface loudspeaker

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ABSTRACT

In the foreseeable future, the adoption of multifunctional car structure (MCS) will offer the potential to radically upgrade the abilities of vehicles in terms of ecological requirements emerging from the social and legal environment. Integrating car structures with functional systems that monitor structural integrity and aging, change shape at local level, act as sound sources and tackle noise vibration harshness issues will eliminate many of the weight, volume, and signature penalties associated with the current approach of designing, manufacturing and maintaining vehicles and functional systems separately. One type of MCS that appears as very promising and which we propose to investigate in this paper is a Load-bearing Loudspeaker Structure (LLS). A LLS refers to structures that are equipped with active elements such as piezoelectric elements that allow for music reproduction and 3D sound spatialization. We consider the fact that the passenger cabin of cars consists of many large surrounding surfaces such as door panels, roof trim panel, trims and dashboards, which can act as membranes. The objective is thus to design surface loudspeaker able to efficiently reproduce sound in the low, medium and high frequency range depending on the sound panel size. Piezoelectric transducers chosen because of their small size, low weight and high force output are investigated in this paper. They are coupled to dedicated mechanical amplification units to increase displacement amplitudes to overcome the lack of low frequency sound production [1,2] and are compared to a piezoelectric ceramic ring. The goal is to efficiently excite the low frequency audio spectrum with this kind of transducers.

Three different actuators have been compared in terms of maximum displacement amplitude, maximum sound pressure level on 300x200 mm2 speaker surfaces, and energy consumption.

A flat piezoelectric ring glued to a surface produces good sound pressure levels at high frequencies but excites confuse mode patterns due to the stiff ceramic glued to the surface making control schemes more challenging.

The next two actuators have been tested in a reactive configuration (fixed between two plates) to overcome the diffuse mode patterns created by a piezoceramic disc or ring glued to a surface. All three show mode patterns similar to those predicted by theory for a flat rectangular plate.

Highest output displacements can be obtained with a APA400MML flextensional actuator which is limited to a maximum frequency of around 500 Hz. Due to the high capacitance, this actuator is relatively power consuming but provide sufficient output force of 200 N to even excite stiffer surface materials.

A flat cymbal piezoelectric actuator from TDK named PowerHap 15G has been compared to the APA400MML actuator. Good acoustic power is produced between 500 Hz and 2.5 kHz. Power consumption is reduced by a factor of three compared to the APA400MML actuator because of the lower capacitance. (3.6µF compared to 10µF). The very compact design (26x26x2.4 mm3) could make this actuator a good choice for medium frequencies in car applications.

REFERENCES

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