Acoustic Energy Transfer

Introduction

Virtually all existing systems for Contactless Energy Transfer (CET) make use of electromagnetic fields for the transfer of energy, which has severe drawbacks. Most importantly the energy transfer efficiency is extremely low when covering a large distance with respect to the system dimensions.

Acoustic Energy Transfer (AET) relies on sound waves for the transfer of energy, making it much better suited for covering large distances. Its basic principle is depicted in figure 1. For comparison: an inductive CET system with a transmitter and receiver radius of 10 cm, a distance between the two of 1 m, and a coil quality factor of 1000 would have an efficiency of 2 %\(^1\). The efficiency limit for a comparable AET system is approximately 65 %, which is a vast improvement.

Further advantages of AET are its highly directional energy transfer and the absence of electromagnetic fields. Lastly, the frequencies involved are several orders of magnitude lower than in the electromagnetic case, resulting in considerably higher efficiencies of the driving power electronics.

Possible applications of such a technology are multi-Degree-of-Freedom actuators (see figure 2a), wireless charging of mobile devices (see figure 2b) or battery powered implants such as pacemakers and energy transfer through metal enclosures.

Approach

The main goal of the project is to investigate whether AET as a CET method is feasible. The research is focussed on modelling of AET systems and experimental validation of these models. The understanding of the system that is gained in the process is employed for increasing the power transfer capabilities and energy transfer efficiency.

One of the major difficulties that must be overcome in AET systems that operate in air is the large acoustic impedance mismatch of the transmitter and receiver with the medium in figure 1. Special attention is given to this problem, since it severely limits the power transfer and efficiency.

Results

Figure 3 shows both the theoretically achievable and measured energy transfer efficiency of an AET system with a transmitter and receiver radius of 1.1 cm. The efficiency limit in the figure is a consequence of diffraction and attenuation in the medium. The effect of the acoustic impedance mismatch is very apparent from the difference between the two lines. It results in many maxima and minima due to a standing wave between both transducers. Impedance matching by means of horns improves the efficiency by a large degree for greater distances, as can also be seen in the graph.

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References