

Voice Coil Design

Project 11656 ITT Beam Steering Project

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I. Voice Coil Basics

A voice coil is a current controlled force device, where depending on how much current you push through the voice coil wire, depends on how much force you will get out of it. Usually it consists of an iron outer shell to get the magnetic field into the right space, a magnet to produce the magnetic field, and a coil of wire to produce an opposing magnetic field which in turn produces the force.

II. Design Considerations

In order to come up with a design the first thing we needed to do was to figure out how far it had to move and if we were going to use an overhung coil, which is a style where the coil is larger than the field area in order to preserve linearity, or an under hung coil, which is has a more limited range of motion, but produces more force per current used. So given that we needed about 1mm of travel up and down, it was decided that an under hung would help us keep the power consumption low. The next thing that was needed was the outer sizing of the voice coil. This was decided to be a maximum of .85 inches, which converted down to 20mm (.75 inches) diameter, in order to not be taking so much space that we wouldn't be able to put it within a 3 inch diameter by 3 inch high cylinder that our entire project is supposed to be within. With the idea that you need an extra 2-3mm for travel distance and a maximum of 20mm outer diameter, the design started.

III. The Program

The program used to model the voice coil so we could mess around with the sizes of everything without having to build everything uninformed of what we might be getting was called COMSOL multiphysics.

IV. Actual Design

With all the design considerations that needed to be made taken into account the diameter was pretty much set in stone. The goal of the design was to produce an area with as much magnetic field as possible without killing the area we have to actually place wire wrappings. The design came out to be 31.55mm tall and with a magnetic strength through the area of the coil of .38 T, significantly smaller than what the magnet itself has as a field strength (1.4T) but still allowed for 300 wrappings of the wire, This allowed for a force of .48N with 100mA of current running through it. Which would produce a power consumption of 1.5W per axis. Our biggest goal was to be less than 5W power consumption, and this would have allowed us a little additional power usage for our circuitry given that we have 3W of power used. The approximation used to find how much wire would fit within the gap, was to take the area in a cross section, minus 2.5mm on the height, and to approximate the wire diameter as a box, so that even in worse case not getting the wire to sit together in the groves of the previous wrap, we get a maximum number of wrapping that can be gotten. This ended up being 390

wire wrappings, with all that information we could get the force produced from this voice coil design.

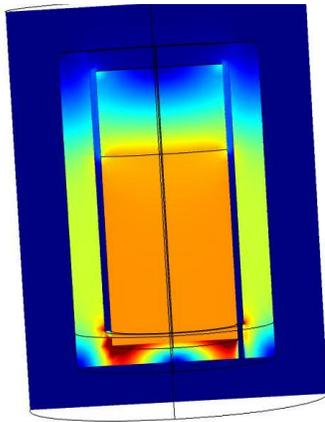


Figure 1.1 Voice Coil Magnetic Field Strength

$$F = 2\pi I |B| N R c \quad (1)$$

From equation 1, and the model strength in the gap of .38T, 300 wrappings to leave room for attachment to a paper cylinder, a radius of 6.5mm, and a current pushed through of 100mA. We get a force of .48 N, this force was later used to design the rest of the system. From Equation 1, B is the magnetic flux, N is the number of windings in the coil, I is the current through the coils, R is the radius of the coil.

V. Additional Files Included

In addition to the information of the voice coil design considerations included on the page this file should be found should be the COMSOL model for the voice coil, so it can be edited with proper software, and sized, gap width, all changed to produce possibly a better voice coil. As well as a design using a smaller magnet, and a more standard design with a wider gap in areas that aren't the place where the gap is desired.

VI. Build

The actual build had some issues compared to the design, first off the inner diameter of the shell ended up being .65 inches instead of the designed for .55 inches. This actually ended up not being an issue due to the largeness of the wire wrapping core. In order to fix the field strength in the gap, it was found that .31T would result if we had .55 inches, having a .1 inch gap.

The building of the cores were a bit interesting, the early design was just a single piece of paper with wire wrapped around it. This had the issue that the wire was not distributed across the appropriate region uniformly, and so would have more wire in the middle, and less out at the edges. This issue was solved using some thin paper wrapped around the outer edges of the correct space to make a sort of barrier to keep it in place. Figure 1.2 shows the final design of the paper core used.



Figure 1.2 Voice Coil core (right final wrapped core with paper barriers, left starting piece of paper to be wrapped around a pole then add strips of paper for barriers)

VII. Suggestions for making voice coils better

The core could be created with a small groove in order to make assembly more accurate and easier. As well as when being placed onto the mount if a small hole is drilled for the wire to come out, that would be ideal, to prevent messy edges that can break the wire. Then for the wire coming off the core, there is a mesh wire that ITT uses that is thin, but has much better strength for motion, and that could be used as well.