Electromagnetic Suspension for Levitation of the Pod

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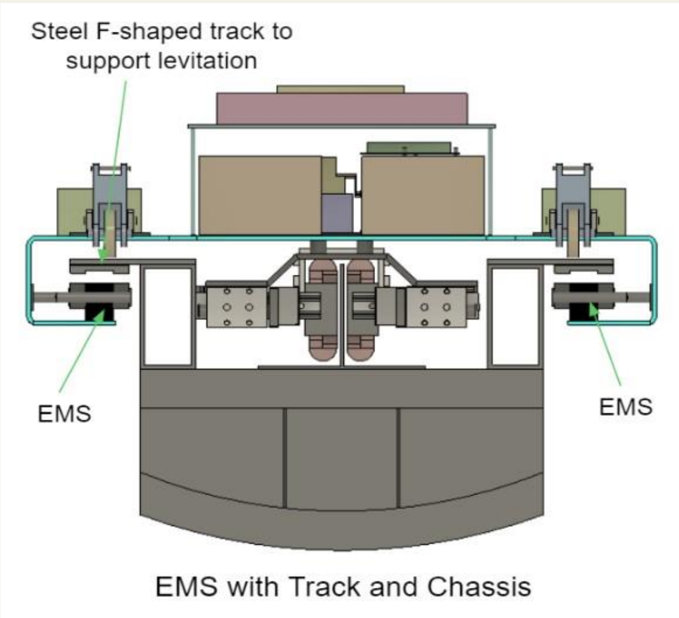
Introduction

Electromagnetic Suspension (EMS) is chosen for levitation as it is economical and can make the pod levitate at zero velocity lesser. It also has lesser magnetic drag at lower velocities when compared to Electrodynamic Suspension (EDS).

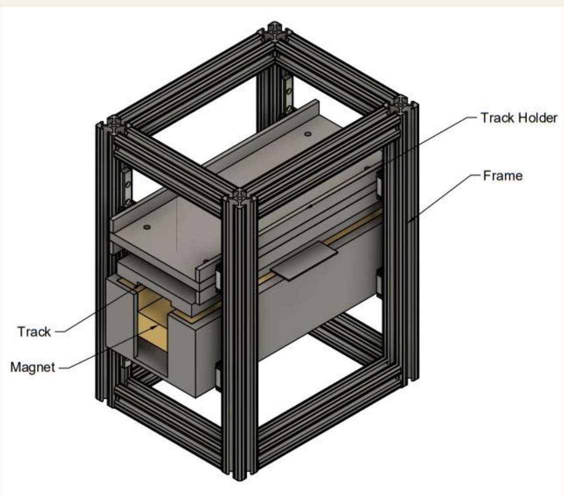
To make the pod levitate, we are to design an Electromagnetic Suspension system keeping in mind the following constraints.

- A minimum of 800N lift force per EMS.
- A robust PID controller is to be designed to control the air gap using DSP.
- To maintain a maximum current of 15A.
- An equilibrium gap of 6mm must be maintained.



Methods / Procedures

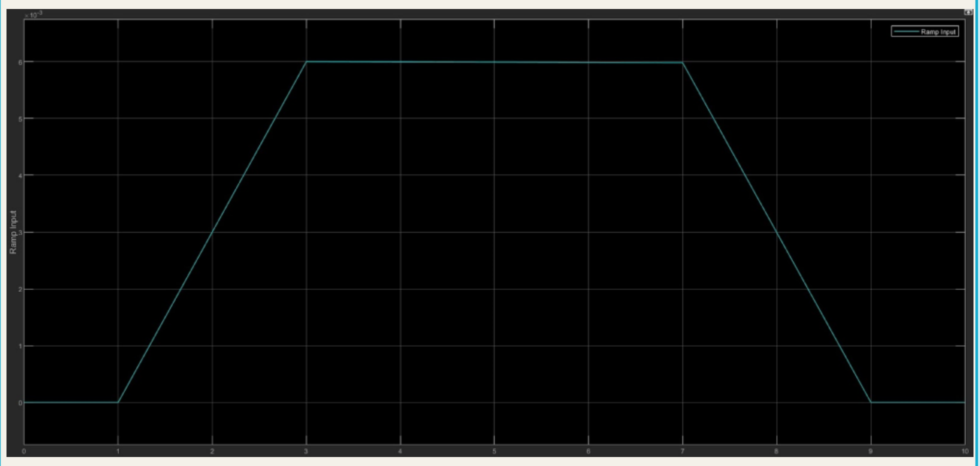
The 1 Degree of freedom (DOF) test setup is used to maintain the equilibrium keeping the air gap as per required.



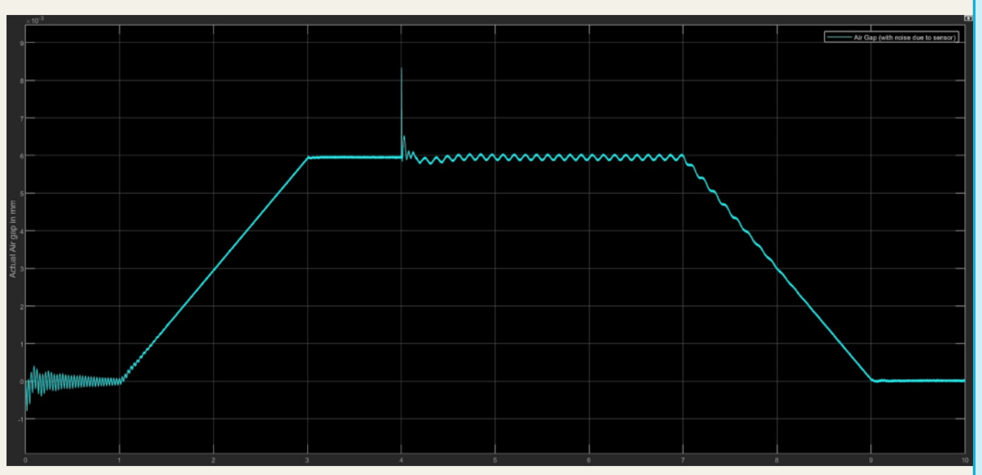
- The track, which is equipped with load cells (to measure the force between the EMS and the track), may be adjusted up and down and secured with nuts and bolts.
- The EMS is mobile and may be moved up and down utilizing linear bearings. To measure the distance between the track and the EMS, the EMS holder is equipped with a Panasonic HG-C 1050 Laser Displacement Sensor.
- The EMS voltage is regulated by a DC-DC chopper, which is controlled by a PWM (pulse width modulation) signal, the duty cycle of which is controlled by the PID controller via feedback loops.
- Simulink was used to model the PID Controller, which was then built using the MSP-EXP432E401Y microcontroller.

Results / Findings

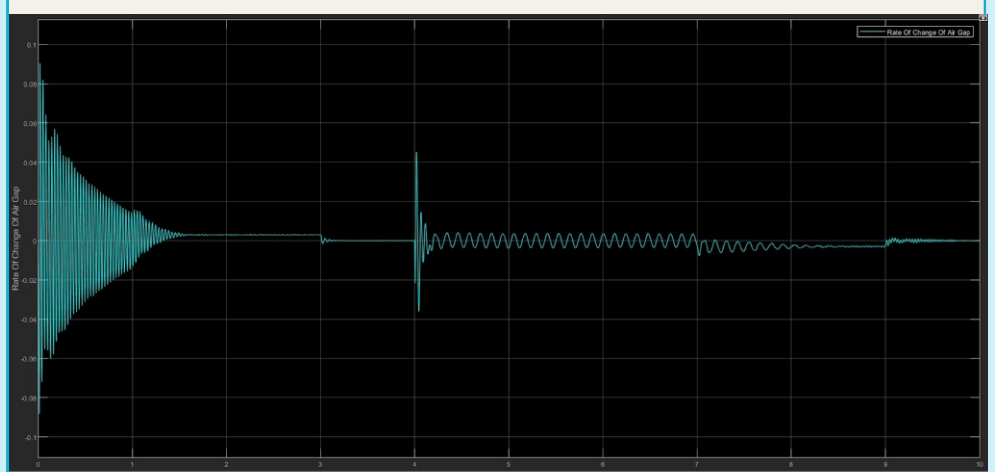
The various results obtained by simulating the PID controller in Simulink are listed below:



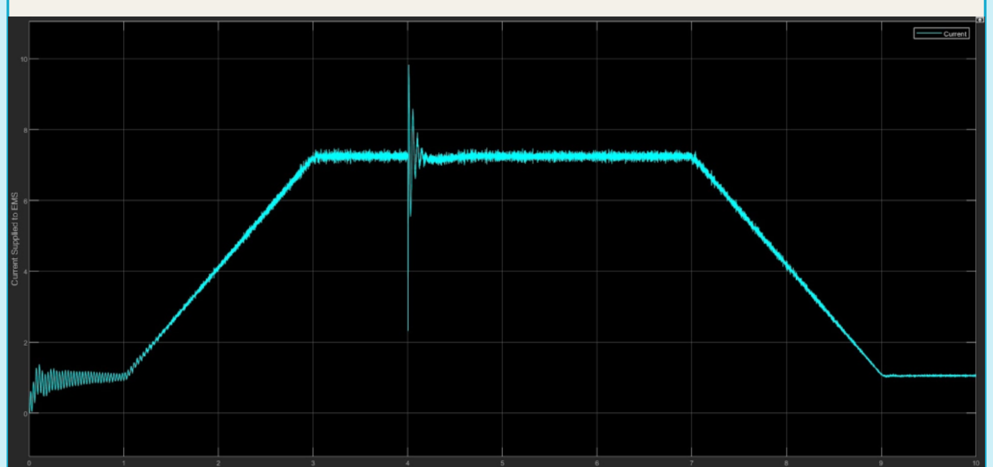
Desired air gap was gradually increased to 6mm and again gradually reduced to zero



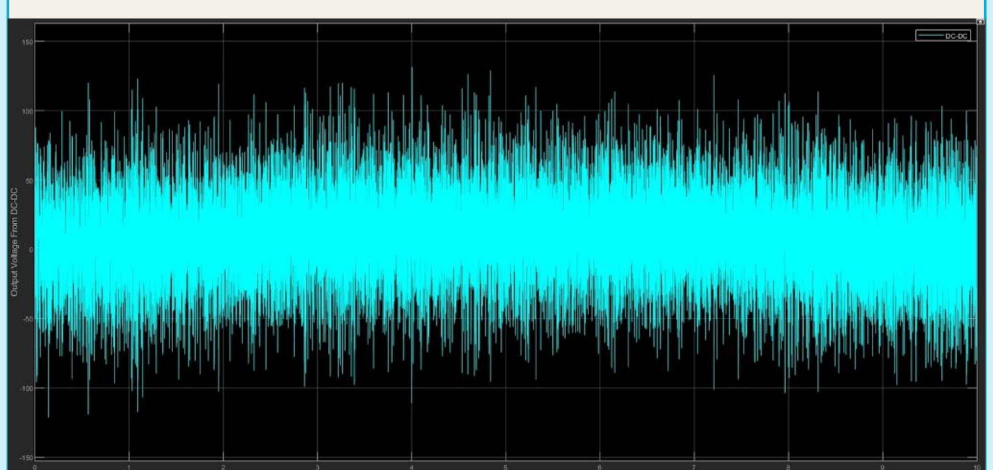
Actual air gap between the EMS and the track



Rate of change of the actual air gap



Actual air gap with the noise due to the gap sensor.



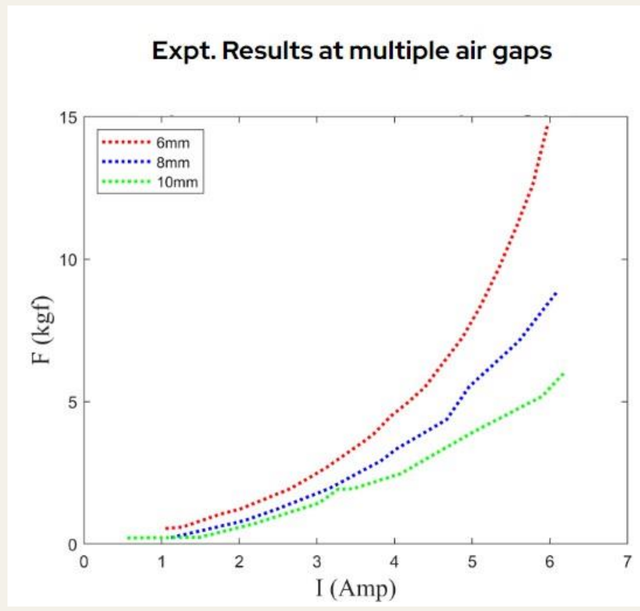
Output Voltage from the DC-DC Chopper.

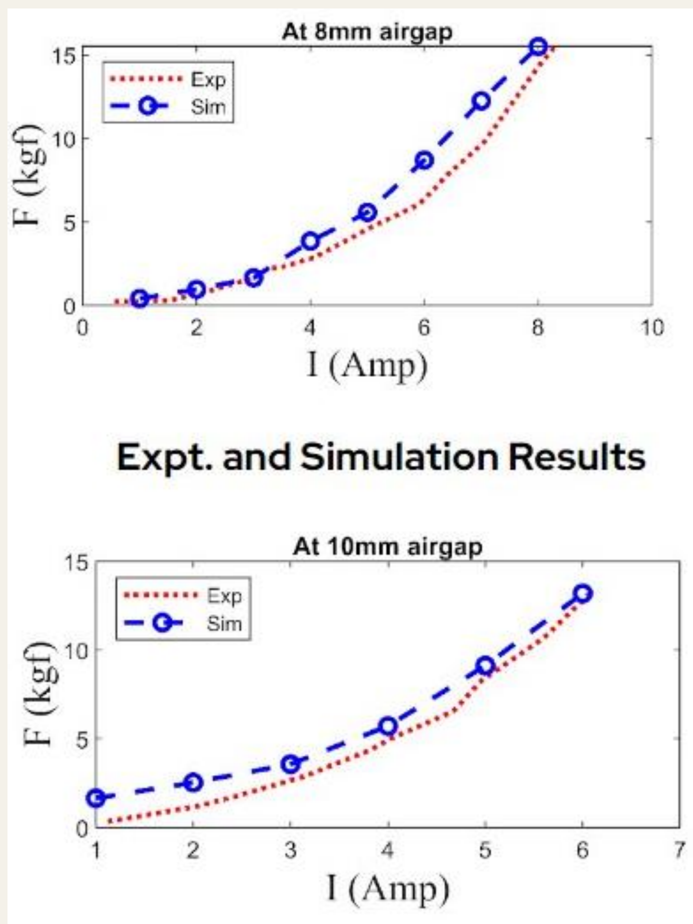
Conclusion / Discussions

The following parameters were chosen for the 1DOF setup.

Parameter	Value
Length of core (l)	27.5[cm]
Number of turns in winding (N)	275
Current in winding (I)	15[A]
Pole length (p)	27.5[mm]
Winding width (w)	50[mm]
Height of core (d)	27.5[mm]
Height of winding (h)	22[mm]
Wire diameter (h)	1.6[mm]
Resistance of coil (r)	1.48[Ω]
Voltage (V)	22.5 (V)
Air Gap mm)	6

- The choice of material for the disc and core of the module is Steel 1010 because of its ability to withstand high magnetic fields without saturation and high thermal resistance.
- A wire diameter of 1.6 mm has been chosen as this leads to a current density of 7.46 A/mm2 , which is an acceptable current density for ohmic heating in the wire.
- Various FEM simulations were performed to determine the most suitable dimensions which are most efficient and keeping other factors in mind like saturation of magnetic inside the track etc.
- A stable response was successfully received from the simulated PID Controller.





The results from the FEM Simulation

Future Work

- Currently working on testing the 1 DOF setup .
- Design a 3DOF test setup which mimics the pod .
- Test the 3DOF setup and achieve stable levitation .
- Implement levitation on the actual pod.
- Parallelly work on developing lateral guidance.