MAGNETIC BEARINGS FOR SPACE FLIGHT DEVELOPMENT

Guillerma Vasquez-Garcia – Mechanical Engineering at Oregon State University
Bryan Majarowsky – Control Automation Engineering at Metropolitan University of Campinas
Anjali Mittu – Aerospace Engineering at University of Maryland, College Park
Michael Morales Otero – Electrical Engineering at Inter American University of Puerto Rico
WHAT IS A MAGNETIC BEARING?

Device to support a load using magnetic levitation

Used for mechanisms that need
  - high-speed operation
  - precision
ADVANTAGES OF MAGNETIC BEARINGS

Reduce vibrations
Allow for higher precision
Eliminate friction and lubrication issues
Works very well in vacuum
Longer life than their mechanical bearing counterpart
GOAL

To set-up and operate the existing magnetic bearing system that was developed at the Electromechanical Systems Branch
OVERVIEW

I will go over:

1. Theory of how it works
2. Electronics
3. Matlab/dSPACE
4. Testing the Sensors
5. Operating the Proportional Integral Derivative (PID)
6. Future work
OPTICAL CHOPPER COMPONENTS

- Chopper Blade
- Hub
- Magnetic Bearing Assembly
- Motor Rotor
- Magnetic Bearing Stator
- Commutation Chopper
- Front Touchdown Bushing
- Bias Magnet
- Multi-pole Motor Ring Magnets
- Motor Stators
- Position Sensor Disk
- Commutation Stator
- Rear Touchdown Bushing
MAGNETIC BEARING ASSEMBLY

- Optical Sensing Disk
- Stator
- Rotor
- Bias Magnet
- Stator
- Rotor
1. THEORY

\[ F_{up} \]

\[ F_{net} \]

\[ F_{down} \]

\[ F_{gravity} \]
THEORY: LINEARIZATION

\[ F_{\text{up}} \propto (B\downarrow 0 + B\downarrow c)^2 \]  
\[ F_{\text{down}} \propto (B\downarrow 0 - B\downarrow c)^2 \]  
\[ F_{\text{em}} = F_{\text{up}} - F_{\text{down}} \]  
\[ F_{\text{em}} \propto 4B\downarrow 0 \cdot B\downarrow c = 4B\downarrow 0 \cdot I\downarrow c \]
2. CIRCUITS

- Continuity tests
- Schematics of motor and bearing circuit
- Simulated schematics on Multisim and LT spice
- Mapped Pin in/out (on circuit boards and dSPACE)
- Created Harness
MAGNETIC BEARING DRIVER CIRCUIT

[Diagram of the magnetic bearing driver circuit with components labeled and connections shown.]

- **R1**: 10kΩ
- **R2**: 270kΩ
- **R3**: 10kΩ
- **R4**: 1.5kΩ
- **R5**: 3Ω
- **R6**: 95.3kΩ
- **R7**: 301kΩ
- **R8**: 301kΩ
- **R9**: 95.3kΩ
- **R10**: 360Ω
- **R12**:
- **L1**:
- **OPA544T**:
- **OPA27GP**:
- **Dspace_out**:
- **Dspace_In**:
- **Sensor In**:
- **U2**:
- **10V**:
- **10V**:

[Diagram showing the circuit connections with nodes labeled appropriately.]
3. MATLAB SIMULINK

Built in Block Library

Build Simulink file in Matlab

dSPACE Block Library
4. PID CONTROL
PATH OF SIGNAL
4. TESTING THE SENSORS

Front Sensors

Back Sensors
TESTING THE SENSORS

Horizontal

Vertical

Vertical

Horizontal
5. OPERATING THE PID
6. NEXT STEPS: DYNAMIC SYSTEM ANALYZER (DSA)

• DSA for optimizing the transfer functions
• Breaking box method for each function
NEXT STEPS

- Optimize closed loop control
- Repair motor circuit
THANK YOU!

QUESTIONS?