

# Design and Construction of a Three Degree of Freedom Air Bearing Spacecraft Reaction Control Simulator

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by

**Andreana Aquino**

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approved by  
Dr. Yawo Ezunkpe  
Faculty Advisor



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## ABSTRACT

### **Design and Construction of a Three Degree of Freedom (DoF) Air Bearing Spacecraft Reaction Control Simulator**

Andreana Aquino

A reaction wheel is commonly used in spacecraft to provide navigation and stability when maneuvering in space. This goal is to design a system that serves reaction wheel designers with a form of verification and validation of their product. Air bearings are utilized in many spacecraft applications by creating space-like environment simulations. For users who design a reaction wheel, the controller must maintain stability.

For this particular system, an air bearing is predetermined due to its availability at a low cost. The use of the air bearing will allow for yaw rotation and translational displacement along an x and y axis. From there the design must consider the limits of the air bearings and additional components to be incorporated. The system design has eight thrusters, half direct rotational movement, and the other half directed for translational movement. Six solenoids for each direction will output to the necessary nozzles. Another solenoid is used to supply airflow to the air-bearing. Fuel in this case is high-pressurized carbon dioxide gas. The system as a whole is very complex due to the integration of all its different subsystems and components within it.

Inertial-Measurement-Unit (IMU) sensors and ultrasonic sensors are used to compute the displacement of the system that occurs. Ultrasonic sensors are necessary to filter out the natural noise of the IMU sensitivity. From the responses recorded, the controller commands the recentering of the air-bearing system to its original location. Controlling airflow is guided by the electronic and GNC (guidance, navigation, and control) subsystem; solenoids are programmed to open airflow dependent on the controller's instructions.

Throughout the entire system's development, defining the characteristics of air within the can and regulator requires a thorough understanding of the aerodynamic principles within the regulator. Since the pressurized tank holds compressed air from the canister to a regulator, there is compressible flow. However, while air is exiting the can, the flow will become incompressible at a certain point. Thus, air should be regulated to maintain output consistency from the tank to the entire system. While the carbon dioxide (CO<sub>2</sub>) canister's output is controlled, each thruster nozzle's output is not controlled since there will be combinations of open and closed solenoids depending on the intended motion. We predict that using a pressure regulator controller will provide a more ordered carbon dioxide distribution to its respective output thruster nozzle.

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# Chapter 1 - Introduction

## 1.1 Motivation

Transportation systems have become one of society's monumental technological advancements, drastically altering humanity's way of life. Due to the focus on quality of life, there have been significant enhancements in various transportation modes. A robust automatic system control forms the foundation of any moving vehicle.

San Jose State's aerospace program offers experience with tools such as a wind tunnel, vibration analysis equipment, and an electrostatic discharge (ESD) protected lab room that allows them to apply coursework with real-life applications. By creating a reaction controller simulator, students will be able further to improve their future senior projects or club activities.

## 1.2 Literature Review

This project revolves around an air bearing where a reaction controller and a physical system will be attached to test future reaction controllers. Within this review, the existing relationships between air bearings and their aerospace uses will be explored. The study will also investigate how the utilization of air bearings can be improved within aerospace practices.

### 1.2.1 Air Bearings and its Studies

Bearings in general are used to reduce energy consumption by having minimal friction [1]. While many types vary in performance, air bearings generally use a thin film of pressurized gas to provide a low-friction load-bearing interface between the surface [2]. Air bearings are commonly used for their high speed [3] and high accuracy [4,5] in applications such as measuring instruments, precision tools, aerospace, medical equipment [6], and more. A specific focus on the evolution of air bearing studies worldwide reveals a surge in new methods, models, and structures, underlining the dynamic nature of this technology. A strong relationship between engineering disciplines and air bearing research is evident from the study [6]. Many studies on the development and optimization of an air bearing performance will be explored. High precision is an important characteristic that optimizes an air bearing's accuracy [3,7] and performance [5]. While other attributes also affect its performance, those will also be addressed.

For example, depending on the design and purpose of an air bearing, it will have varying load-carrying capacities. While an increased supply of air pressure is an option to support the load capacity, the limits of the air bearing will inevitably affect its performance. Especially for porous and orifice air bearings [5], based on the design of the air bearing's resistor performance is studied by how thick the film of pressurized gas was generated with the air bearing's load capacity.

It has been shown in an aerostatic thrust air bearing by Sahto, Wang, and more, that Navier Stokes equations have been used in a CFD simulation on an axisymmetric model. The goal is to observe the effects of porous material and its geometrical parameters. Understanding the pressure distribution calculations for this study is the backbone of this experiment. As pressure increases, load capacity increases and the load capacity will decrease when the film thickness increases. Additionally, the mass flow rate within the porous restrictor of the bearings will increase but approach a limit as the film thickness increases. The study highlights the design project that the amount of pressure chosen to supply the design's air bearing will affect the load capacity of the entire structure [5]. The assumptions for the design must consider what is an ideal film thickness for the air bearing to produce since that will also affect the load capacity.

Similar to the previously mentioned study, air bearings have been tested for their durability. Due to their property of having minimal wear, air bearings are expected to have a long lifetime. Areas of error and inconsistency can occur when the air bearing is overloaded. By conducting testing on a high-precision machine with realistic operational parameters including air pressure, load, speed, and acceleration, we were able to replicate a real crash phenomenon. In addition, an air bearing with an average surface pressure of 0.22 MPa was still operable after 50 trials of crash tests. These results were significantly comparable to the air bearings that failed to stay operable because they only performed up to sixteen crashes. Additionally, the measurements of the defects from the crash were significantly bigger within the resulting inoperable air bearings, compared to the still operable bearing. Porous carbon media from the promising air bearing guides utilizing low friction properties to maintain a long-lasting air bearing system [3]. Though it is not expected of the project design to crash, these results are a good measure to consider.

Another study on precision utilizes a simulation and physical experiments upon an ultra-precision dual stage. The article navigates the complex process of dynamically modeling the air bearing's travel to set up the experiment. Two sets of air bearings are used within the dual-stage. The study's simulations run modal tests and analyses intending to receive vibration responses. CFD simulation is also performed to observe displacement and confirm the results from the modal tests and analysis. Small vibrations from this test are an important data set since they hinder an air bearing's position precision and can likely cause instability in the position stages. The results of the study are presented at the end of the article but not discussed in depth, the authors simply conclude that their modeling method is effective and accurate. While this study differentiates from the design project, it offers insight for future research that controlling and air bearing can be done to the most precise measure [7]. Should precision navigating be a future goal for aerospace engineers, the use of an air bearing can influence such studies. Thus, these studies on studying and improving the precision performance of an air bearing display that there is room for experimentation in the field. For now, understanding the limits of this project's air bearing will help to avoid any possible discrepancies.

In spacecraft, guidance, navigation, and control are pivotal for the proper execution of missions. The only way to navigate through space's distinct environment is via a controller that controls a propulsion system for the spacecraft's means of travel. Since it's not feasible to physically test mobility and navigation in space as easily as one would like, air bearings allow an environment that will neglect the angular and translational velocities in consideration. Zero-G can be simulated. This means the body of mass can displace itself upwards & downwards (along the y-axis), left & right (along the x-axis), and pivot clockwise and counterclockwise (about the z-axis). [8]

### 1.2.2 Variations of Controller Stability Testing

The practice of testing a control system in air bearings is not a recent innovation [2,9,10]. Existing studies vary in the air bearing system design itself, as well as the air bearing used in the study. For instance, a Florida Embry-Riddle student focused on designing a non-linear dynamic inversion controller that would carry a Sawyer robot. The goal was to have the Sawyer Robot atop the PIGlide HB air bearing to interact with a stationary robot, mimicking a serving satellite. This study did not physically test their controller system since it revolved around MatLab simulation testing if their controller could combat the disturbances from the Sawyer robot with stability while changing its angular orientation. Ultimately, the study experienced a lot of difficulty tracking due to the noise generated by the Sawyer robot [2]. In contrast, a study from a

Brazilian institute (INPE) investigated an extended Kalman filter (EKF) and a least squares (LSQ) control system individually for dumbbell air bearings, which are larger compared to the NewWay(R) air bearing that will be used for this project. The results relied on sensors and the system recognizing correct movements when its platforms would spin [9]. An aerospace-focused (Nanjing) university in China published a study on simulating satellite motion through an air bearing, though it is unclear what type of bearing. Their simulation system was particularly designed with attitude sensors and satellite actuators. Purely focused on attitude control through three-axis stabilization, experimentation of this research was modeled via CATIA modeling and solely collected data through its attitude sensors [10]. From a Mexican institute, a project on designing a small satellite attitude determination and control simulation uses a three-axis air-bearing platform. The study was conducted with realistic assumptions to provide an accurate control environment. The design features make use of every detail close to the realistic assumptions. This design features a proportional-control algorithm to direct the attitude controls and a spherical air bearing [11].

In the literature that relates air bearings to spacecraft studies, the utilization of sensors, Matlab, and CFD are the most common forms of analyzing their pieces of data. While there were a few reports that provided a lack of verification, their options for analysis can be considered for this project. Through its attitude sensors, the Nanjing control system's stability can be observed through the attitude angle's trend over time for each respective response, yaw, and pitch [10]. In the case of the Embry-Riddle that utilizes Sawyer Robots, the robot's design itself creates instability within the system. Sensors are used to track the displacement of their robot hands. Matlab is used to generate noise and model the disturbances from the robot, which will allow the designer to observe the trend of the Euler angles output [2]. As mentioned, unlike Embry-Riddle's approach INPE utilizes an extended Kalman filter to track the Euler angles and angular velocities. The moments of inertia from the dumbbell's platforms are also observed to consider the kinetic energy dissipated due to the LSQ control method significantly relying on any energy lost for its simulation results [9]. Many graphs through Matlab Simulink display the disturbances and how we want stability to be controlled to avoid drift. Through Matlab testing, verification of stability can be obtained regardless of what controller is chosen.

The controller design will considerably affect the results of the system, and in the long run, a built physical system will allow one to test the efficiency of any prototype spacecraft control system. However, based on the studies for each distinct controller that will be tested, the realistic limits and assumptions must be considered within the calculations and results of each experiment per controller design.

### 1.2.3 Use of Solenoids

To understand the mobility of the system, solenoids will be used to operate displacement translationally and rotationally. Solenoid valves are an electromagnetic device that can be used through the controller design to dictate opening or closing airflow from the system's air supply. For this project an electronic charge of 12V is necessary to power on the desired solenoid [12-14].

The project will consider two-port solenoid valves for consistency. However there are two types of two-port valves to know about, which are normally closed valves and normally open valves. [15]. Both types of valves are typically used as safety devices. In the case of a normally closed solenoid, the valve should ideally open when the system begins to experience overpressure but it will not open until the solenoid's coil is powered to open its valve. Respectively, a normally open solenoid will stay open until power is sent to signal the valve to

close. Normally open valves are used as a safety divide to reduce and regulate pressure levels when a system is building pressure [15].

### 1.3 Project Proposal

The goal is to be able to physically test and validate the controller's efficiency while connected to an air bearing and a self-design propulsion system.

### 1.4 Methodology

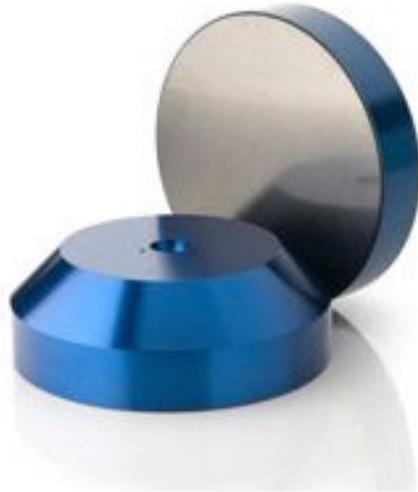


Figure 1.1 – NewWay(R) air bearing

A physical controller will be designed, tested, and mounted on a New Way(R) air bearing used for control system testing of NASA's SPHERES systems. The system will be defined by three degrees of freedom: X-Y translational, and Z rotational. The mass body can displace itself upwards and downwards (along the y-axis), left and right (along the x-axis), and pivot clockwise and counterclockwise (about the z-axis), assuming the system will be out of the sphere of influence of any massive bodies. The hardware will be controlled by an Arduino-compatible microcontroller, driving either pneumatic valves to small thrusters or small RPM computer fans, depending on a further review of the implementation complexity.



Figure 1.2 – Solenoid

The initial focus will be on the control system and electrical system as subsystems. The control and electrical system will work hand in hand to recognize how the air bearing moves and reacts to the system's direction and movement. As the project progresses to the hardware phase, the overall structural aspect will be taken into consideration. The use of solenoids (see Figure 1.2) will provide controllability over the system's airflow. Thus, the propulsion system must be compatible with the project's structural stability, as it will determine the speed and force of the air bearing's movement connected to the control systems. Due to low budget, components that were easily accessible define the necessary parts of the system. Figure 1.3 is computer-aided design (CAD) to approach the general structure of the system.

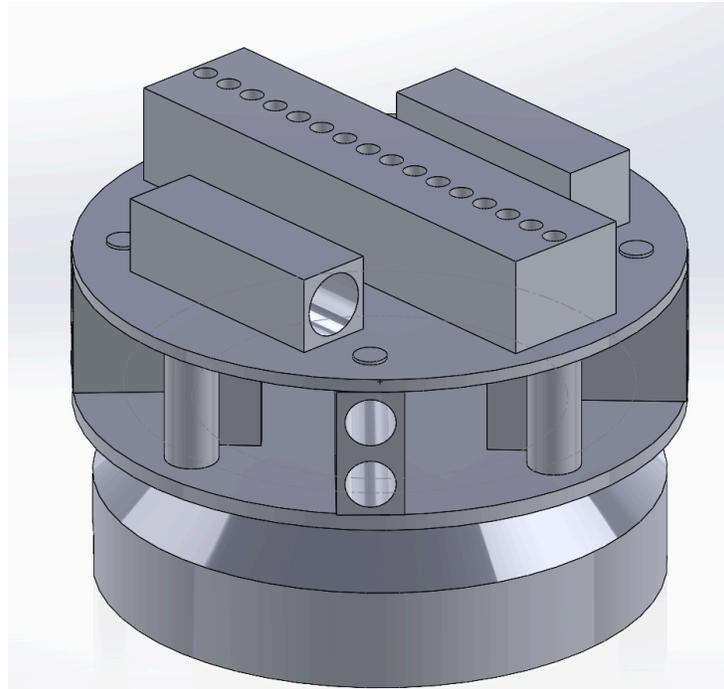


Figure 1.3 – Initial CAD design of air bearing system

In terms of structure, the first chapter addresses the challenge we want to take. The second chapter addresses the knowns and the overview of the systems and subsystems. Chapter 3 will provide more insight on how each subsystem plays a significant role to the whole system through its respective subsystem equations. The following chapters will detail the theory, process, results and analysis from this whole designing process. By the end of the report future works can be discussed and conclude the project.

## Chapter 2 - Requirements and System Design

### 2.1 Assumptions

#### 2.1.1 Design Input - Critical Mission Requirements

This project will be an ADCS tester that should be adaptable to various control systems. The design will have incompressible assumptions so that it can be tested in controllable conditions. The specific type of air bearing limits the project. Since this revolves around the air bearing provided for us, it defines the requirements for the design. In the case of the NewWay(R) air bearing, there are set inputs from its size and weight. Provided in Table 2.1 are the defined dimensions. The project's main focus is to create a functional physical system compatible with the NewWay(R) air bearing being used.

Table 2.1 – NewWay(R) specification knowns

| Title                 | Specifications                                   | Title                         | Specification |
|-----------------------|--|-------------------------------|---------------|
| Size                  | 7.87 in  | Bearing Size                  | 7.87 in       |
| Input Pressure        | 60 psi   | Bearing Height                | 2.76 in       |
| Ideal Load            | 1747 lb  | Bearing Weight                | 10.50 lb      |
| Stiffness             | 4.0 lb/ $\mu$ in                                 | Bearing Surface Size          | 7.76 in       |
| Max Speed             | 164 ft/s   | Pressure Port Thread          | M5 x 0.8      |
| Fly Height            | 0.0002 in  | Flatness                      | 0.00002 in    |
| Porous Media Material | Carbon   | Viable Pressure Range         | 60 - 80 psi   |
| No Load Flow          | 6.7 - 7.5 SCFH<br>(standard cubic feet per hour) | Max Allowable Pressure Supply | 100 psi       |

In terms of user input for the project, the designer will have controllability over the weight load, speed, and pressure rate which are significant values to consider throughout the design process.

#### 2.1.2 Design Parameters - Measures of Merit

A future consideration to have for this design is to be autonomous and displace its whole body a certain distance from point A to point B. While this is not the goal of the project it is something to consider should extra time be available. Other design parameters to consider are making cost-efficient decisions within the design. Part of this parameter includes seeking the optimal pressure for the entire system. Further research needs to be done to study the effects of low or high pressure and how it will limit or boost the design's performance. Fortunately, the NewWay(R)'s air bearing performance is accessible to the public. This information (Figure 2.1) can be used when calculating optimal pressure for the entire system.

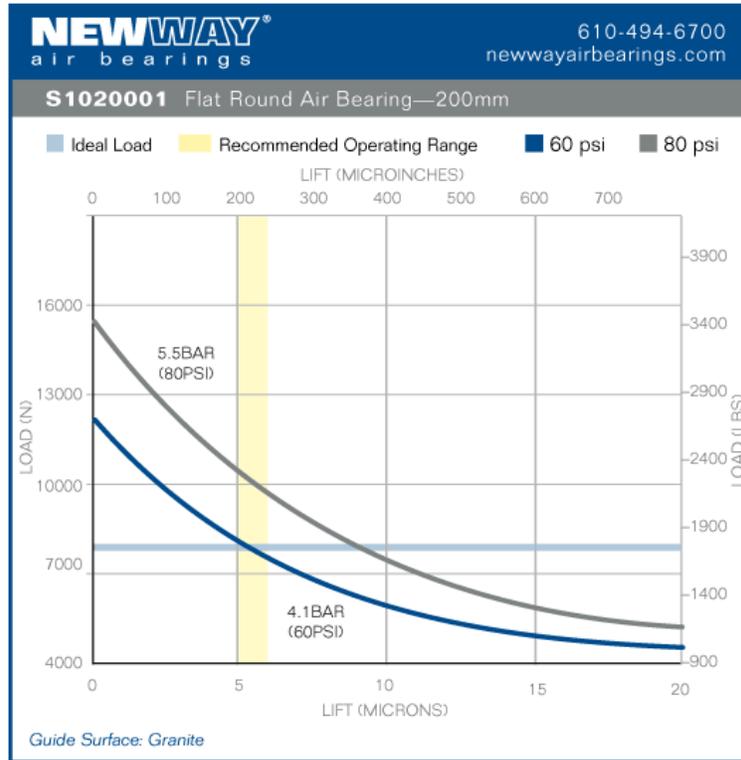


Figure 2.1 – 200 mm flat round air bearing performance

## 2.2 System and Component Overview

The necessary systems within this project are a guidance-navigation-control (GNC) system, a propulsion system, and a structural system. Though these subsystems have different purposes, their performance will depend on each other. Figure 2.2 displays a simple diagram of how the systems' components will interact with each other. Figure 2.7 and 2.9 display a more broken down block diagram of the respective subsystems.

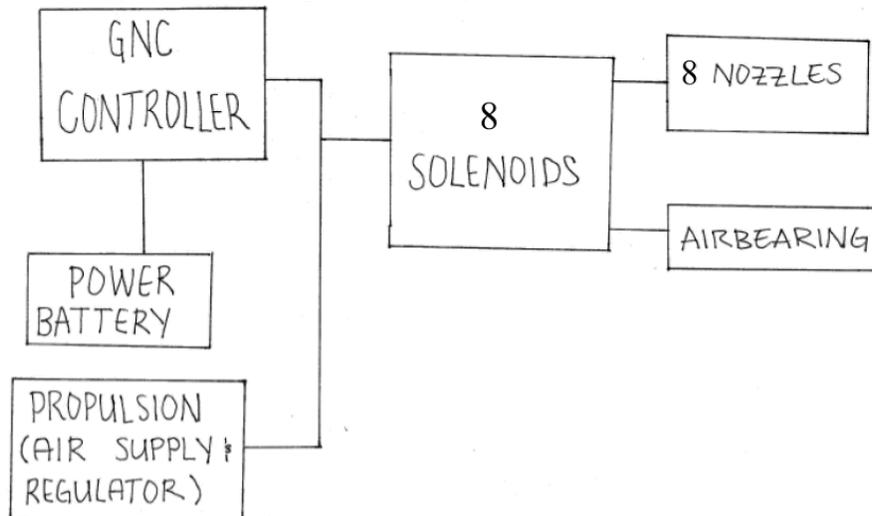


Figure 2.2 – Subsystem components integration

The structure is significant to hold the air bearing (that carries up the whole system) and must be reliable so that when the system displaces itself at the speeds we set, both the propulsion and GNC system are durable and stable. Thus, depending on the load and thrust the GNC and propulsion system offer, will limit or define the requirements needed for the system's structure.

The GNC system is necessary to dictate what the system will read and what type of performance is expected. In this case, the system must identify its location and its movements. Numerous components are used within this system due to its complexity in electronics, programming, and controls. For instance, a form of collecting data would be taken through sensors, but another arduino needs to record and compute the data it receives. This will be further addressed in the following subsections. Additionally, an arduino will command the solenoids whether they need to turn on or off, which will allow air to flow out when desired. Since the GNC sub-system will control how the entire system operates, by defining the propulsion performance it should be integrated within the GNC's brain that will compute the power and thrust necessary.

The project's propulsion (or pneumatic) system consists of the air bearing, nozzles, regulators, solenoids, and air tank. Crucial in creating a desired close-to-zero friction environment, the air bearing must be regulated with air to be kept afloat. Other propulsion devices are part of the design to maneuver the air bearing in the 3 degrees of freedom it can travel. The amount of air "outputted" for displacement should also be regulated, since this will affect the entire system.

#### 2.2.1 GNC and Electronic Subsystem

The GNC and electronic subsystem will consist of a breadboard (to hold the electronics), an Adafruit 9-DOF Orientation Inertial Measurement Unit (IMU), Adafruit ItsyBitzy M0 Express, battery, solenoids, resistors, and MOSFETs. Additionally for wireless communication between systems a voltage regulator, and another arduino will be incorporated within the design. Figure 2.7 best depicts how the main components of the GNC sub system will be configured.

An IMU (Inertial Measurement Unit) can measure the angular rate and the specific force/acceleration that it is attached to. With this piece of technology, the IMU works as a gyroscope and accelerometer which will store the code and be the controller itself. Through the Adafruit 9-DOF Orientation IMU we can expect a read of the output Euler's, quaternions, and sensor movements through it, and data will be collected[17]. Ultrasonic sensors are used to assist in recording translational displacement. The project requires a system that will compile the data for analysis. Ideally, the GNC system should output its results back to the computer. This is made possible through the Adafruit ItsyBitsy since it can store files and the Python code used to command the IMU sensors [18-19] The ItsyBitsy will communicate between the command area (which is the Elegoo Uno R3) and any piece we want to add to the overall breadboard.

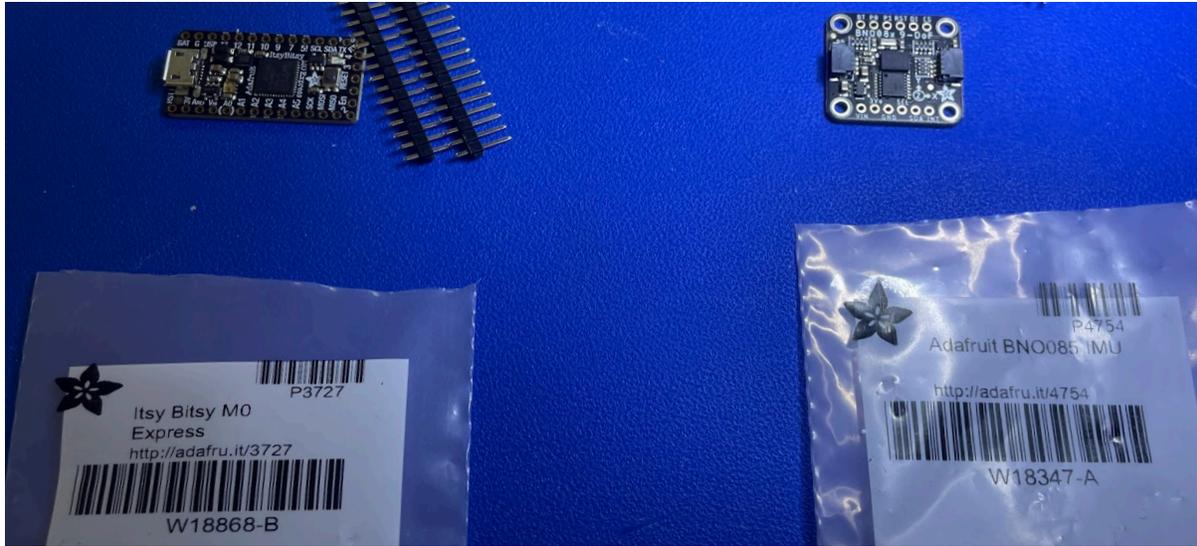


Figure 2.3 – Adafruit arduino (left) and IMU sensor (right)

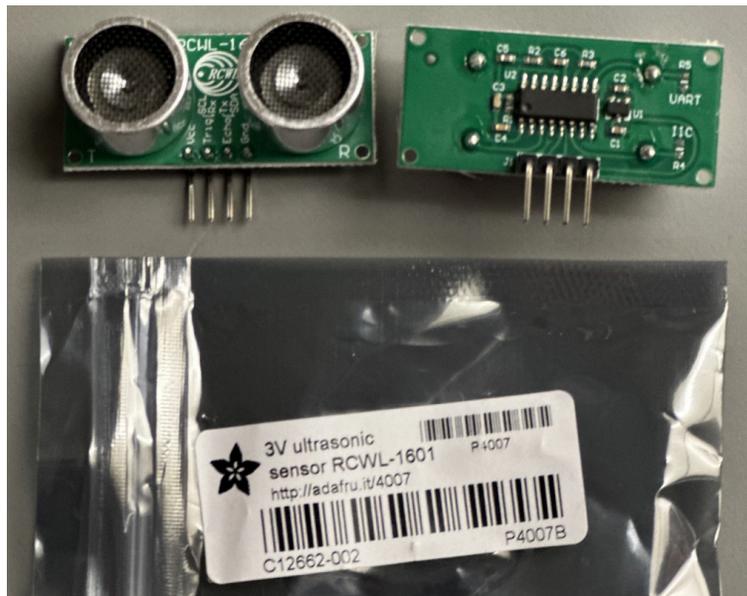


Figure 2.4 – Adafruit ultrasonic distance sensors



Figure 2.5 – HC-SR04 ultrasonic sensor

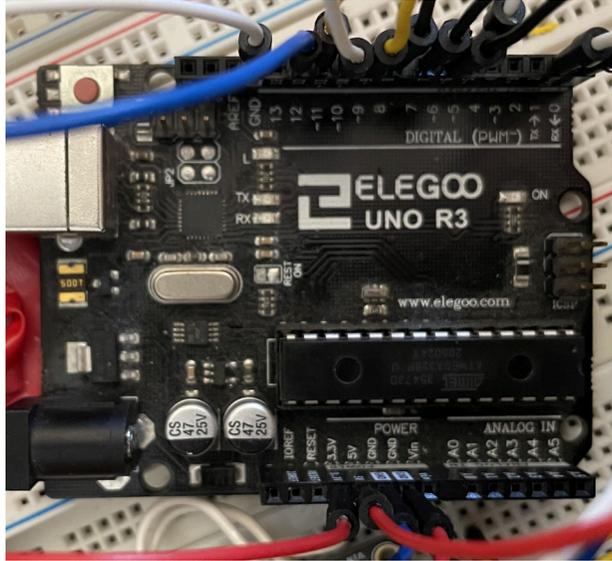


Figure 2.6 – Elegoo uno R3 arduino



Figure 2.7 – GNC hardware diagram

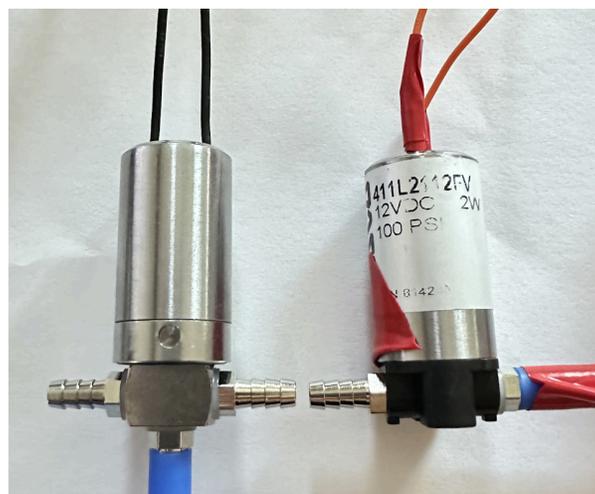


Figure 2.8 – Normally open (left) and normally closed (right) solenoid

Eight electrical solenoids are used for this design system to act as the on/off switch for any output of air. Notice in Figure 2.4 that there are eight wires and eight solenoids. A quantity of 6 solenoids is necessary for movement control, regardless of whether they are normally open or closed solenoids. Due to the limited availability of normally closed solenoids, we will use 2 normally closed solenoids to minimize fuel consumption. It is expected for the movement solenoids to constantly turn on/off affecting the air distribution throughout all the nozzles. Thus, a single solenoid directed to the air bearing will maintain flow consistency to the air bearing. This breakdown will be explained in chapter 4. All solenoids will require a 100k Ohm resistor to ensure any electronic components will not short out. All these components need to be powered to work; thus a power management system has to be put in place that monitors the voltage being used and the level of power that the battery is providing.

### 2.2.2 Propulsion and Air-bearing Subsystem

As mentioned, a propulsion system is established since gas must be supplied to the air bearing for it to stay afloat and create a zero-to-no friction environment. Necessary within this propulsion system is an air supply system and tank that will supply 1,000 psi. Regulators will ensure stability within the propulsion system and ensure no extra undesired gas escapes. Regulators and solenoids will dictate the commands from the Adafruit & the design controller. Valves attached to nozzle thrusters will be used to direct the airflow. Eight nozzles, depicted in Fig. 2.7 and Fig 2.9, are required for 3-DOF. The design will have 4 translational solenoids paired with their nozzle and 2 rotational solenoids that will individually divulge into 2 nozzles.

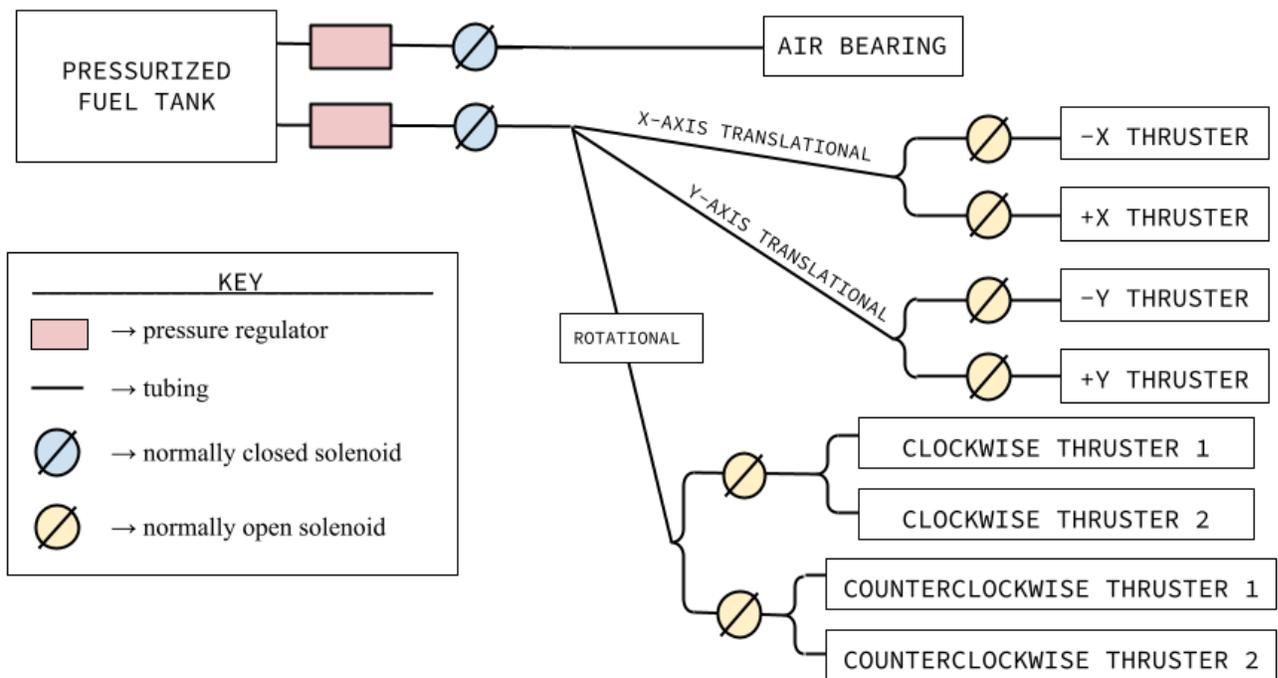


Figure 2.9 – Pneumatic block diagram

The components of the air bearing subsystem itself will be similar to the propulsion subsystem. The regulator and air supply can be shared between the air bearing and the thruster nozzles, however, an additional solenoid is needed for the air bearing to shut off its air when necessary, as mentioned. To maximize the supply of air to both the air bearing and the thruster nozzles two pressure regulators, seen in Fig. 2.9, will be used. A tube is already connected to the

NewWay(R) air bearing that will be used, that is where the solenoid should attach and act as an on/off switch for air travel, controlled by an arduino.



Figure 2.10 – Propulsion subsystem components

### 2.2.3 Structural Subsystem

The structural system connects the electronic components and the controller to the air bearing itself. While the electronics will power and control the mobility of the air bearing, a structural hub is needed to protect the electronic components and hold them in place as the entire system moves. In addition to an electronic hub, a bearing mount provides a connection and secure holding plate for the electronic hub, solenoids, and nozzles onto the air bearing. See Figure 2.11.

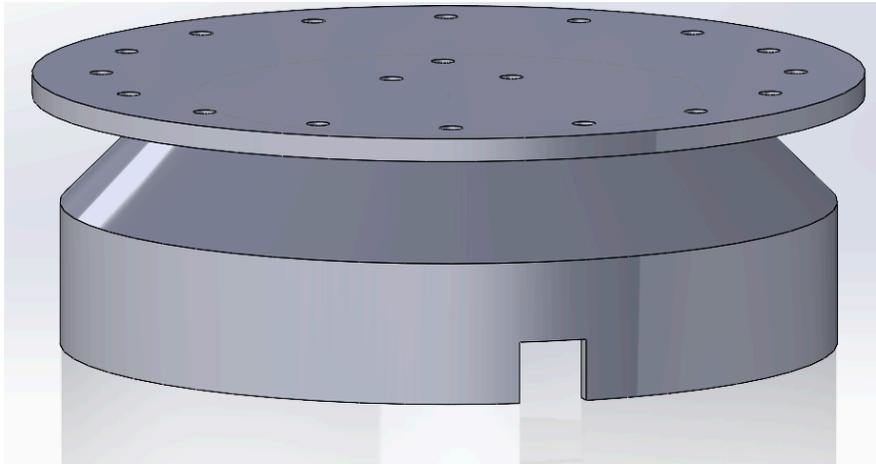


Figure 2.11 – Air bearing mount CAD design

The following figures are rough initial CAD designs for the rest of the structure that will hold the tubes, regulators, and solenoids for the system. Figure 2.12 displays the layer in which the directional solenoids can be, such as translational and rotational. The electronics will all also sit on that layer. Figure 2.13 will hold the solenoid that controls air from the regulator to the air bearing and the directional valves.

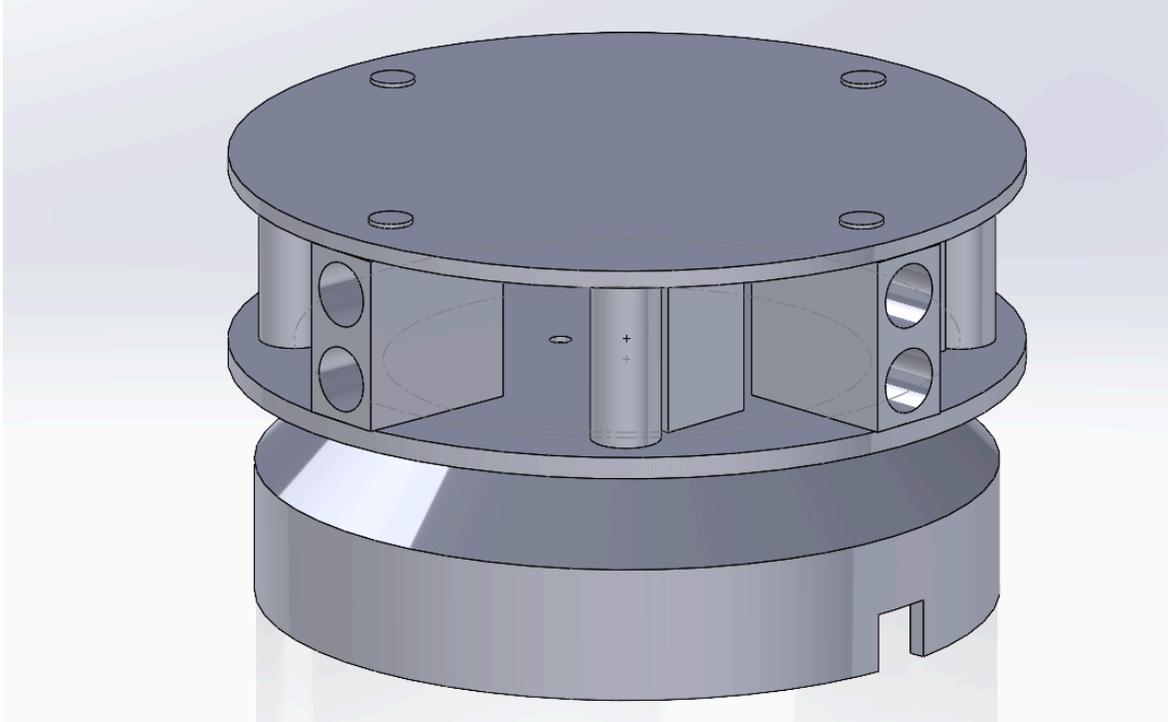


Figure 2.12 – Normally-open solenoid layer CAD design

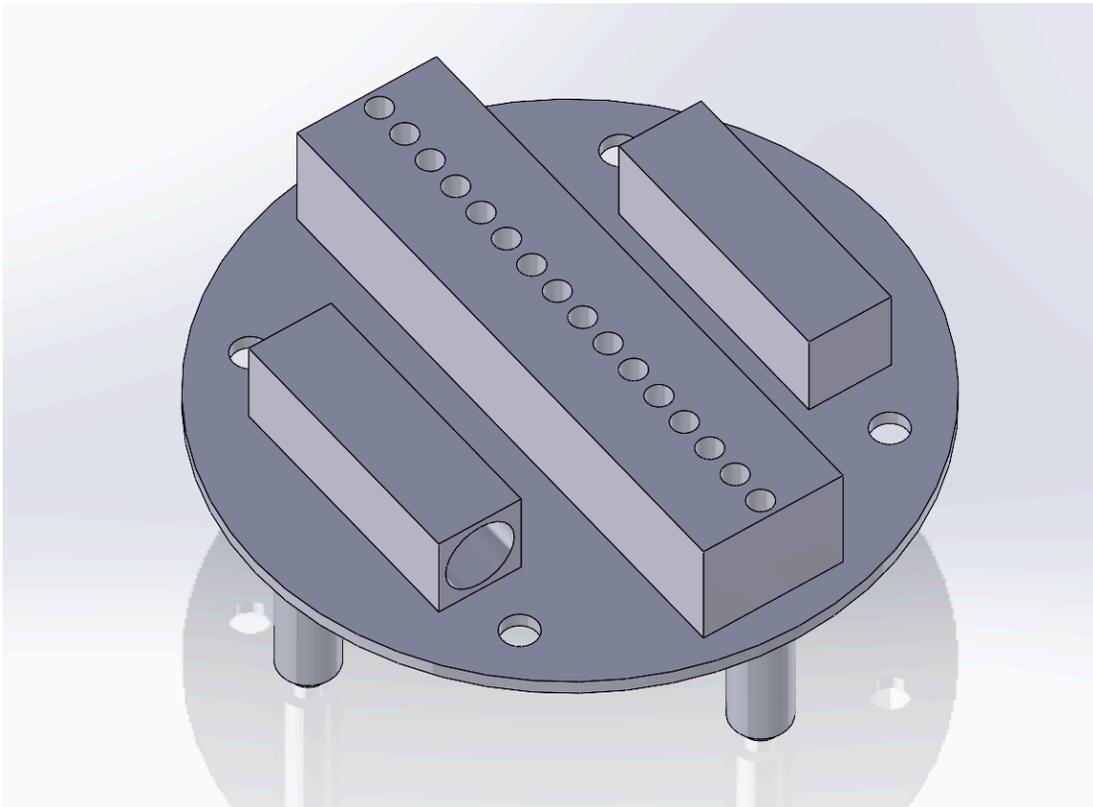


Figure 2.13 – Normally-closed solenoid layer CAD design

## Chapter 3 - Governing Equations

### 3.1 General Governing Equations

#### 3.1.1 Structural Equations

The following equations are considered when designing the entire structural system. [22]

Centroid Equations:

For a rectangular area,

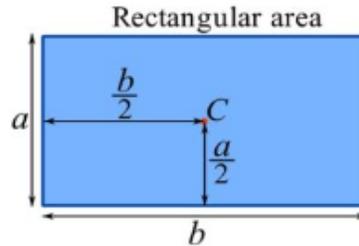


Figure 3.1 – Centroid of a rectangular area

$$C_{y_{\text{rectangular}}} = \frac{a}{2} \quad (1)$$

$$C_{x_{\text{rectangular}}} = \frac{b}{2} \quad (2)$$

For a trapezoidal area,

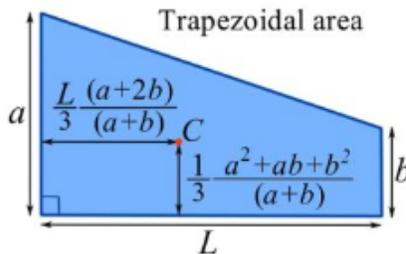


Figure 3.2 – Centroid of a trapezoidal area

$$C_{y_{\text{trapezoidal}}} = \frac{L(a+2b)}{3(a+b)} \quad (3)$$

$$C_{x_{\text{trapezoidal}}} = \frac{1}{3} \frac{(a^2+ab+b^2)}{(a+b)} \quad (4)$$

For a semi-circle area,

$$C_{y_{\text{semicircle}}} = \frac{4r}{3\pi} \quad (5)$$

$$C_{x_{\text{semicircle}}} = r \quad (6)$$

For complex shapes,

$$C_{y_{\text{complex}}} = \frac{\sum A_i y_i}{\sum A_i} = \frac{\sum A_1 y_1}{\sum A_{\text{total}}} + \frac{\sum A_2 y_2}{\sum A_{\text{total}}} \quad (7)$$

$$C_{x_{\text{complex}}} = \frac{\text{width}}{2} \quad (8)$$

Center of Gravity:

Coincidentally, the center of gravity equation for a semicircle is the same equation for the centroid of a semicircle. However, we cannot assume that the center of gravity of the air bearing will be the same due to the different components that are part of the air bearing, adding weights in varying areas. An example provided by NASA shows how calculations should be made for a system's center of gravity [21].

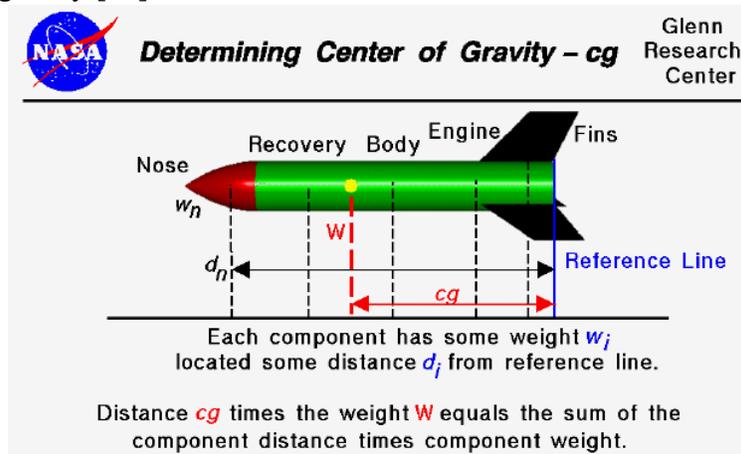


Figure 3.3 – Center of gravity diagram

$$cg * W = d_n w_n + d_r w_r + d_b w_b + d_e w_e + d_f w_f \quad (9)$$

Load Equations:

Table 3.1 – Load diagrams

| Shape     | Diagram | Equivalent Point Load |
|-----------|---------|-----------------------|
| Square    |         |                       |
| Trapezoid |         |                       |

For a square shape load and a trapezoidal load, their respective force equation is listed.

$$F_{W_{square}} = bh = Wd \quad (10)$$

$$F_{W_{trapezoid}} = \frac{1}{2} b(h_1 + h_2) = \frac{1}{2} d(W_1 + W_2) \quad (11)$$

### 3.1.2 Electrical Power Equations

Ohm's Law:

$$V = IR \quad (12)$$

Power Equation:

$$P = \frac{V^2}{R} = \text{Work} / \text{Time} = (\text{Force} * \text{Displacement}) / \text{Time} \quad (13)$$

Charge Capacity (Ah):

$$Q = It \quad (14)$$

Energy Capacity (Wh):

$$E = QV \quad (15)$$

Single-Coil Solenoid:

Since solenoids will be used to regulate and output air, the following equations of motion that relate to solenoids and their magnetic field are referenced from Paluszek's "Spacecraft Attitude Determination and Control". [22] Eq. 16 shows that by calculating for the H fields, we find that the sum of all the currents that flow normal to the surface S and with the closed path is equal to integrating the magnetic fields on a closed path around a surface S.

$$\oint_C H \cdot dl = \int_S J \cdot nda \quad (16)$$

Within a single-coil solenoid, there are three regions in which the magnetic field can be found. By studying the relationships between the regions, flux, inductance, terminal voltage, and electrical force can be found.

Total flux linked (where each flux is linked N times):

$$\lambda = \frac{\mu_0 cdN^2}{g} \left(1 - \frac{x^2}{d^2}\right) i \quad (17)$$

Inductance:

$$L = L_0 \left(1 - \frac{x^2}{d^2}\right) \quad (18)$$

$$L_0 = \frac{\mu_0 cdN^2}{g} \quad (19)$$

Terminal voltage:

$$v = iR + \frac{d\lambda}{dt} \quad (20)$$

or

$$v = iR + L \frac{di}{dt} - \frac{2L_0 xi}{d^2} \frac{d\lambda}{dt} \quad (21)$$

Electrical force:

$$f_e = \frac{\partial W'_m}{\partial x} \quad (22)$$

EOM for a singular coil solenoid [21]:

$$M \frac{d^2 x}{dt^2} + c \frac{dx}{dt} + kx + b \frac{\frac{dx}{dt}}{\left| \frac{dx}{dt} \right|} = - \frac{L \cdot xi^2}{d^2} v = iR + L \frac{di}{dt} - \frac{2L \cdot xi}{d^2} dxdt \quad (23)$$

### 3.1.3 Propulsion Equations

$$PV = nRT \quad (24)$$

$$\dot{M}_{in} = \dot{M}_{out} \quad (25)$$

$$\dot{M} = \rho v A \quad (26)$$

$$\rho = Mass/V \quad (27)$$

A general equation to consider is the ideal gas law, provided below (Eq. 24). This equation and variations of it will be constantly used so that we can define the pressure and temperature of the flow at a certain stage. The mass flow rate equation is a model of conservation of mass and is used to define the density and volume of the flow. Equations 24-27,  $\dot{M}$  represents the mass flow rate, while V represents the volume in which flow will travel through. Respectively, pressure, temperature, density, and mass are represented by P, T,  $\rho$ , and Mass. Compressible and incompressible assumptions will be explained further, but those assumptions will be highly dependent on temperature which affects the Mach number. See the following equation. Due to the path in which flow travels changing, there are different stages that the gas will have. For compressible (and isentropic) assumptions where Mach is above 0.3, we use equations 28-30. M symbolizes Mach number, R is the gas constant and  $c_p$  represents the specific heat at constant pressure of the gas. Note the subscripts for pressure, temperature, density, volume, mass, and Mach number symbolize a different stage (or environment) of the flow. From the canister of gas into a regulator, the stage changes.

Compressible Assumption Equations:

$$\frac{P_2}{P_1} = \left( 1 + \frac{\gamma-1}{2} M^2 \right)^{\frac{-\gamma}{\gamma-1}} \quad (28)$$

$$\frac{P_2}{P_1} = \left( \frac{\rho_2}{\rho_1} \right)^\gamma \quad (29)$$

$$c_p * \ln\left(\frac{T_2}{T_1}\right) = R * \ln\left(\frac{P_2}{P_1}\right) \quad (30)$$

Incompressible Assumption Equations:

$$P_1 + \frac{1}{2} \rho v_1^2 = P_2 + \frac{1}{2} \rho v_2^2 \quad (31)$$

Equation 31 is Bernoulli's equation that is considered when flow is incompressible. Regardless of whether the flow is compressible or incompressible, the flow of air will also change in volume and tube area, thus Eq. 32 is considered since pressure will split among the various paths of flow it will follow. The subscripts for Equation 32 do not represent stages in this case, instead they represent each tube or volume of gas that changes. For each stage that the gas is in the amount of pressure is conserved past the regulator. For example, for one case, we expect the gas after passing through a normally closed solenoid to split into three tubes. The pressure total will split into three among the tubes.

$$P_{Tot} = P_1 + P_2 + P_3 + \dots + P_n \quad (32)$$

Dalton's Law of partial pressure was also considered in the investigation due to the multiple species within the mixture that might be within the system. For each distinct gas that is in the mixture, the distinct pressure a gas has will add up to the total pressure. However, ultimately any external air was considered negligible since none of the external air will be put into the system, air will only leave the entire system through the air bearing or the thruster nozzles themselves.

$$P_o = P_i * (n - k) = P_{Tot} - P_i * k \quad (33)$$

Equation 33 is used to consider a digital pressure regulator implemented in the pneumatic system where the output pressure is constantly controlled based on which solenoids are closed or open. For this specific equation, n is the number of possible solenoids that can output air (which is 6), k will be the number of solenoids that are instructed to be closed,  $P_i$  is the individual pressure desired for each solenoid,  $P_{Tot}$  is the total pressure outputted if all six solenoids are open. Recognizing that  $(n - k)$  ultimately represents the desired number of solenoids open,  $P_o$  becomes the desired output from the digital regulator. For more force to displace the system, the maximum pressure each solenoid has is 60 psi; thus, an input of 60 psi or less is assumed for  $P_i$ .

We should consider this equation since it is expected for gasses to travel, and eventually provide displacement. Pauluszek's textbook also offer's equations to consider specifically for the pneumatic subsystem. To consider a scenario close to the system's design, a first-order system model can be considered whether or not fuel is flowing into the thruster [22]. From here, non-dimensional thrust is  $u$ , while thrust is represented as T, and the maximum thrust given is k.

$$\dot{u} + \frac{u}{\tau_f} = 1 \quad (34)$$

$$T = ku \quad (35)$$

Within the maximum thrust equation (k), P represents pressure after the regulator, represents the thrust coefficient, and  $A^*$  is the nozzle or throat area. Equations of motion are investigated in the following sub-section.

$$k = C_F A^* P \quad (36)$$

## 3.2 Dynamics of the Air Bearing System

### 3.2.1 Physical Displacement Dynamics and EOM

The dynamics of the air bearing can be modeled as a rigid body. A fully detailed CAD model of the physical air bearing can be used to find the exact mass properties of the air bearing. At the moment, a reasonable approximation for the air bearing is a cylinder of uniform mass distribution as seen in Fig. 3.4.

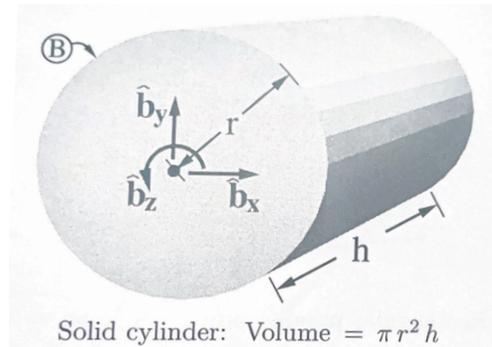


Figure 3.4 – Moment of inertia

$$I_{xx}^{B/B_{cm}} = I_{yy}^{B/B_{cm}} = \frac{1}{12}m(3r^2 + h^2) \quad (37)$$

$$I_{zz}^{B/B_{cm}} = \frac{1}{2}mr^2 \quad (38)$$

$$I_{xy}^{B/B_{cm}} = I_{xz}^{B/B_{cm}} = I_{yz}^{B/B_{cm}} = 0 \quad (39)$$

In the equations above,  $I$  is the mass moment or product of inertia, the subscripts correspond to the axes that the moments and products of inertia are calculated about,  $m$  is the overall mass of the cylinder,  $r$  is the radius of the cylinder, and  $h$  is the height of the cylinder. If the two subscripts are the same, the value is a moment of inertia. If the two subscripts are distinct, the value is a product of inertia. The  $x$  and  $y$  axes are two perpendicular axes oriented on the faces of the cylinders and the  $z$  axis is oriented through the center of the cylinder, axially. All three axes are orthogonal. The center of mass is also assumed to be at the geometric center of the cylinder ( $r = 0, z = h/2$ , in cylindrical coordinates) and all moments and products of inertia are measured about the center of mass of the cylinder. This results in all of the products of inertia calculating to 0. Mass properties can also be represented in an inertia dyadic. This project is mainly concerned with planar motion, so the only significant mass property is  $I_{zz}$ .

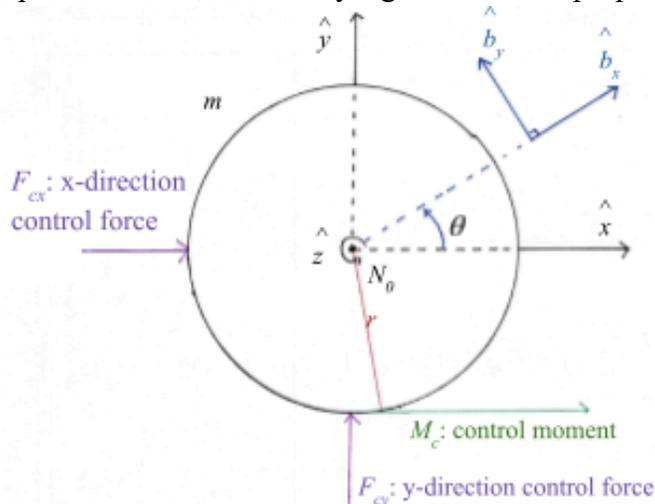


Figure 3.5 – Air bearing free-body diagram

Figure 3.5 displays a free-body diagram of the air bearing system. Here mass ( $m$ ) is assumed to be constant and  $N$  is the body's center of mass.

$$\Sigma \mathbf{F}_x = \mathbf{F}_{cx} = m\ddot{x} \hat{x} \Rightarrow F_{cx} = m\ddot{x} \quad (40)$$

$$\Sigma \mathbf{F}_y = \mathbf{F}_{cy} = m\ddot{y} \hat{y} \Rightarrow F_{cy} = m\ddot{y} \quad (41)$$

The following calculations are used to estimate the time required for the system's thrusters to translate or rotate by a certain displacement. Since the system as a whole will take impulse commands from the controller, impulse force must be considered. The equation solved is how impulse displacements will be assumed for future calculations.

$$\text{Impulse} = J \equiv F_{average} \Delta t \quad (42)$$

Assuming  $m$  is constant,

$$F = F_{avg} \quad (43)$$

$$F_x = ma_x = m \frac{dv_x}{dt} \quad (44)$$

$$F_x \Delta t = m \frac{dv_x}{dt} dt \quad (45)$$

$$\int_0^t F_x dt = \int_{v(0)}^{v(t)} m dv_x \quad (46)$$

$$F_x = P_v A_v, \quad (47)$$

where v represents a valve and

$$\frac{\partial}{\partial t}(P_v A_v) = 0 \quad (48)$$

$$\Rightarrow P_v A_v t = m(v_x(t) - v_x(0)) \quad (49)$$

$$\frac{P_v A_v}{m} t + v_x(0) = \frac{dx}{dt} \quad (50)$$

$$x(t) - x(0) = \frac{P_v A_v}{2m} t^2 + v_x(0)t \quad (51)^*$$

$$\tau_{net} = I\alpha \quad (52)$$

$$\tau_{net} = |\bar{r} \times \bar{F}| = rF \sin \sin(90^\circ) = rF = rP_v A_v \quad (53)$$

$$\theta(t) - \theta(0) = \frac{rP_v A_v}{2I} t^2 + w(0)t \quad (54)^*$$

Equation 51\* and 54\* will be utilized the most for the dynamics of the system.

### 3.2.2 Block Diagram Input and Output

Initial Block Diagram Assumptions:

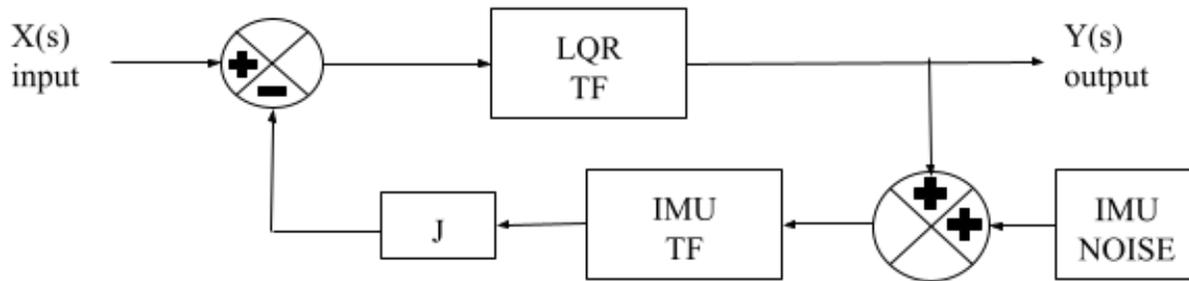


Figure 3.6 – Initial block diagram

$$Y(s) = LQR * A \quad (55)$$

$$LQR * A = X(s) + (J * IMU * (IMU\_Noise + LQR * A)) \quad (56)$$

$$\Rightarrow X(s) = J * IMU * IMU\_Noise + J * IMU * LQR * A - LQR * A \quad (57)$$

$$\Rightarrow Y(s) = X(s) + J * IMU * IMU\_Noise + J * IMU * Y(s) \quad (58)$$

$$\Rightarrow Y(s) - J * IMU * Y(s) = X(s) + J * IMU * IMU\_Noise \quad (59)$$

$$\Rightarrow Y(s) = (X(s) + J * IMU * IMU\_Noise) / (1 - J * IMU) \quad (60)$$

With the assumption that the system will use DC motors, the following figure is a reference from Paluszek's "Spacecraft Attitude Determination and Control". [21]

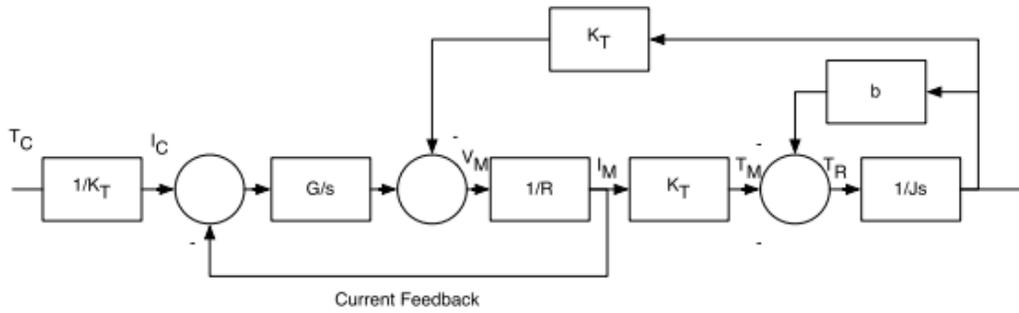


Figure 3.7 – Paluszek’s block diagram

The following equation is the transfer function from commanded torque to reaction torque.  $J$  represents the reaction-wheel inertia,  $b$  represents the viscous damping coefficient,  $R$  represents motor resistance,  $k_T$  represents the current to motor torque gain, and  $G$  represents the forward gain.

$$\frac{T_R}{T_C} = \frac{G}{R} \frac{s}{s^2 + \left( \frac{b}{J} + \frac{k_T^2}{RJ} + \frac{G}{R} \right) s + \frac{bG}{JR}}$$

(61)

## Chapter 4 – Theory

### 4.1 Electrical and Hardware Process

#### 4.1.1 Electronic Preparation

Safety is one of the most important precautions for this design since a mistake could risk an injury or damage to a component rendering it useless. Resistors are used to not burn out the LED lights, arduino, and solenoids. Throughout the development of the system, electronics are kept in an ESD safe environment and containers to avoid shocking any of the sensitive components. For example, MOSFETs that are used to connect the solenoids to the hardware are easily shocked if left in non-static shield bags.

The MOSFETS are critical components as they allow for the microcontroller to operate the 12V solenoids. While the solenoids require the Pololu voltage regulator/boost converter to amplify the 5V signals it receives, the MOSFETS act as a switch to power each solenoid. MOSFET or also known as metal-oxide-semiconductor field-effect transistors are electrical components used to manage the current flow for regions within an electronic circuit. MOSFETs usually consist of 3 terminals: gate, drain, and source. In N-channel MOSFET, the drain is connected to the power supply with the load while the source is connected to ground. The gate allows circuit completion between the source and drain terminal by allowing the insulated electrode to conduct once a voltage is applied to the gate terminal. MOSFET TN0606N3-G were selected for our application and used as switches to allow for the Arduino to command the actuations for the 12V solenoids. TN0606N3-G are considered as enhancement type transistors that normally act as open switches and require a HIGH 5V signal from an arduino to be turned on. In addition, to avoid the possible floating or high-impedance, implementation for a pull-down 1 kilo ohm resistor is used at the gate terminal.

Furthermore, the MOSFETs are used to develop a UART level shifter between the Arduino and Adafruit itsybitsy serial communication on the RX and TX pins. As the Itsybitsy operates on 3.3V while the Arduino UNO operates on 5V, it is important that the serial communication signal is converted respectively to each microcontroller to avoid possible damage between the devices. The UART level shifter allows for the disabling of the serial port when uploading code and thus reduces the need for physically disconnecting the RX and TX pins.



Figure 4.1 – Pololu voltage regulator

#### 4.1.2 Solenoid Testing

As mentioned in Chapter 2, the available solenoids limit the design of the whole system. Ideally for this system, only normally-closed solenoids would be used to control the air flow. This is so that the CO<sub>2</sub> is not excessively expended. Regardless, eight solenoids will connect to M0 Express Arduino that will command when to open or close. Individual tests for each solenoid are done by delaying the analog high and low signals on pin 13 on the M0 Express Arduino. After individual testing was completed, a prototype seen in (Figure 4.2) was constructed to test solenoid actuation in response to the IMU data feed by the Adafruit Itsybitsy through serial communication.

One of the most difficult aspects for this project is the physical actuation of the system. Since a solenoid will close and open based on its commands from the program, the electronics will need to work smoothly so that the propulsion devices will function as expected.

To test the functionality of the electrical subsystem, LEDs were arranged to indicate whether or not the signal was successfully transmitted to the solenoids. This allowed for a convenient functionality test to be performed without depleting the limited CO<sub>2</sub> supply. The LED lighting up indicates that the solenoid is receiving the signal to be powered on. The following figure (Figure 4.2) is a picture of testing with LED lights for functionality.

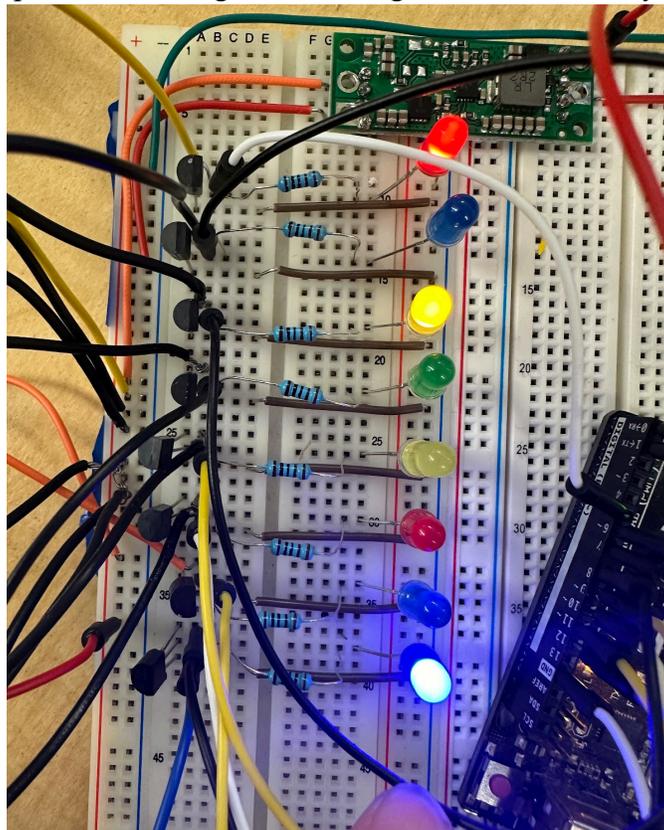


Figure 4.2 – LED testing before using all solenoids

#### 4.1.3 Printed Circuit Board Design

PCB (also known as printed circuit board) designing is implemented in this project. While solely building the electronic sub-system is easy, designing a PCB to attach to the entire system is necessary to prevent loose connections. Additionally, a PCB maximizes space for the whole system, so that other subsystem components fit. Table 4.1 lists the components that will be

placed within the PCB design. Such elements and their necessary connection are depicted in Figure 4.3-4.7, which is also the schematic design done through KiCAD. After translating the components used in the system into a schematic diagram using the KiCAD program, one can import the components that will be used through KiCAD’s PCB editor as seen in Figure 4.8.

Table 4.1 – List of all electronic components

| Electronic Component | Qty | Purpose   |
|----------------------|-----|---|
| BNO085X              | 1   | IMU sensor (contains gyros, accelerator sensor)                                     |
| Itsybitsy            | 1   | Arduino that receives input from other sensors and outputs commands from the ELEGOO |
| Pololu               | 1   | Regulates power to Itsybitsy & ELEGOO Arduinos                                      |
| ELEGOO UNO R3        | 1   | Arduino that compute the solenoid output based off the input from the Itsybitsy     |
| HC SR04              | 2   | Ultrasonic Sensors  |
| Connector 01x02      | 8   | For each of the 8 solenoids   |
| Connector 01x03      | 10  | Eight for each of the 8 mosfets, two for a level shifter                            |

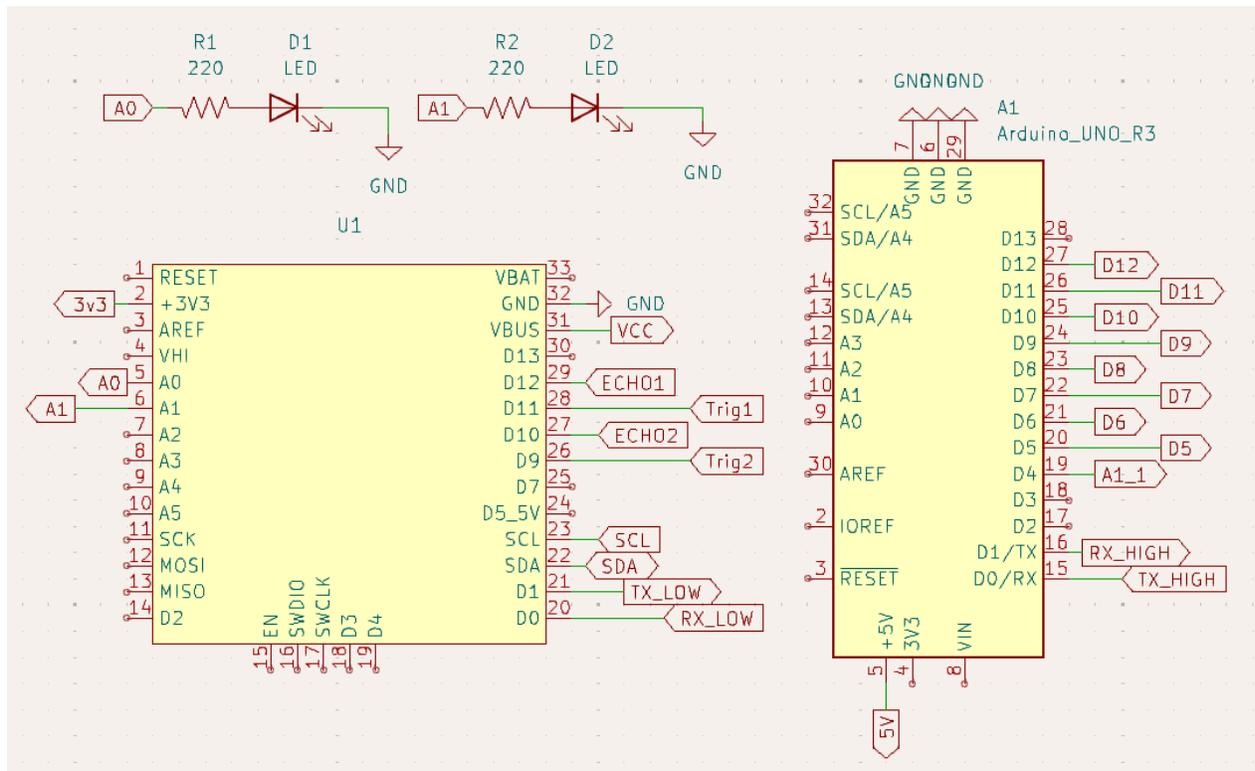


Figure 4.3 – Kicad schematic of the arduino pins used

The two Arduino’s used for the whole system, M0 Express and Elegoo Uno R3, are displayed with the global labels of which pins will be used and the type of input-output signal

they will receive (Figure 4.3). Two LEDs are also added to this system as a form of verification that certain commands are correct. The following figure shows the global labels/inputs/outputs and pin connections within the two types of sensors; thus, the schematic shows two ultrasonic sensors and one IMU sensor (Fig. 4.4). As mentioned before, the addition of a level shifter utilizes the two additional MOSFETS so that it can act as a switch for turning on specific pins on the Elegoo Uno R3 arduino.

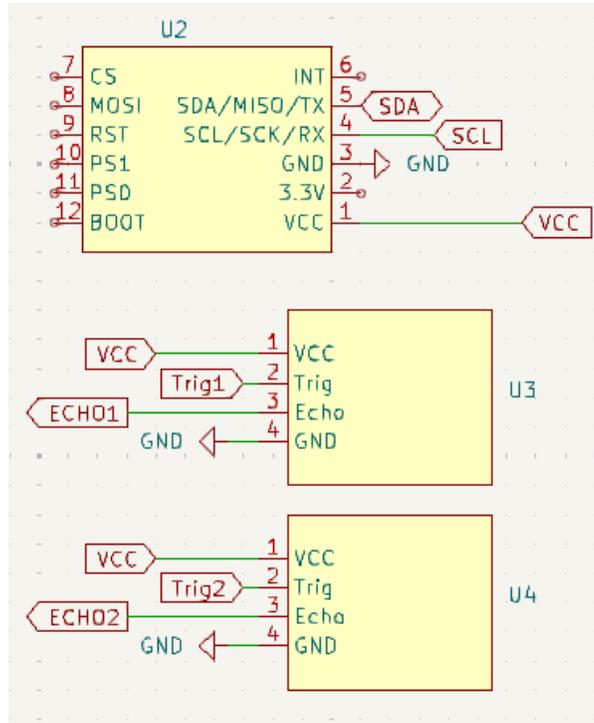


Figure 4.4 – Kicad schematic of ultrasonic sensors and IMU sensor

All sensors (Fig. 4.4) will be connected to the M0 Express Arduino. Since the level shifter depicted on Figure 4.6 along with the voltage booster/regulator (U5). From the schematic diagram in Figure 4.4, U2 is the IMU sensor, while U3 and U4 are the ultrasonic sensors. To understand how the global pins will physically connect the sensors, the Itsybitsy and IMU sensor are physically depicted in Figure 4.5 with the wires that connect the pins. Ultimately, the PCB will minimize the use of loose wires.

In addition to the Itsybitsy Arduino requiring 3.3V, the sensor components are compatible with 3.3V and 5V. With the sensors directly powered by the Itsybitsy, it is preferred that the sensors receive 3.3V power supply. In chapter 2, there are two different ultrasonic sensors (Fig. 2.4 & Fig. 2.5). The HC-SR04 in Figure 2.5 requires 5V, unlike the Adafruit model based on the HC-SR04. The ultrasonic sensors were changed to the Adafruit model so that there are no further power problems.

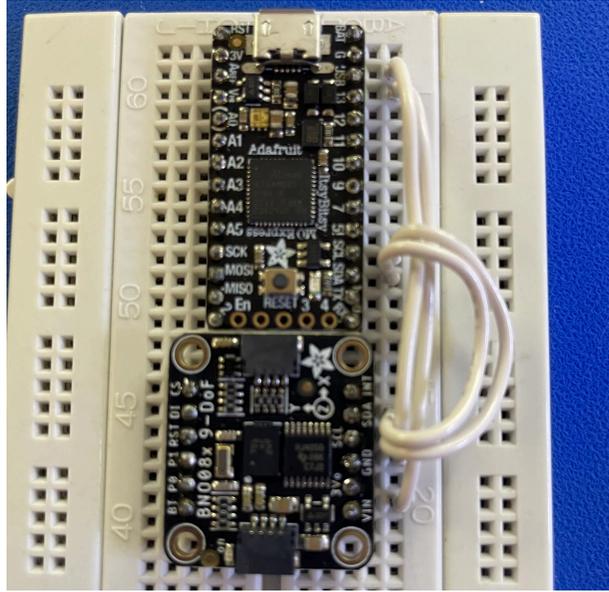


Figure 4.5 – IMU sensor connected to M0 Express arduino

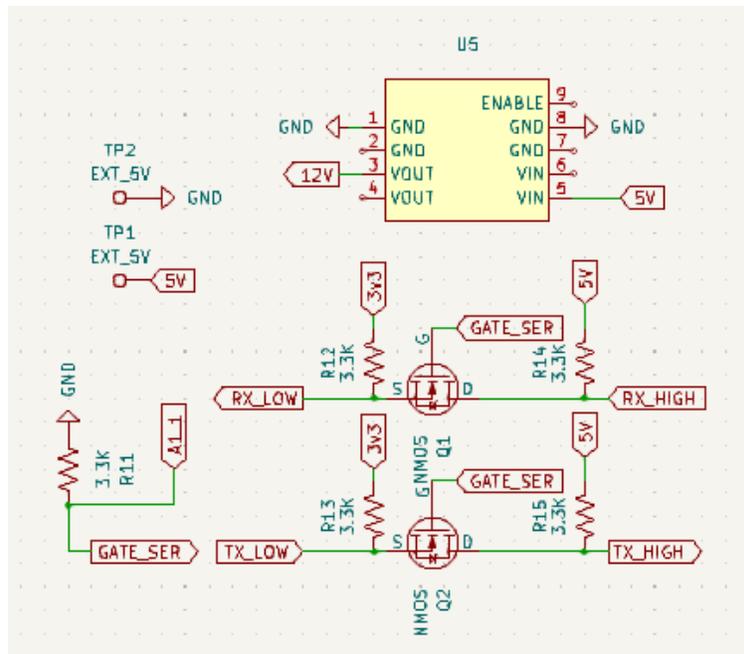


Figure 4.6 – Kicad schematic of level shifter

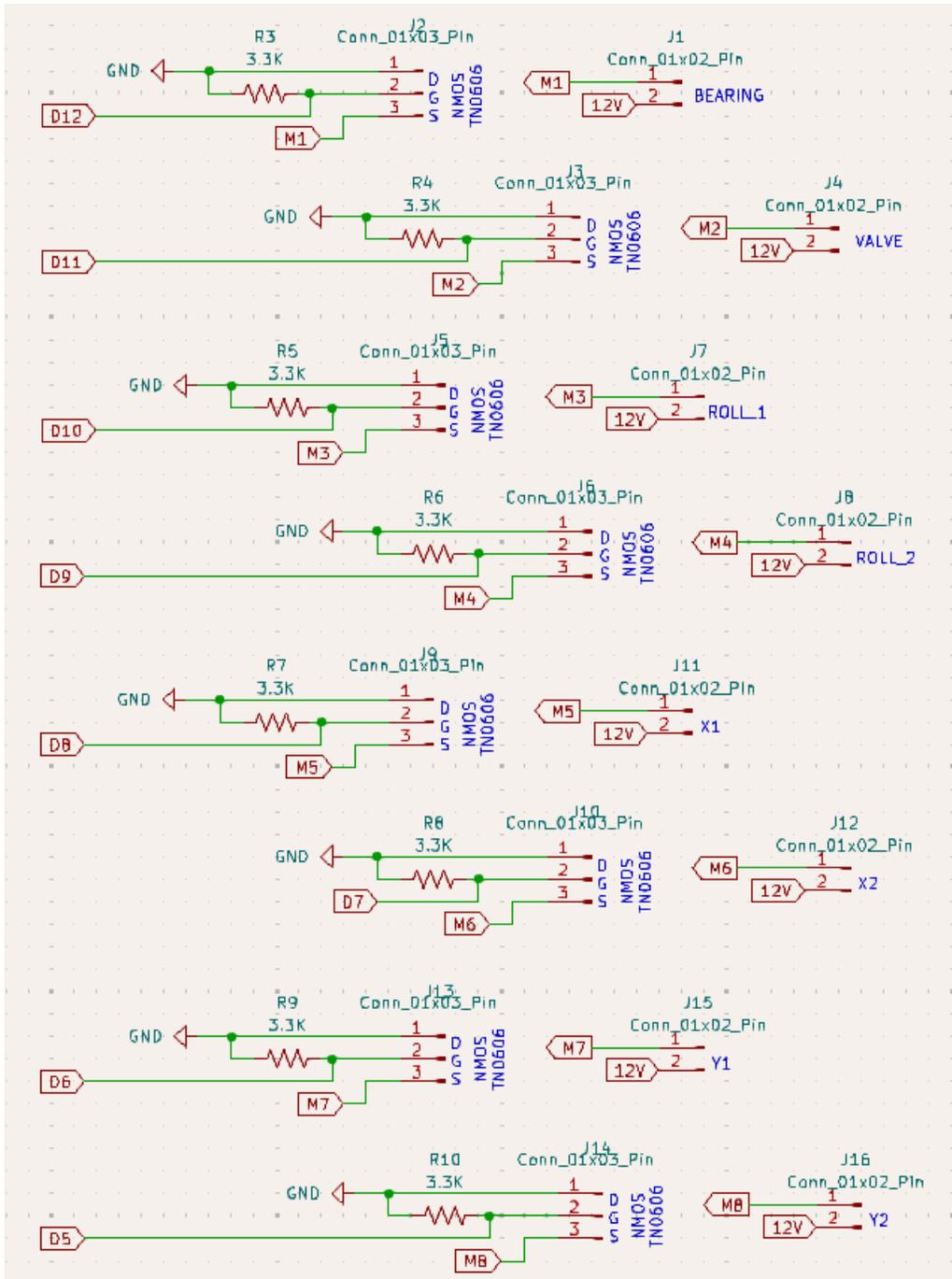


Figure 4.7 – Kicad schematic of the arduino-mosfet-solenoid connection

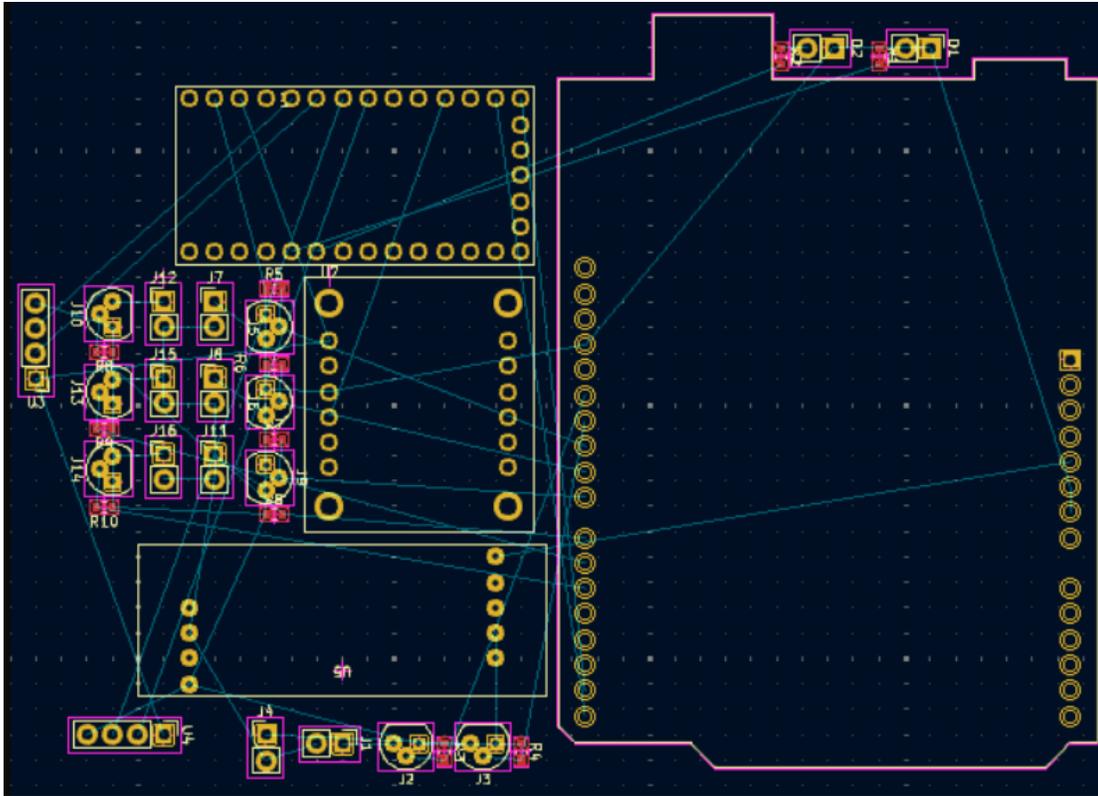


Figure 4.8 – Initial component footprint layout on Kicad program

## 4.2 Propulsion and Pneumatic Sub-system

By understanding what aspects affect the pneumatic system and what components will affect other systems, the undefined design choices guide how to continue establishing parts of the project. For example, the selection of the system's air tank will affect the structural system in terms of shape and mass. This will ultimately affect the force outputted from the nozzles. Thus, understanding the pneumatic system's output allows us to predict how much force will be generated.

An initial investigation for the subsystem is to explore what is an optimal tank for this project. Like other well-established systems, an optimal tank should provide a lot of fuel with a light payload. Minimal weight allows for flexibility in the entire system and increases stability.

Upon deriving the EOM's as seen in Chapter 3, the speed and force of movement heavily depend on the size of the nozzles and the speed at which air flows out of the nozzles. Airflow from the canister tank will be affected by the volume at which it travels. Additionally, if the airflow is regulated, that also affects the consistency of the air output.

### 4.2.1 Flow Characteristics

While knowing the speed at which air travels is significant to the controller's reaction system, such calculations depend on whether the air is compressible or incompressible at the given time. Compressible flow occurs when the flow of a fluid or gas is moving faster than Mach 0.3. When flow is under Mach 0.3, flow is considered incompressible, and the density of the fluid can be considered constant. For example, Bernoulli's equation (Eq. 31) — which is considered when determining the flow properties at different locations along a streamline within the flow — can be further simplified when density is constant. Through this project, the system will facilitate compressible flow and incompressible flow at different stages. This will be due to

the canister expelling pressurized gas into the atmosphere over time, decreasing the volume of the pressurized gas as well as the pressure contained within the canister. Thus, there are numerous situations to consider and calculate for.

Assumptions that also affect the pneumatic calculations are if the transfer of air from one place to another is adiabatic and isentropic. An adiabatic process is considered to be an irreversible process and an isentropic process is a special case of an adiabatic process in which there is no transfer of heat.

#### 4.2.2 Other Environment Considerations

During the development of the project, a situation in which gas and air would be a gas mixture within the tubes of the system was considered. Through Dalton's Law of Partial Pressure, the different pressures of the different gasses (CO<sub>2</sub> and air) would be summed to get the theoretical pressure of the gas mixture in the tube. Ultimately, it was decided to not consider a mixture of gasses since outside air would ideally not enter the system. While the gas may be sitting within the chambers of the tubes, it would be pushed out by the CO<sub>2</sub> once a regulator was opened.

#### 4.2.3 Pressure Output from Canister to Outside the System

The mission of the system is to create a physical system, concerning pneumatics, the goal of the system is to output air to the air bearing and valves that will establish a way of displacement. Figure 2.9 displayed the designed airflow. From an established air supply, the air would output into a regulator (to control the amount of airflow exiting the air supply) and continue to travel to either the air bearing's output or the valves of the entire system. Solenoids in between the valves and air bearing will open and close depending on the desired motion and mission. As mentioned, the amount of airflow that exits the air supply is controlled by the designer. This allows speed to be controlled. Additionally, regulating the air pressure out of the air supply will create a controlled environment within the air supply tank of choice. A regulator allows the user to maximize the period that one can utilize the air, and maintain consistent conditions for a longer time period. As mentioned, at a certain point, when the gas decreases its pressure output, speed is expected to change which will ultimately change the flow from compressible to incompressible.

A concern to expect due to the nature of the normally-open solenoids, this will drain a considerable amount of power to ensure the desired solenoids are closed the whole time the system runs.

#### 4.2.4 Approach Without a Pressure Controller

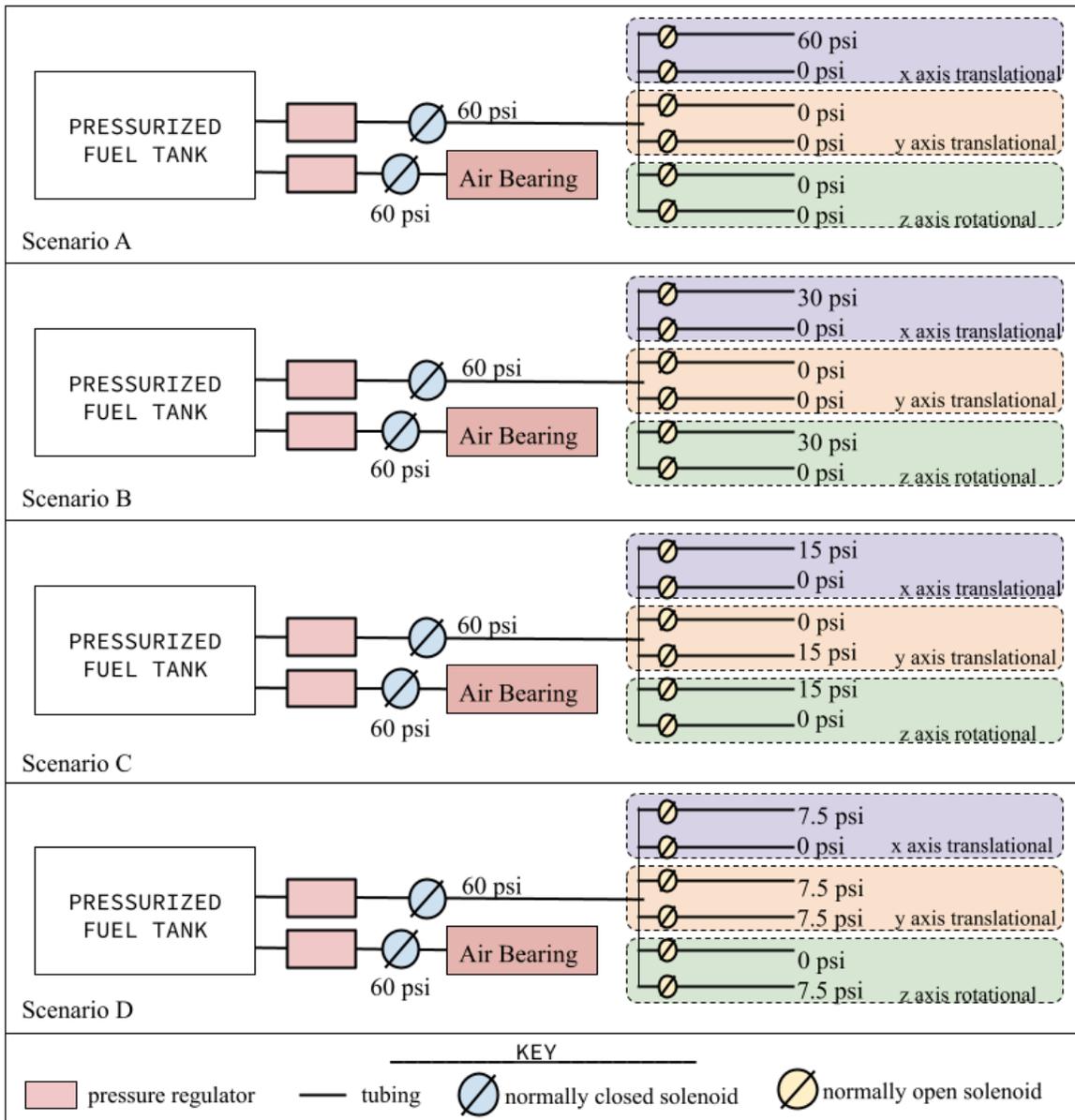


Figure 4.9 – Initial component footprint layout on Kicad program

Due to the solenoids constantly opening and closing depending on its direction instruction, with a manual regulator the output pressure from the valves will vary continuously. This is due to the distribution of pressure changing. Fig. 4.9 provides an illustration. Two solenoids are expected to always be on. Due to the design and regulator limitations, consider the pressure distribution from one 60 psi regulator to an individual solenoid.

Table 4.2 – Pressure distribution without pressure valve controller

| Number of Open Valves | Pressure Output in Solenoid | Scenario/Discussion   |
|-----------------------|-----------------------------|---|
| 0                     | 0 psi                       | All valves closed, before controller turns on ( However, the air bearing valve will ideally always be on, when the controller starts data collecting, but is being supplied by a separate regulator.) |
| 1                     | 60 psi                      | Only 1 thruster is turned on to return to origin.   |
| 2                     | 30 psi                      | 2 thrusters on, either 2 translational thruster, or 1 rotational thruster & 1 translational thruster.   |
| 3                     | 15 psi                      | 3 thrusters on, for each direction powered on.  |
| 4                     | 7.5 psi                     | Not ideal situation of 4 thrusters powered on.  |

### 4.3 Structural Design Theory

The structure is a necessary aspect to consider for the entire system. The general laws that are fundamentally considered during design are Newton’s 1st law, 2nd law, and 3rd law. Newton’s first law relates that an object at rest in the absence of external forces will remain at rest. The second law relates acceleration to force and the 3rd law relays that for each force on an object at equilibrium, there is an equal and opposite force. These laws must be considered for the whole structure since the air bearing is expected to constantly move. Thus, the pieces atop the air bearing must have stability while moving to perform with little error.

As seen in the CAD design from Chapter 1, Section 4, the majority of the structural components will be 3D printed. Before reaching this design there were numerous versions of design. The initial assumptions made to maintain stability include not building weight at the highest point of the structure as well as avoiding designing a structure with a distinctive height. Due to the dependence of the structure on the size of the canister, there were design options that held a height greater than 1 ft. If a tall structure were chosen, a triangle-shaped structure would have been preferred over a rectangular/cylindrical structure due to unknown forces that may act on the top. A big consideration carried through the previously mentioned aspects was the center of momentum of the structure. The air-bearing itself holds a lot of weight, the mount itself must be able to clasp on the air-bearing and provide a foundation for the rest of the structural pieces. Ultimately, using smaller canisters allowed for an improved design to avoid a top-heavy structure. This also improved mobility by allowing the translational and rotational thrusters to be coplanar with the center of mass.

To check its structural integrity, stress and tension tests through a reliable simulating program should be done eventually.

### 4.4 Full Configuration Design

The finalized design consists of the two main 3D printed parts as structure, the whole pneumatic subsystem picture in the block diagram (Fig. 2.9) and the electronic subsystem depicted in the schematics (Fig. 4.3-4.7). The four (normally open) translational solenoids will

be placed in their optimal locations along the x and y axis. The translational solenoids themselves are placed at these locations with the hope to minimize tube volume in which the flow will travel. As for the (normally open) rotational solenoids, they will be placed on a different layer than the translational. The CO<sub>2</sub> canisters and regulator attached will sit on the top layer with the normally closed solenoids and the rotational solenoids. The tubing after the rotational solenoids will spit into two nozzles each. This is desired so that when a rotational solenoid is commanded to open, theoretically the tangential force on opposite sides along the bearing's circumference will only allow it to displace rotationally, with no translational movement. Figure 4.9 displays the necessary regulators and solenoids that will sit on the top layer. The figure holds the general layout of the pneumatic system on the top layer without the tubing. The two open nozzles at the bottom left of the image will lead to the translational solenoids on a bottom layer (right on top of the bearing mount). The clear tube in the figure is the direct tube that supplies air to the air-bearing, which will connect to the regulator at the bottom of the picture via tube.

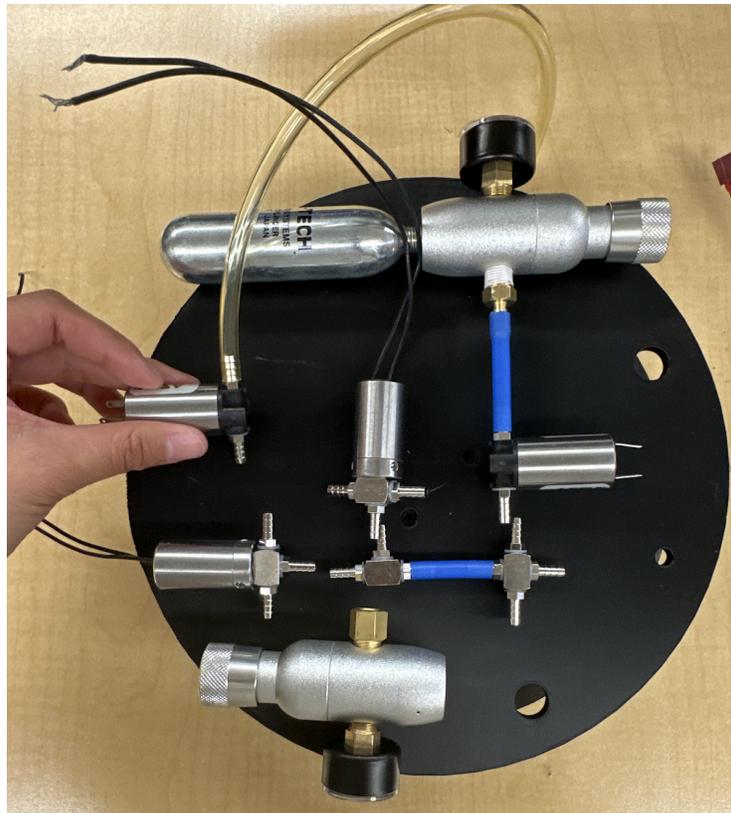


Figure 4.10 – Top layer physical pneumatic configuration layout

Constructing the entire system will require tubes that fit the nozzles, and the proper screw connectors that will attach the tubes to the regulator. Depending on the flexibility of the tubes, this will affect the amount (or length) of tubing that will connect all the solenoids, nozzles, and dividers.

## Chapter 5 – Results

### 5.1 Physical Structure

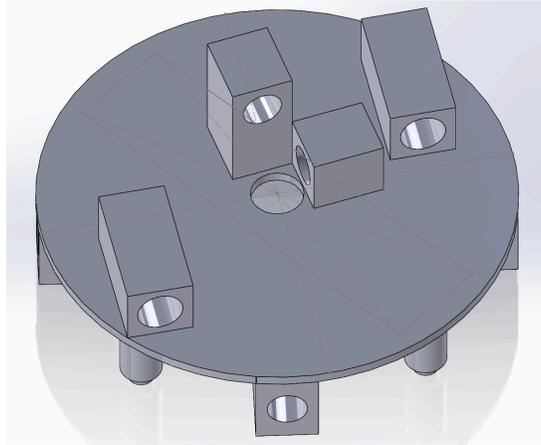


Figure 5.1 – Top isometric view of 3D CAD solenoid layer design

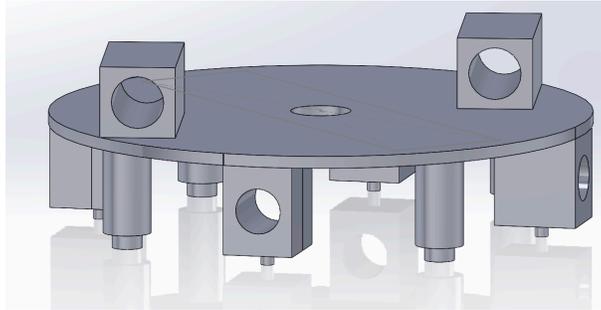


Figure 5.2 – Side view of 3D CAD solenoid layer design

Eventually, many variations of the initial design were altered for this project. The finalized CAD designs for solenoids are seen in Figure 5.1 and Figure 5.2. In the figure, notice four cubes in the underside allocated for the translational solenoids. The upper side of the design will hold the canisters, regulators, normally closed solenoids, and rotational normally open solenoids.



Figure 5.3 – 3D print of air bearing mount upside down

The finalized PLA prints from a Prusa MK4 3D printer are seen in Figure 5.3 and Figure 5.4. Figure 5.3 also shows the excess print used to provide structure while printing the part.

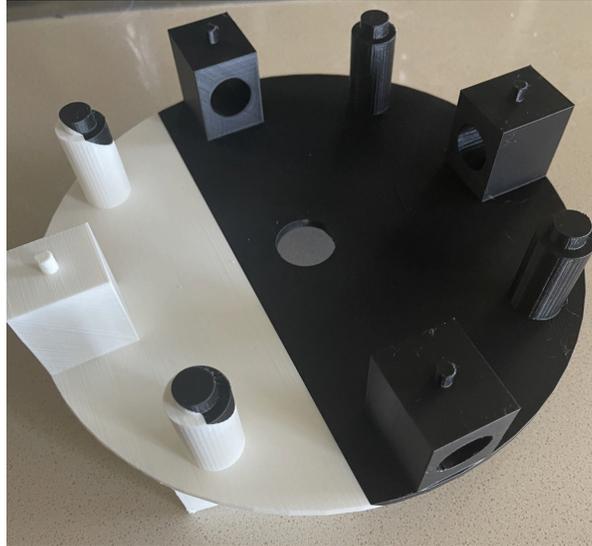


Figure 5.4 – 3D print of translational solenoid structure upside down

From there, provided in the following Figure 5.5, the translational solenoids fit well onto the underside of the structure, and the CO<sub>2</sub> canisters also fit well on top of the structure.

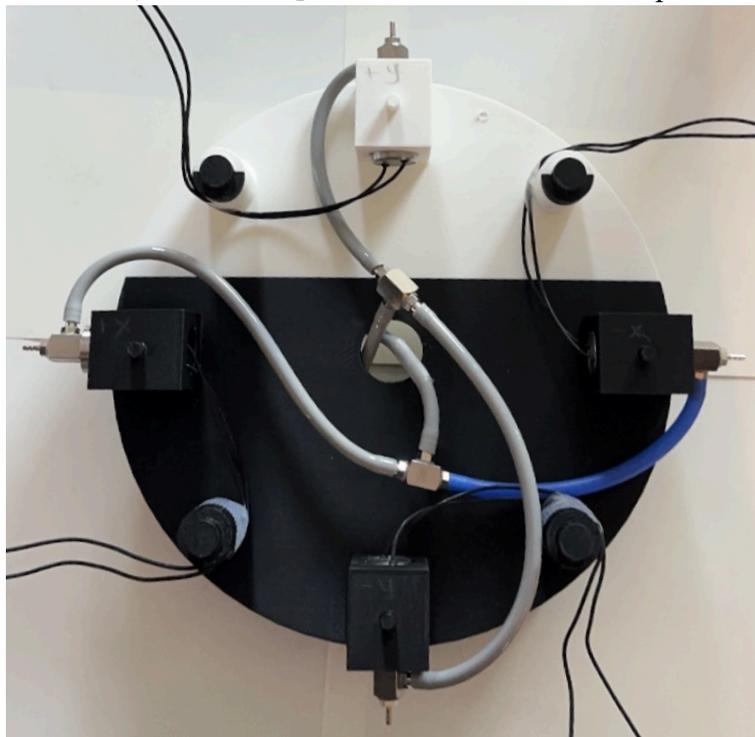


Figure 5.5 – Translational solenoids attached underside of its structure

## 5.2 Electronic and Pneumatic Functionality

The C++ code that allows the Adafruit arduino and Elegoo arduino to communicate with each other was completed. See Appendix E & F for the C++ code that instructs the arduino to read sensors, and instructs the solenoids to turn on and supply air through the system's thrusters. Table 5.1 lists the pin location and name each solenoid is linked to, and its expected function.

Table 5.1 – Solenoid to arduino pin location

| Pin Number | Pin Name      | Solenoid Type   | Solenoid Function                            |
|------------|---------------|-----------------|--|
| 12         | solbearingPin | Normally Closed | Opens gas to air bearing.                    |
| 11         | solvalvesPin  | Normally Closed | Opens gas to valves.                         |
| 10         | solroll1Pin   | Normally Open   | When open, rotates clockwise.                |
| 9          | solroll2Pin   | Normally Open   | When open, rotates counterclockwise.         |
| 8          | solx1Pin      | Normally Open   | When open, displace in negative x direction. |
| 7          | solx2Pin      | Normally Open   | When open, displace in positive x direction. |
| 6          | soly1Pin      | Normally Open   | When open, displace in negative y direction. |
| 5          | soly2Pin      | Normally Open   | When open, displace in positive y direction. |

Figure 5.6 shows the system partially constructed with every solenoid electronically connected and pneumatic tube configured. Undepicted, and later shown in Figures 5.11-5.13, is the ordered printed circuit board(PCB) and 10W+ power bank. Figures 5.14-5.17 are pictures of the fully constructed system as designed. The PCB not yet attached in Figure 5.6 will have all the components visible in the picture with the addition of the implemented power shifter, two ultrasonic sensors, and the wireless printed board itself. This configuration can still successfully power any respective solenoid at command. The single ultrasonic sensor response was programmed to react for both sets of translational solenoids. The sequence of powering any of the six thrusters-solenoids after opening the two normally-closed solenoids is necessary for the project's design. With the setup in Figure 5.6, the sequence was tested with promising performance, flaws in wire connections and power supply. However, the PCB design submitted to a fabrication company will provide us with more consistent results (Fig. 5.7)

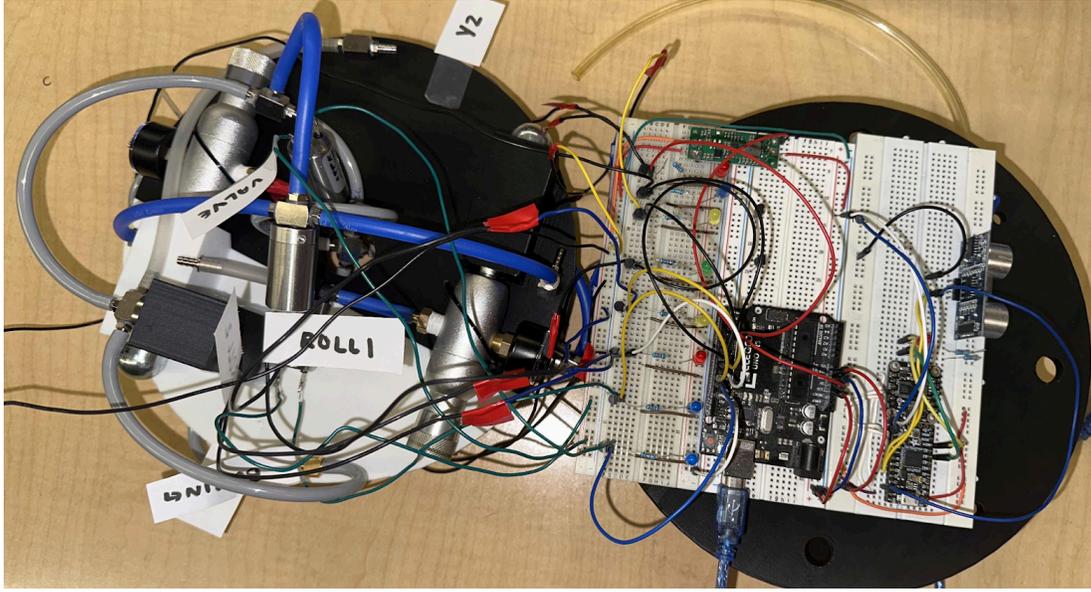


Figure 5.6 – Partially constructed system with breadboard (not PCB)

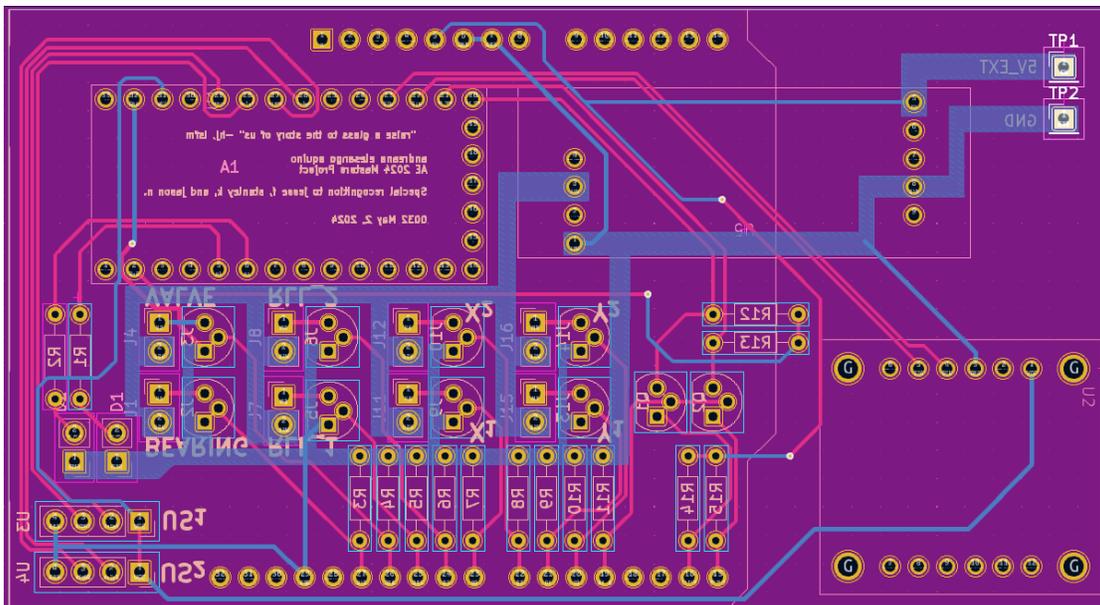


Figure 5.7 – KiCAD PCB full design of system

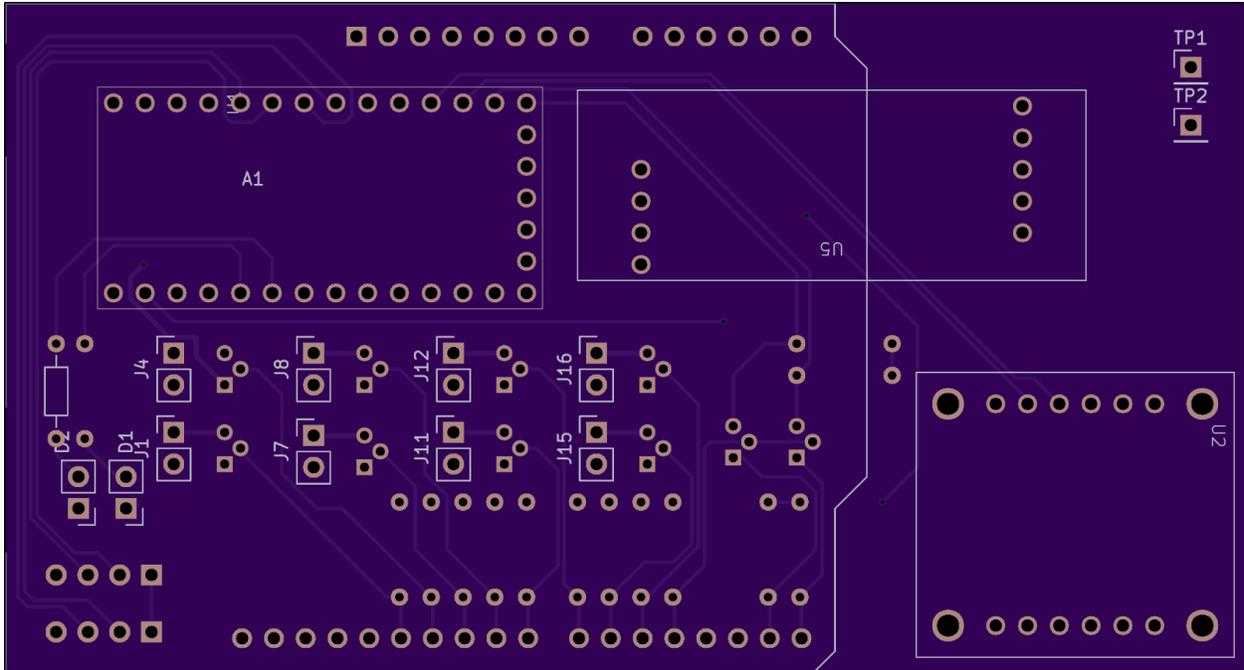


Figure 5.8 – Bottom board of PCB design from OSHPark

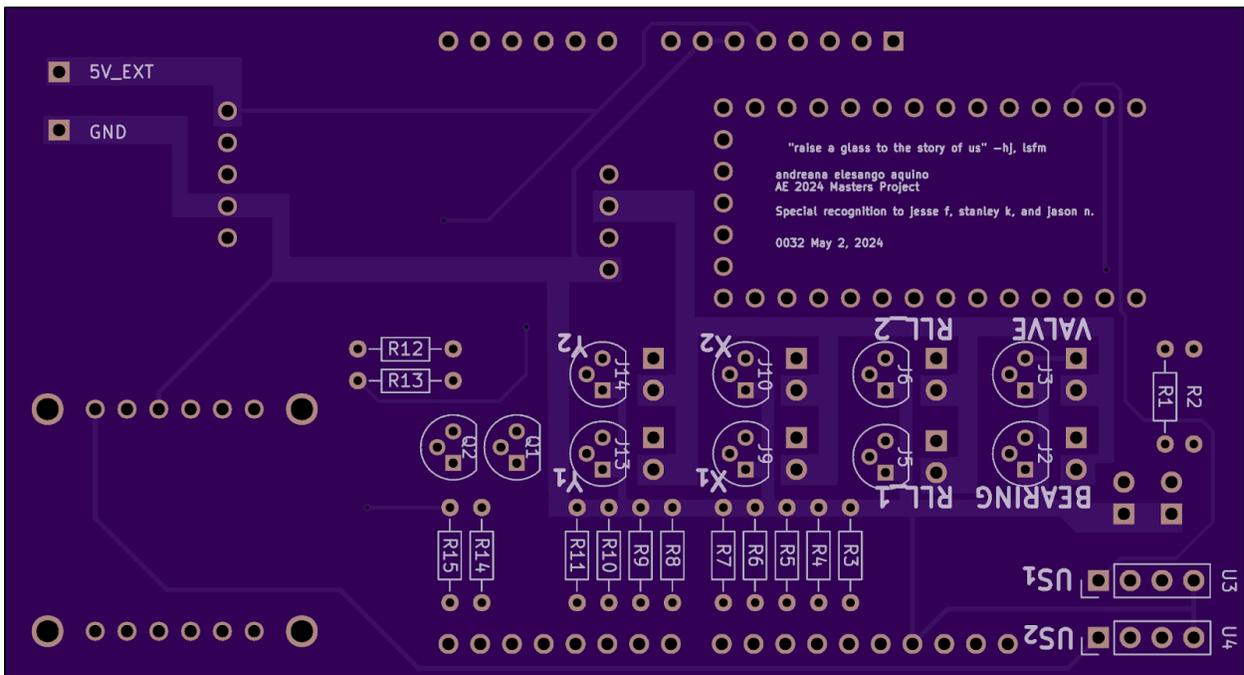


Figure 5.9 – Top board of PCB design from OSHPark

The beauty of using a PCB is that two boards can be utilized to create connections in intricate ways. Figure 5.10 displays the two layers connected by the holes between the top board (Fig. 5.8) and bottom board (Fig. 5.9). Throughout the figures provided, all the components used are attached to the PCB holes and are soldered to the board.

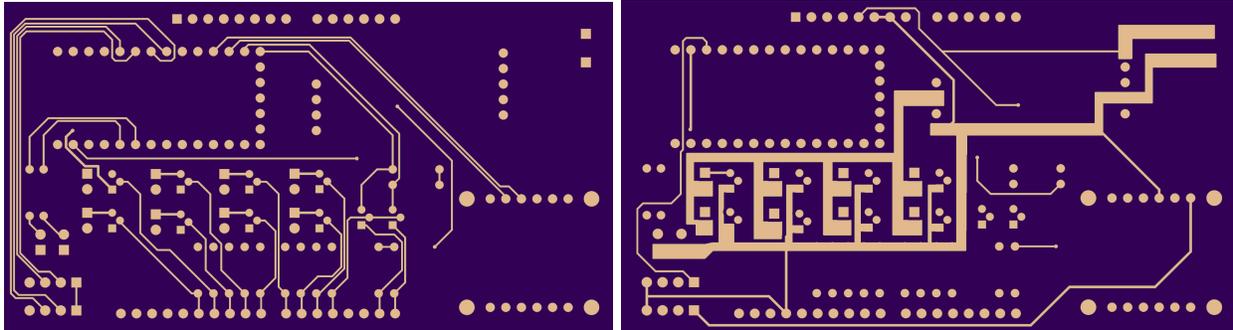


Figure 5.10 – Bottom and top layer respectively of wire connections

Before verifying that the electronic and pneumatic subsystem can work together hand in hand, there are separate ways to show that each subsystem will function as expected.

For the electronic subsystem, as mentioned the C++ code within Appendix E & F are used to initiate a reaction system between the two Arduinos where the Itsybitsy M0 Express will gather the sensor data and the Elegoo R3 Uno will power the solenoids based off the data recorded. The solenoids will act in reaction to the sensor readings, such as when the IMU BNO085 sensor reads a rotational displacement through its gyroscope, the specific rotational solenoids are commanded to open its valve with the goal to rotate back in the opposite direction. The output response of the Elegoo can be seen from the computer verifies the connection between the both Arduinos and that the simplified reaction system is functioning as expected.

The pneumatic subsystem's functionality can be verified by testing if airflow will travel from the CO<sub>2</sub> canister to the regulator to a solenoid to its desired output. Thus in this case, when the air bearing levitates with the connections that lead to it and the air-bearing solenoid is powered, then the airflow is traveling as desired for the air bearing.

In the following subsections, pictures are provided with the PCB connecting to the other electronic components including the solenoids. C++ code provided in Appendix D was used to verify that all the solenoids were properly soldered and connected to the PCB by powering each of the eight solenoids individually. Through this test, an audible click would be heard every millisecond. If silence was heard, this would communicate that a power connection was too weak or a solenoid wire's connection was influenced by uncontrolled external forces. By the time the full configuration was constructed, this test was performed multiple times before powering on the CO<sub>2</sub> canisters-regulators. Once the CO<sub>2</sub> canisters-regulators were powered on, the sound of air flowing out of the nozzles as expected, instead of clicking. In terms of functionality, the electronic subsystem functions as desired with the PCB connected to the full system. This code (Appendix D) also shows that the pneumatic subsystem delivers air out of the desired nozzles commanded as intended.

### 5.3 Complete Configuration

Figures 5.11-5.13 show the top and bottom layer of the PCB board connected to its required components. On the bottom layer of the PCB attached are the Adafruit ItsyBitsy M0 Express Arduino, Pololu voltage booster, BNO085 IMU sensor, and ultrasonic sensors as seen in Figure 5.11. After attaching all the solenoid wires to the top layer of the board, then the Elegoo R3 Uno Arduino will be attached. On the top layer of the PCB, the necessary resistors, MOSFETS, and solenoid wires are connected. Figure 5.12 shows such components without the solenoid's wires, since the wires will come from various places. The latter (Fig. 5.13) displays the wired connections of the solenoids to the PCB on its top layer.

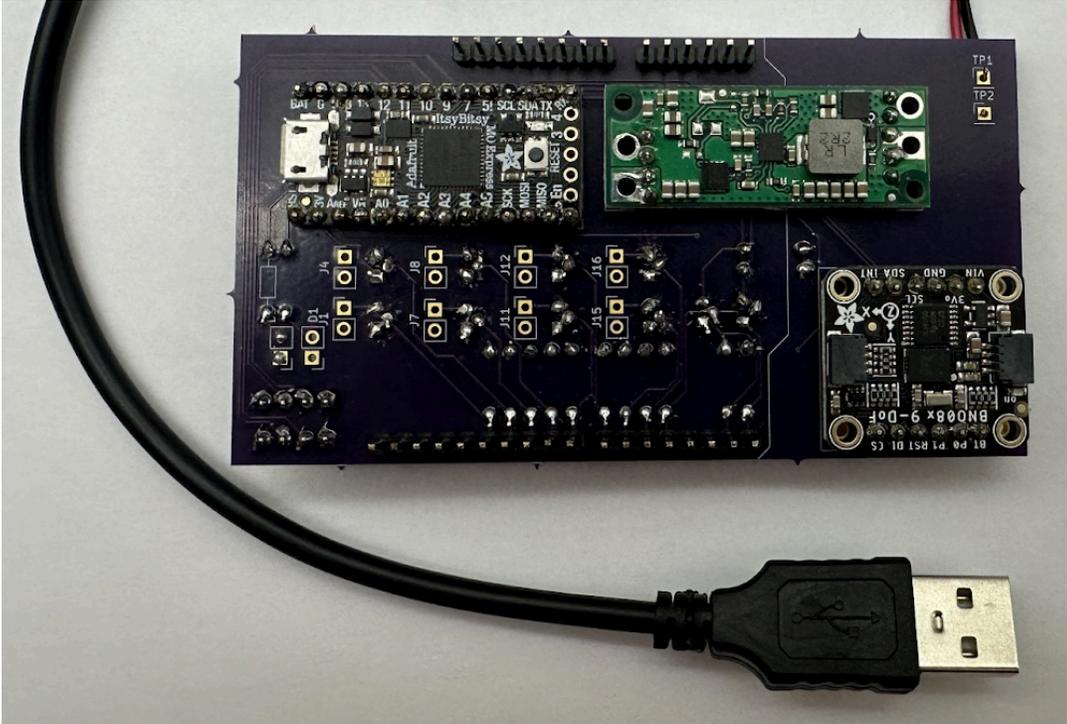


Figure 5.11 – Bottom view of PCB with components

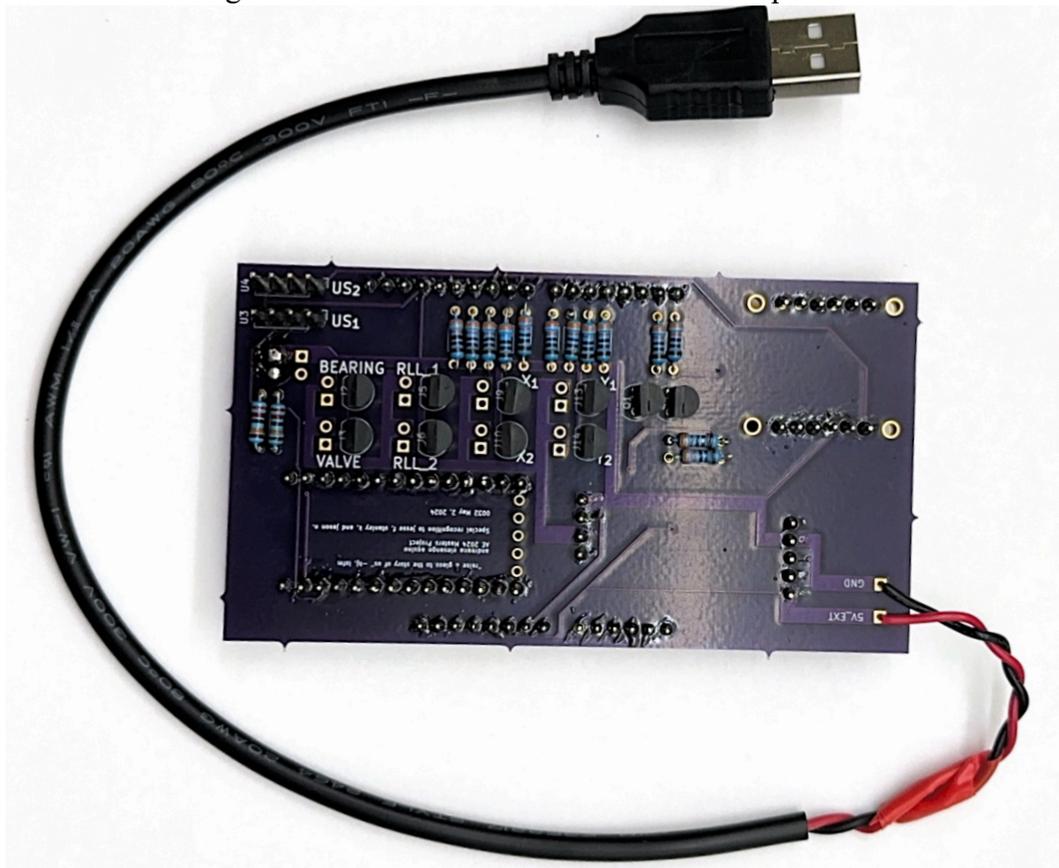


Figure 5.12 – Top view of PCB with components, without solenoid

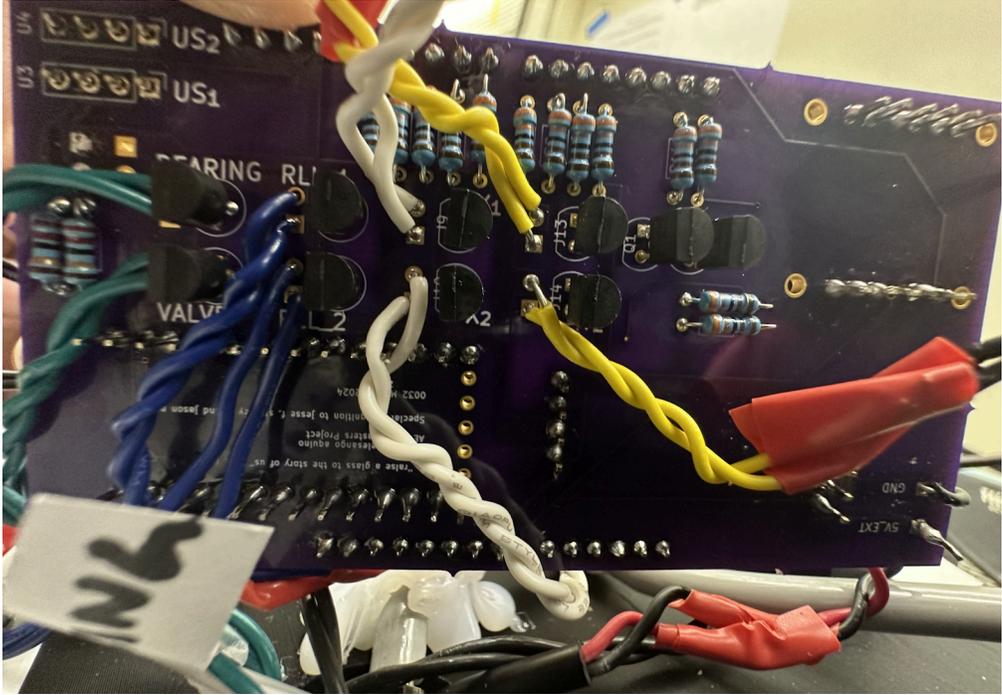


Figure 5.13 – Solenoid wires attached to the printed circuit board

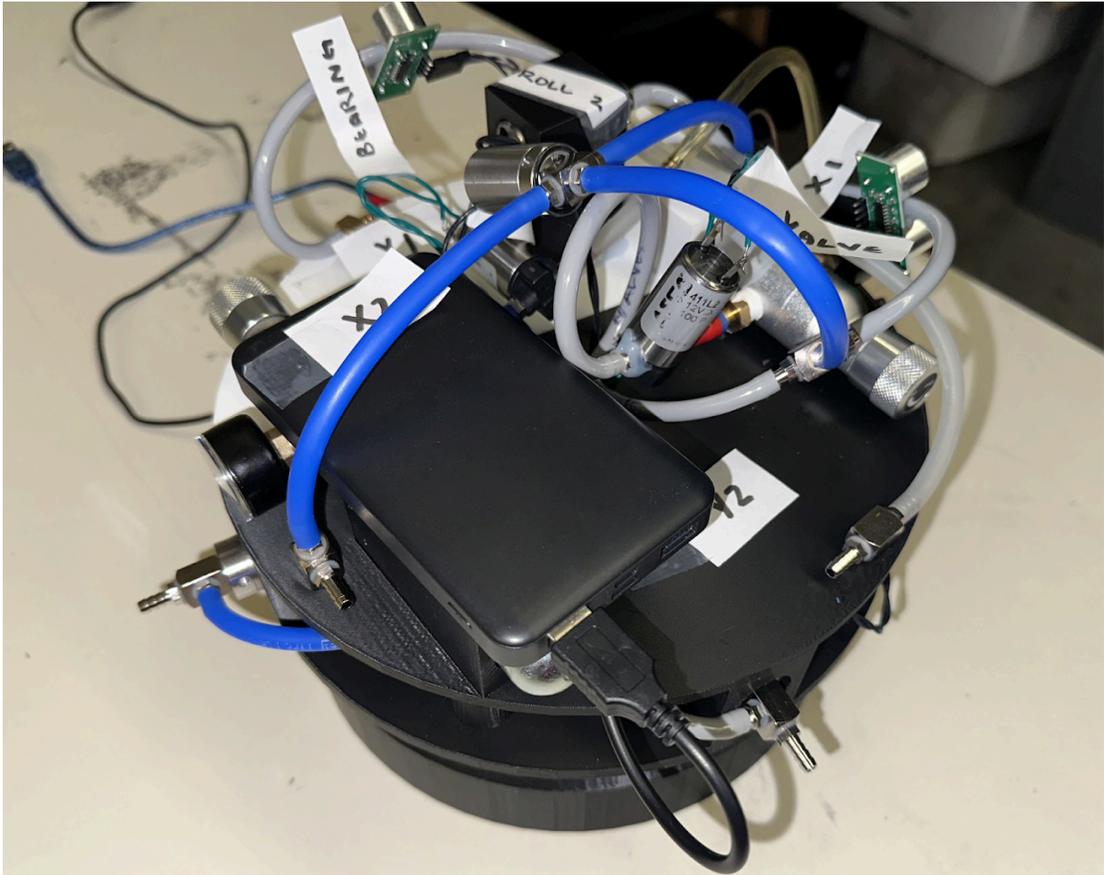


Figure 5.14 – Front left isometric view of air bearing system

Full configuration of the system is depicted in Figures 5.14-5.17 with multiple angled views. Noticeably seen from the figures is the battery pack to power the whole system, the canister-regulators secured within the structure, and the solenoids in various places. All four translational normally-open solenoids sit in their respective slots under the top layer. For the top layer, three out of four solenoids are easily viewable while one of the rotation (normally-open) solenoids is concealed within a vertical block that holds it securely above a canister. The elasticity of the tube affects the placement of the solenoids because choking the flow of the tube would affect the pneumatic air flow. The rotation nozzles were drilled into the structure and can be observed along the rim of the system in Figures 5.14-5.17. Unseen, beneath the layer that holds the solenoids, is the PCB shielded by the Elegoo Arduino. Figure 5.13 as it appears lays against the top solenoid layer with a few centimeters of clearance.

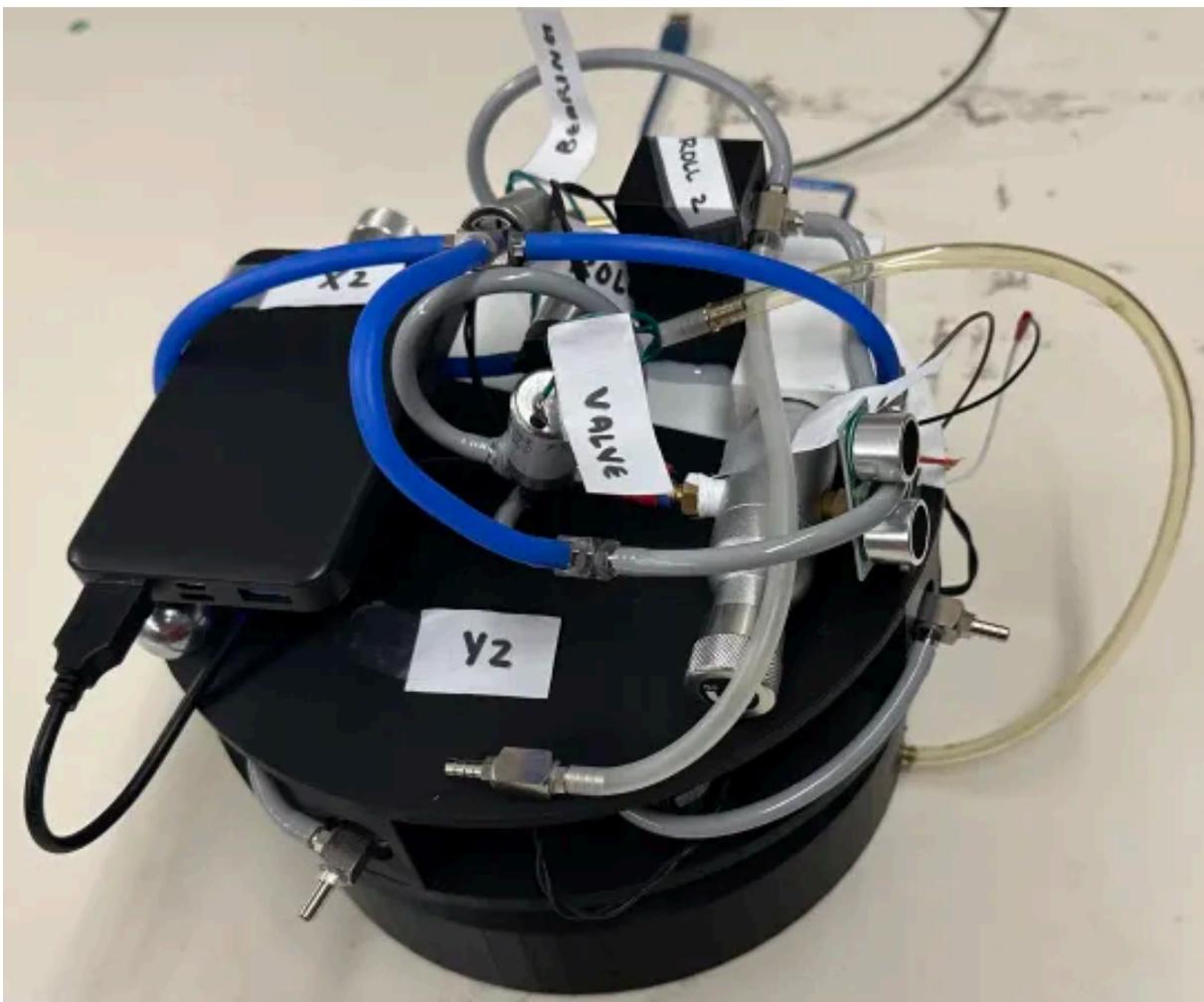


Figure 5.15 – Front right isometric view of air bearing system

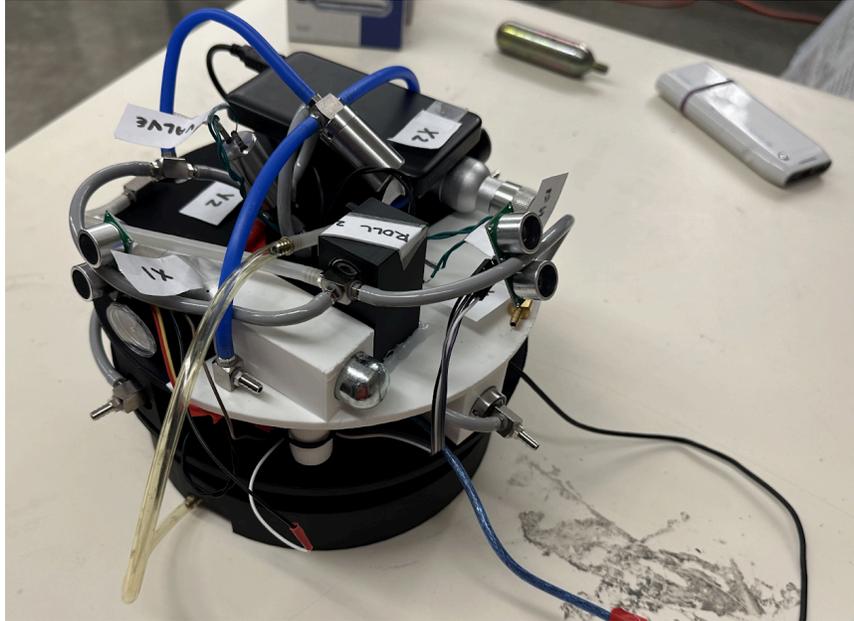


Figure 5.16 – Back isometric view of air bearing system

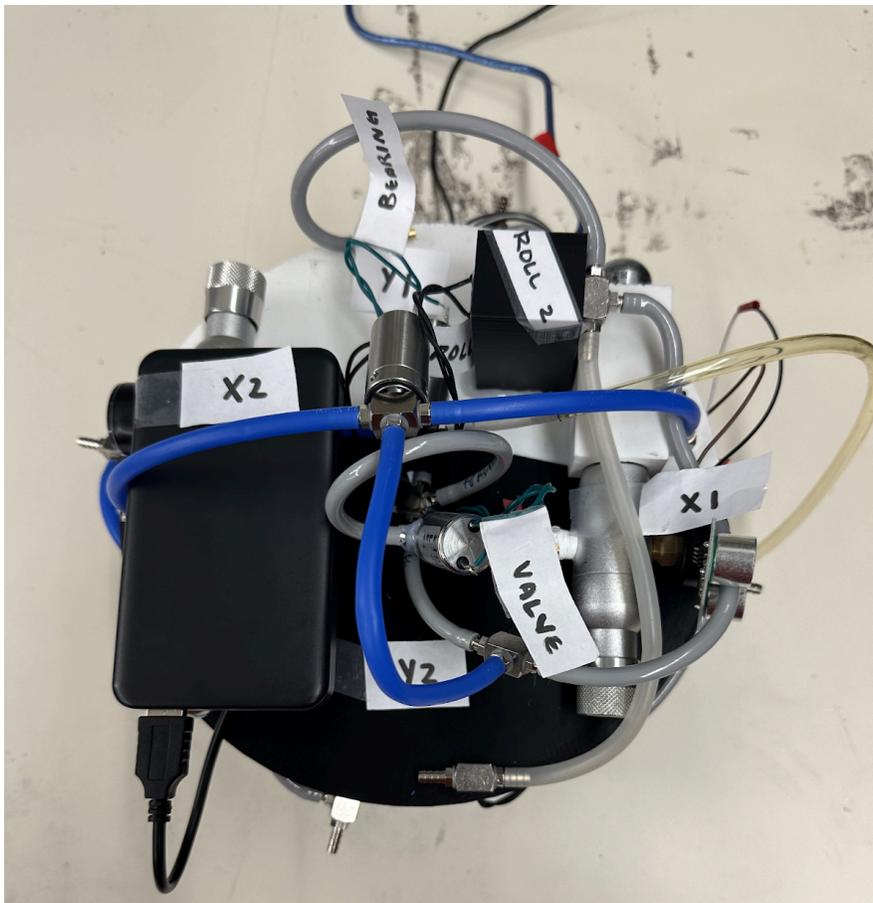


Figure 5.17 – Top view of air bearing system

More visible in Figure 5.17 is a centralized slot that allows all electronic wires to connect under the top structure while all the pneumatic tubing connects above the structure. Right within the slot, you can see where air that is supplied from the normally-closed “valve” solenoid splits among the x-translational, y-translational, and z-rotational air supply.

#### 5.4 Performance

As mentioned, to an extent a very simple reaction system functions properly due to the ultrasonic sensors and the IMU functioning and reporting as expected between the Arduinos. Functionality of the full system was also tested through audible and physical vibrational means. The system was tested from observing if audible clicks were heard for each solenoid without CO<sub>2</sub> to feeling air output from the necessary nozzles.

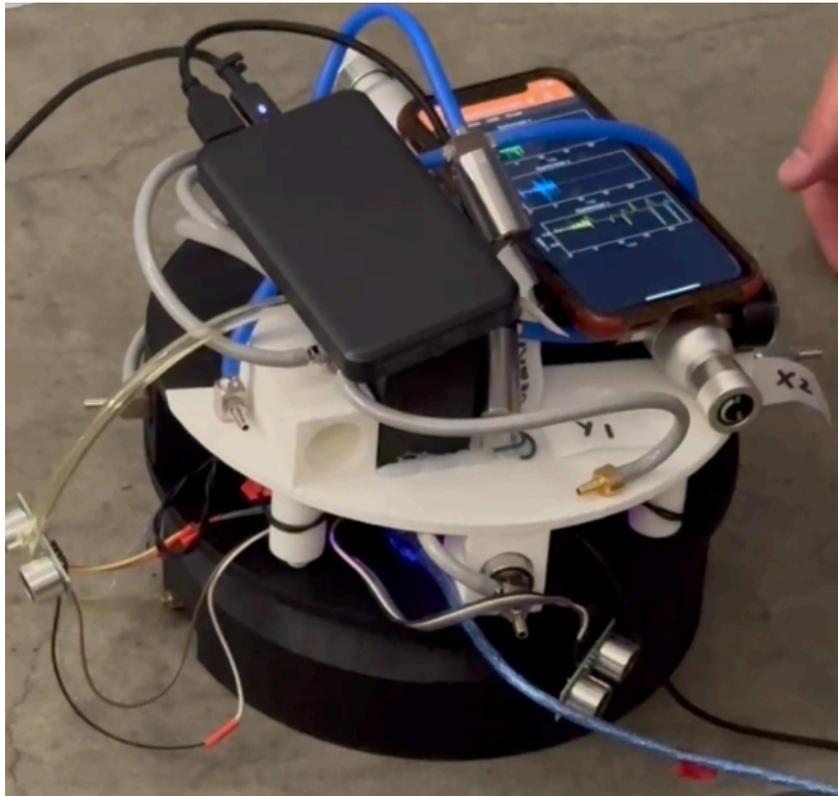


Figure 5.18 – Collecting gyroscopic data

The electronic and pneumatic subsystems are secure and functional on the full system. However, displacement from the pneumatic subsystem was very minimal. To observe the angular velocity and displacement even further, data was recorded through a smart-phone gyroscope application atop the air bearing system. For about a minute, the rotations about the x-axis, y-axis, and z-axis were collected with a time step of 0.001. (See Appendix H.) From there, the whole data set was plotted, as seen in Figure 5.19. A high frequency response at the start and ends of the whole time frame was due to starting the data recording, placing the smart-phone and later picking up the smart-phone and ending the data collection. The overall x and y gyroscopic responses have minimal change in magnitude likely due to not establishing a stable and axially aligned environment for the smart-phone, notably visible in Figure 5.18. A notable spike from the y-axis gyroscopic response is likely due to the smart-phone being adjusted or slipping off from its placement. The only relevant data, in this case, is the Z-axis response since the bearing system rotates about the z-axis (Figure 5.20).

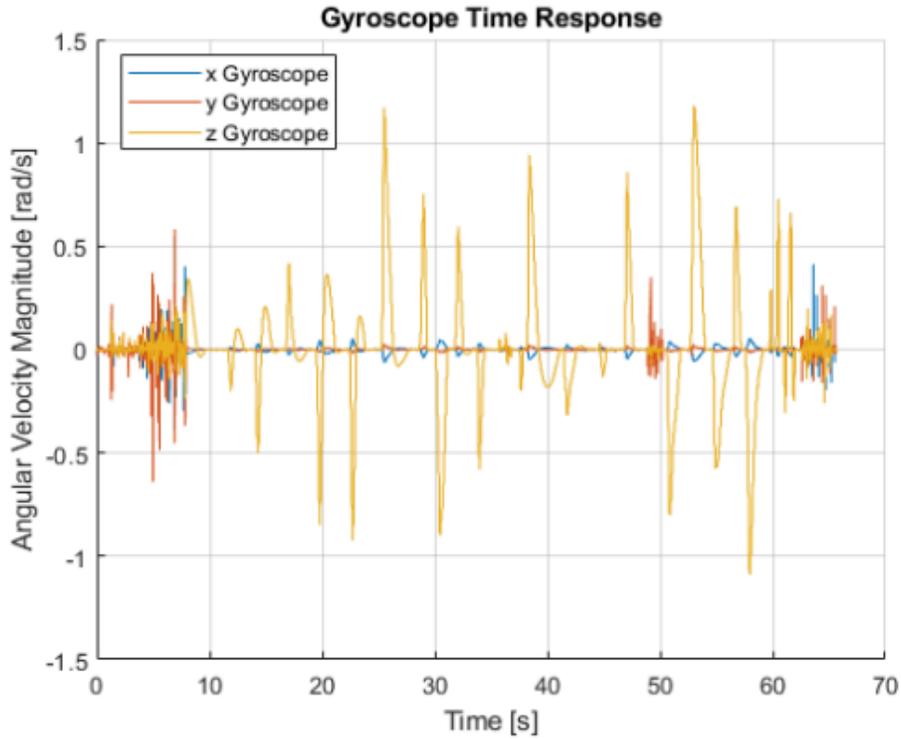


Figure 5.19 – Gyroscopic data collected from smart-phone

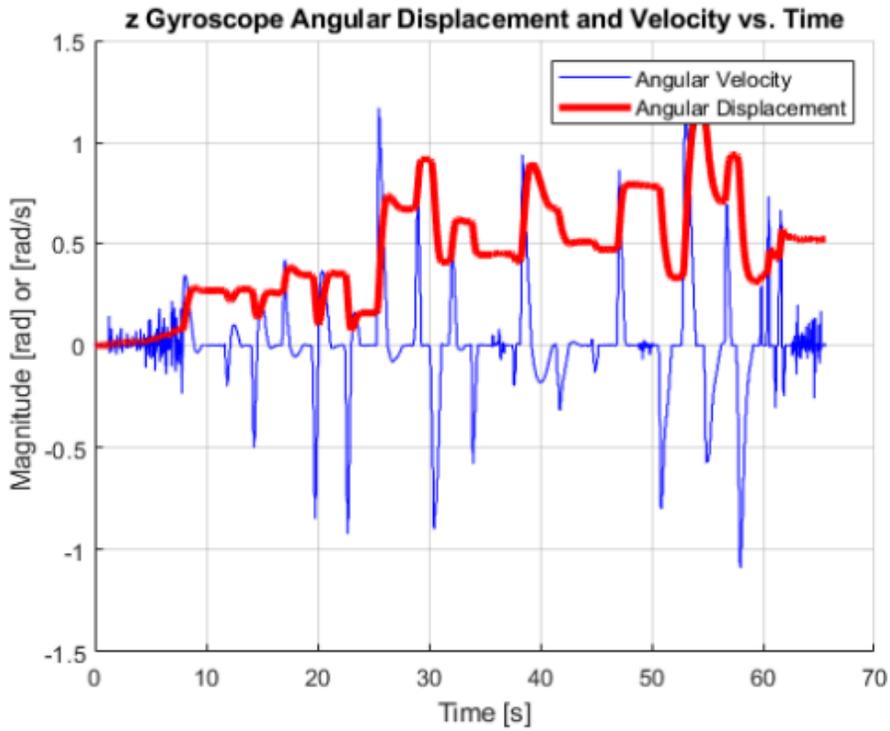


Figure 5.20 – Gyroscopic angular displacement about the z-axis

This shows that the bearing does perform a reaction response to when it is rotated. The descents within the angular displacement plot is when the system turns on the specific rotation solenoids to turn counter clockwise to its last angular position. This is expected since the current C++ Code with the IMU gyro sensor does not store the original position of the bearing. The sensor and arduino only records its previous position, and then redefines the previous position for every moment it records a displacement. In addition, the solenoid is only commanded for that moment to allow airflow, the arduino code at this time does not calculate the necessary force and displacement needed to return to its past positions.

## 5.5 Travel Capabilities

Overall, the full air-bearing system displayed very minimal displacement from point A to point B. While angular displacement was seen while testing the full system, there was no distinct translational displacement from the pneumatic subsystem. There was not enough force from the nozzles outputting CO<sub>2</sub> gas to cause the system to move. Additionally, factors that contributed to the minimal display of movement was due to the testing environment, and limited supply of CO<sub>2</sub> gas. Further development in testing is necessary to justify that the pneumatic system can provide enough gas to the thruster nozzles that will affect its movement.

While there was a lack in force from the nozzle thrusters supplied by one CO<sub>2</sub> canister, the air-bearing's pneumatic connection was well supplied to keep it afloat during testing. The structure itself held stability during testing. The system's structure showed that it could contain all the components when it was pushed. The bearing and the attached structures likely would have been able to hold all the components securely should it have displaced more and the Arduinos were coded to calculate the output force and gas output for each valve.

## Chapter 6 – Discussion

While physical results have come forth from this design, additional verification in structural analysis programs or computational fluid dynamics can be performed to further validate aspects of the whole system. Challenges that occurred during the development and how such challenges were dealt with will also be discussed within the chapter. This chapter will also analyze the results that occurred and how improvements for future works will enhance the performance of the whole air bearing system.

### 6.1 Developmental Challenges Discussion

Power distribution was one of the key concerns that would show up while testing the solenoid's functionality with the Arduinos. This is where small tests discussed in Section 4.1.2 and the latter of Section 5.2 provided meaningful insight on whether the electronic connections were set up properly or if the solenoid was unusable because some solenoids would not audibly click when programmed. Instead, a buzzing sound and low constant vibration would be felt upon contacting the solenoid, while LED lights displayed that their respective solenoid should be powered. Regardless of the fact that the Pololu regulator boosted the 5V signal as desired to power a solenoid, power solely from the computer (which was also uploading the code) was not enough to supply all solenoids. This challenge led to the conclusion that a 10W power bank supply was necessary to supply the entire system. As a result, to minimize any excess CO<sub>2</sub> building up in the regulators, tests were performed with checks to turn on the electronics first so that an audible click would be heard from the solenoid before opening any of the regulators.

With the addition of the power bank, the implementation of the PCB (as opposed to using the breadboard set up) fulfilled the need for secure connections between all the electronic components.

### 6.2 Overall Performance and Improvements Discussion

#### 6.2.1 Pneumatic CO<sub>2</sub> Supply

To reiterate what was mentioned at the end of the last chapter, while some travel capabilities were seen, the full system needs to be tested even further to verify that the bearing system will travel as desired. Consequently, limited supply of CO<sub>2</sub> gas restricted the time spent to test the whole system. The air distributed throughout the tubes and among the solenoids did not provide sufficient propulsion to displace the air bearing system. To improve the pneumatic subsystem, minor changes in the configuration can be done to minimize tubing, or upgrade the supply of pressurized gas.

#### 6.2.2 Testing Environment Restrictions

Additionally, the testing environment was insufficient to conduct precise measurement since the air bearing required a frictionless surface for optimal performance. Regardless of whether or not the air bearing was being provided CO<sub>2</sub> to operate, the testing environment that was used had some friction and likely contributed to the lack of displacement as well. A better testing environment for the air bearing will improve its performance significantly for future tests.

#### 6.2.3 Restrictions of Cost-Efficient Motives

Another attribute that affected the current performance of the system was the constrictions of having a low cost build. Many design choices were due to such constrictions, such as the canister choice which sequentially affected the 3D printed structure that held all the components. The use of normally-open solenoids was also influenced by cost-efficient motives since only two of three normally-closed solenoids used in this project were reused from past

projects. For future works, utilizing at least six normally closed solenoids in total will allow for maximum usage of the air provided in the air tanks and minimize power usage. Minimizing power for future works should be a highlighted consideration due to the heat the solenoids would build up since they would either be powered to stay closed or opened for long duration, as opposed to their normal function when not powered. The types of tubes used for this project were also provided freely by a vendor, and affected the configuration design.

### 6.3 Costly Improvements

One of the considerably expensive components that can be used for improvements is a pressure controller regulator. Ideally, a pressure regulator is desired so that the solenoids will perform without any problems and output below the required output pressure. Additionally, a controller to constantly regulate the pressure will control the velocity of the nozzle thrust as well as the force outputted from the nozzle. This is significant because inconsistent force output from the nozzles ultimately affects the displacement that the system is commanded. If the 60 psi regulator used in design was instead a pressure controller regulator, which is a very expensive piece of equipment 60 psi would be outputted from all solenoids.

Table 6.1 – Pressure distribution with pressure valve controller

| Number of Open Valves | Desired Pressure Regulator Output | Scenario/Discussion  |
|-----------------------|-----------------------------------|--|
| 0                     | 0 psi                             | All solenoids are closed. No air is passing through any.   |
| 1                     | 60 psi                            | One solenoid is open, typically only the air-bearing solenoid.   |
| 2                     | 120 psi                           | Two open solenoids, air-bearing & a directional solenoid. Either a translational or a rotational solenoid is open.   |
| 3                     | 180 psi                           | Three open solenoids. The air-bearing, one translational, and one rotational solenoid are open. Or the air-bearing and two translational solenoids are open. |
| 4                     | 240 psi                           | Four open solenoids. The air-bearing solenoid is open, and each respective degree of a solenoid is open.   |

Ultimately, a lot of improvements in this design call for more time, and more components that could be bought to further make the system even more efficient.

## **Chapter 7 – Conclusion**

The development of this project has come a long way with the intent to inspire future colleagues. Designing a full system with many subsystems to consider required a thorough understanding of each component since many components influenced more than one subsystem. Prioritizing specific merits such as cost and time showed its influence upon the project. Although more testing should be performed, especially in a more sufficient testing environment, overall each subsystem performed its basic function on its own and showed that its performance was reliable in consistency. Based on the results discussed, improvements to each subsystem will allow the whole air-bearing system to function even smoother.

Even when the pneumatic subsystem is polished to provide more force and show distinct displacement, the GNC subsystem can be upgraded even further. Such improvements can be implementing C++ with MatLab Simulink. By merging the Matlab program with C++, there is room to develop a translational form of measurement (rather than using ultrasonic sensors). One of the tools MatLab offers is an algorithm that combines mapping and localization and pose estimation; this algorithm is called simultaneous localization and mapping (SLAM). SLAM is a possible replacement for the current ultrasonic sensors if the GNC system is further developed. This project provides a solid foundation for future students to enhance as a project or utilize in testing for their separate projects.

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## Appendix A - Sketches and Notes

### List of Figures and Tables in Appendix A

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Attached are all the initial sketches and drafts recorded for the design choices of the system.

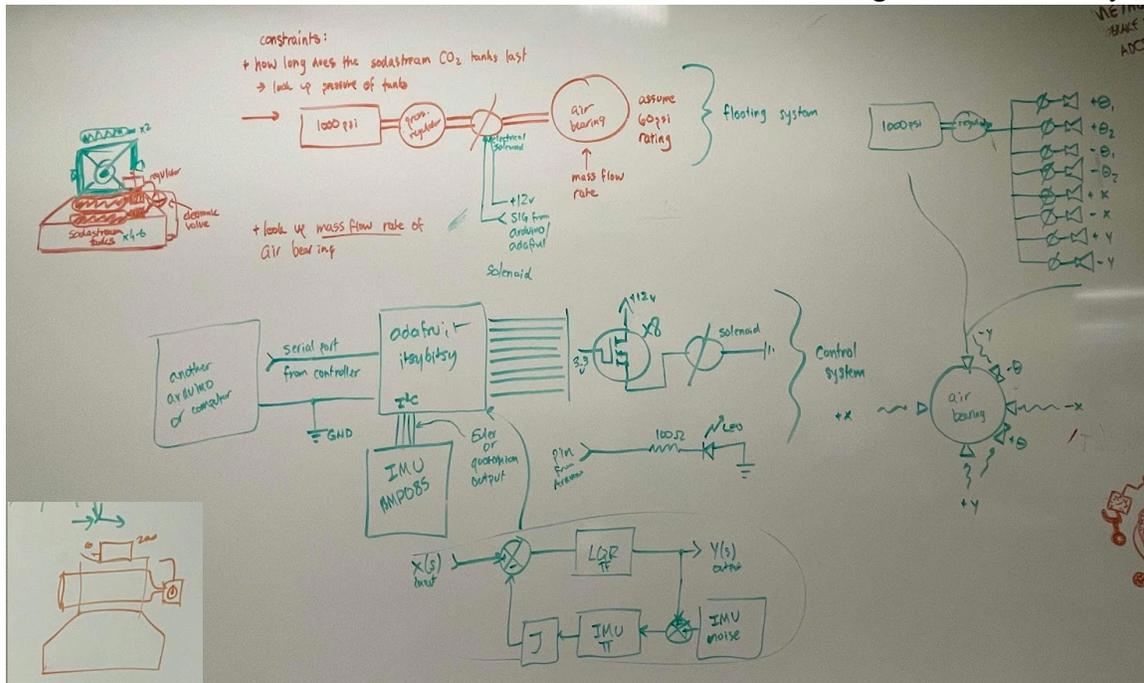


Figure A.1 – Initial draft of project

The following drawings were also used to simplify and create a general idea for the whole system.



Figure A.2 – Main subsystem-component sketch breakdown

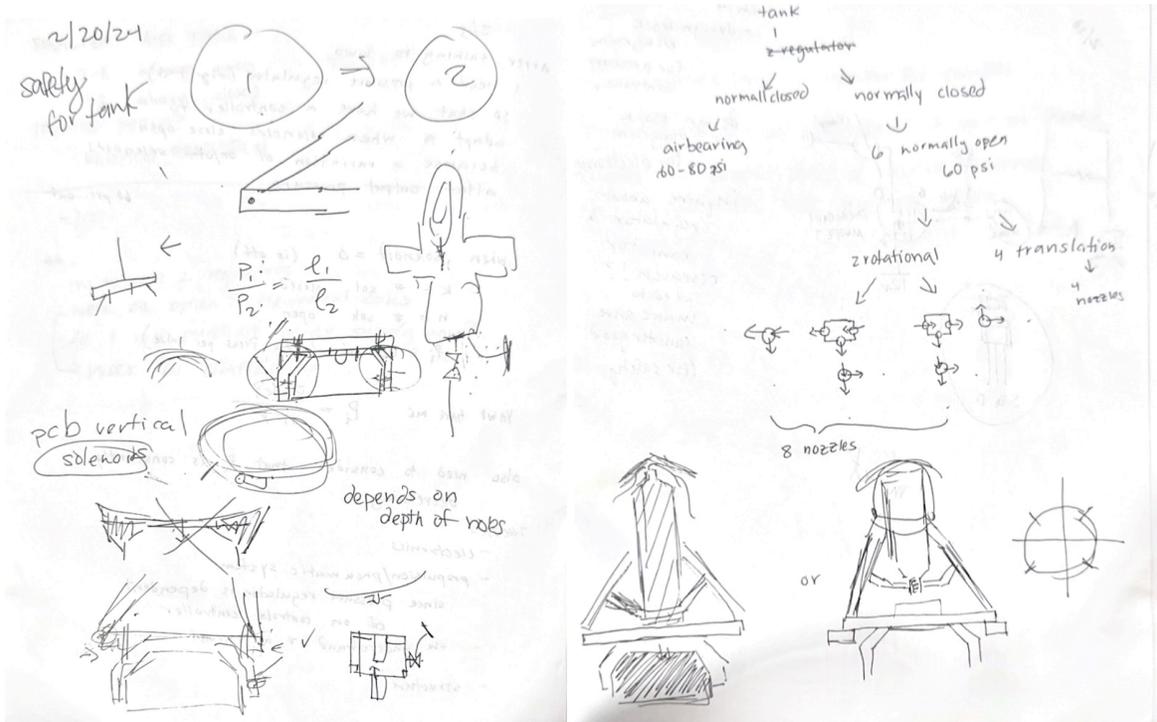


Figure A.3 – Air bearing mount and pneumatic configuration sketches

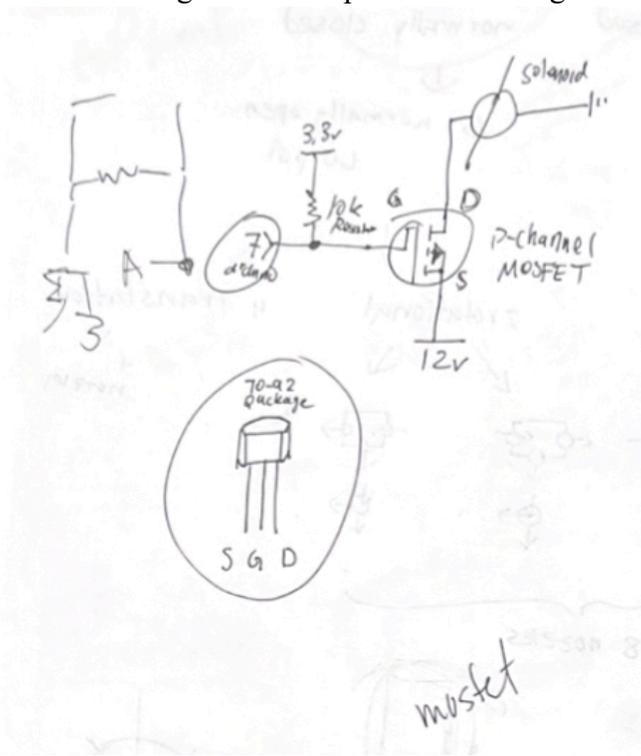


Figure A.4 – MOSFET electrical set up sketch

Figures A.3 and A.5 are both images of working to comprehend and plan the tubing arrangement, and planning how the air supply would split to all the necessary solenoids.



Figure A.5 – Splitting the airflow to the desired solenoids

Figures A.6 & A.7 are taken when constructing the pneumatic system onto the solenoid structure. Also seen is electronic functionality is continuously checked throughout this process.

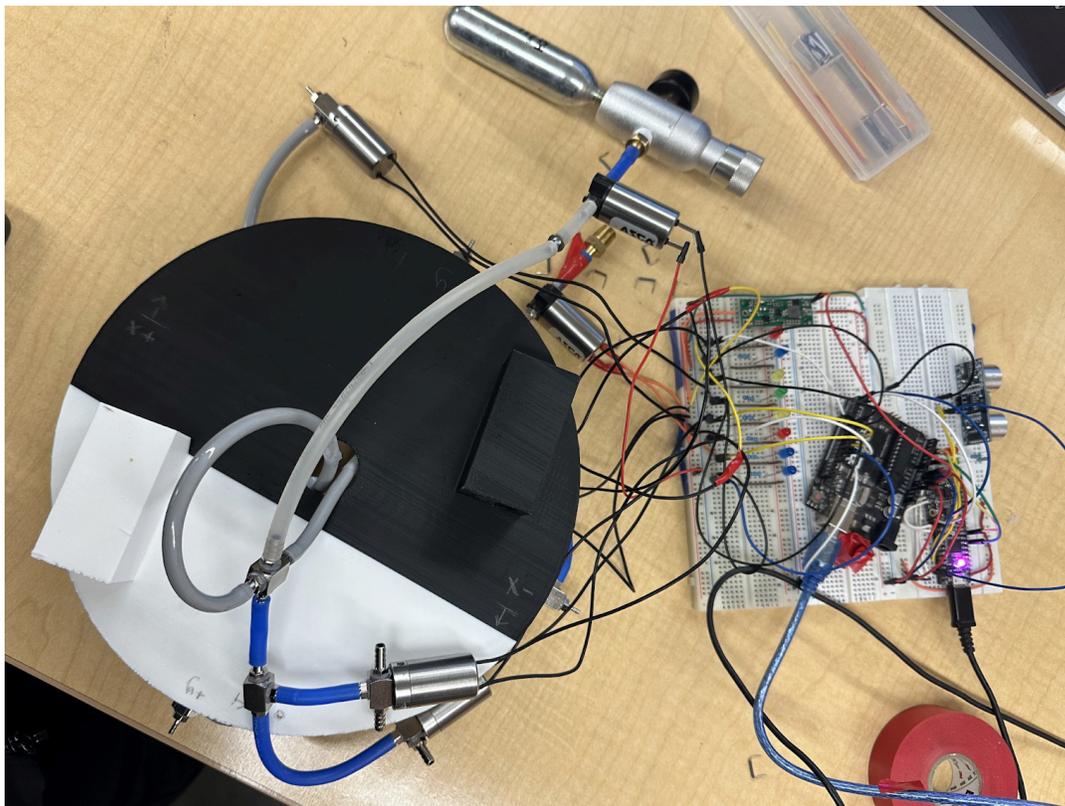


Figure A.5 – Testing solenoid functionality with partially constructed system

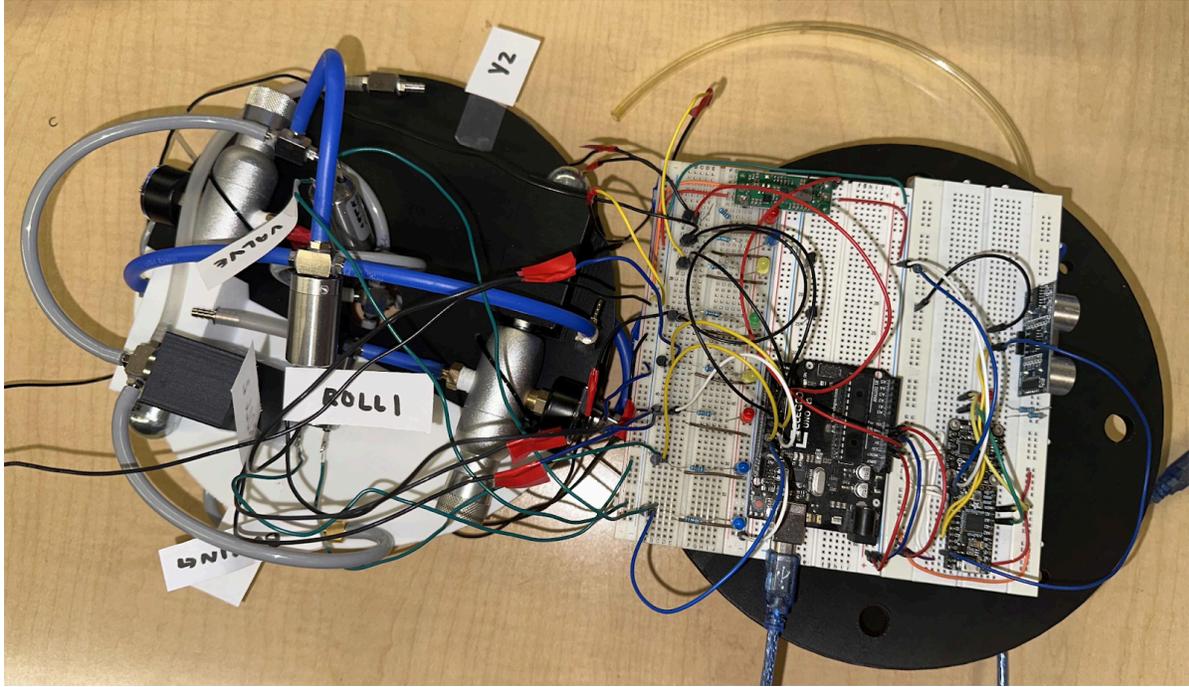


Figure A.6 – Testing solenoid functionality connected to CO<sub>2</sub> canister

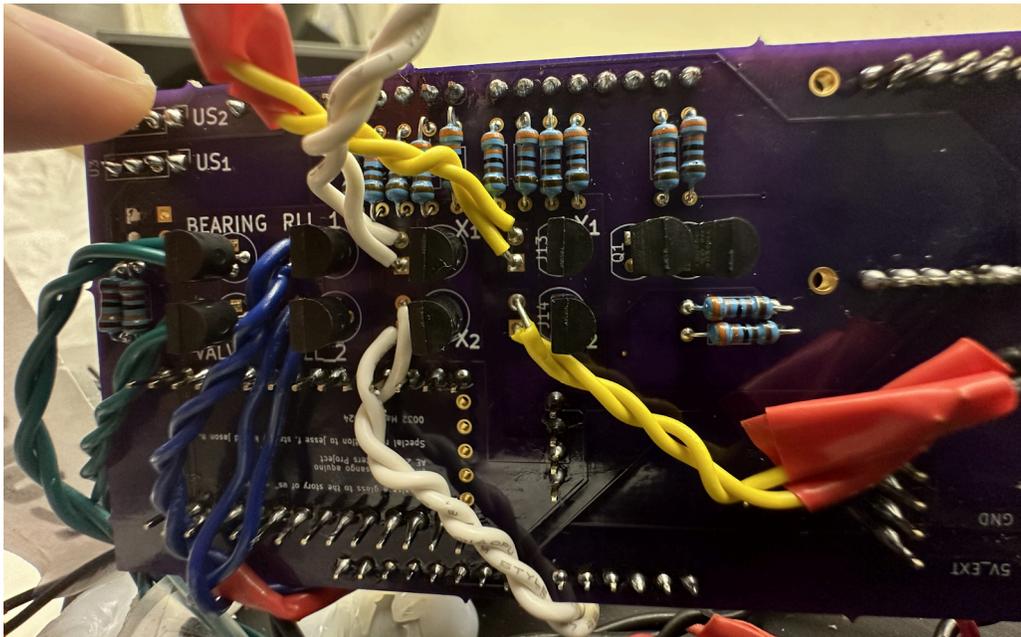


Figure A.7 – Additional picture of solenoid wires connected to the PCB board

Above is another picture taken of the solenoid wire connections onto the PCB board. With cost-efficient motives for this design, the table below lists the expense breakdown, the solenoids and air bearing's themselves were not bought since they were used for past SJSU student projects. Additionally, most of the pneumatic tube connections and tubes were not paid for and provided by a vendor for free.

Table A.1 – Expenses for full project

| Date       | Component                       | Price           | Supplier             | Purpose   |
|------------|---------------------------------|-----------------|----------------------|---|
| 05-04-2023 | Arduino                         | \$11.85         | Adafruit             | Arduino to compute sensor input   |
| 05-04-2023 | Sensor                          | \$24.95         | Adafruit             | 3DOF Sensor   |
| 05-04-2023 | Shipping & Tax                  | \$9.68          |                      |   |
| 01-08-2024 | MOSFET N-CH 60V<br>500MA        | \$16.68         | Digi-Key Electronics | For solenoids   |
| 02-20-2024 | Power Supply                    | \$25.25         | Pololu               | Supplies power to all electronics                                       |
| 02-29-2024 | 2 Beer Keg Charger<br>Regulator | \$45.98         | Amazon, LUCKEG       | Regulates 60psi, 1 regulator for air<br>bearing, 1 regulator for valves |
| 03-14-2024 |                                 |                 |                      |   |
| 02-29-2024 | Canisters 10 PCK                | \$16.99         | Amazon, ICO Trading  | Supplies air for entire system  |
| 02-29-2024 | (Amazon tax)                    | \$6.46          | Amazon               |   |
|            | Print Filament                  | \$25.00         |                      | for 3D printed structure  |
| 04-08-2024 | 2 screws connector              | \$11.00         | ACE Hardware         | for pneumatic connections   |
| 05-01-2024 | Ultrasonic Sensors              | \$13.76         | Adafruit             | for translational code  |
| 05-02-2024 | PCB Board                       | \$89.18         | OSH Park             | PCB Board for electronics   |
|            | <b>Total:</b>                   | <b>\$296.78</b> |                      |   |

## Appendix B - Pneumatic MatLab Code

MatLab code on pneumatics, Andreana Aquino.

```
%% AA Airbearing System Project
% AA pneumatic assumptions and calculations
%% CO2
gammaCO2 = 1.28 ; % specific heat ratio of CO2
R_CO2 = 188.92 ; % [J/kg*K] Gas constant for CO2
M_CO2 = 44.01E-3 ; % [kg/mol] molecular mass of CO2
rho_CO2 = 1.977 ; % [kg/m^3] CO2 density %1.98
Cp0 = gammaCO2*R_CO2/(.28) ; % [J/kg*K] heat capacity, constant pressure
Cv0 = Cp0/gammaCO2 % [J/kg*K] heat capacity, constant volume
if Cv0 == Cp0 - R_CO2
    fprintf('specific heat calcs are correct \n')
end
% https://www.atlascopco.com/en-us/compressors/wiki/compressed-air-articles/co2-vs-compressed-air#:~:text=The%20density%20of%20carbon%20dioxide,temperature%20is%201%2C977%20kg%20%2F%20m3.
%% Cannister
% if we assume V0 is the volume of can
% V0 = (pi*((9/2)^2)*11); % [mm^3] assume volume of canister gas
V0 = (pi*((7/2)^2)*11)/(1E9) ; % [m^3]
V0 = 2.1E-5 ; % 21 mL volume
% knowing canister weighs 16g
m0 = 16E-3 ; % [kg]
% 21 mL of volume
rho_cannister = (m0/1000)/V0 ; % calculates to 472.9277 [kg/m^3]
rho0 = m0/V0 ; % 3.7796e+03 [kg/m^3]
% if we assume the temperature of CO2 is standard temp
% Ideal Gas Law: PV = N*R*T
P0 = 1000*6894.76 ; %ASSUME MAX PSI @ 1000psia and 40 psi
P0 = 5946.55*6894.76
% note 2400 psi = 1.6547e+7 Pa
T0 = P0/(rho0*R_CO2) ; % 9.6 K
P0min = 40*6894.76 ; T0min = P0min/(rho0*R_CO2) ;
%% Regulator outputs 60 psi, CO2 straight into tube
P1 = 413685 ; % [Pa] = 60 [psi] Initial output from canister and air bearing
V1 = pi*.150*.002*.002 ; % volume of tube
% .1 = 10 cm length of tube, 4mm diameter
% Pressure Ratio
% ASSUME COMPRESSIBLE, rho is not the same
% 
$$P_2/P_1 = (1 + (M^2(\gamma - 1))/2)^{\gamma/(\gamma - 1)}$$

% 
$$(P_2/P_1)^{1/\gamma_{CO2}} = ((\rho_2/\rho_1)^\gamma)^{1/\gamma_{CO2}} = \rho_1/\rho_2$$

% 
$$(P_2/P_1)^{1/\gamma_{CO2}} = \rho_2/\rho_1$$

% 
$$\rho_1 = \rho_0*(P_1/P_0)^{1/\gamma_{CO2}}$$

% Maximum P0 affects maximum Mach 2.4
gammCO2i1 = gammaCO2 - 1 ;
value1 = (P0/P1)^(gammCO2i1/gammaCO2) ;
value2 = (value1 - 1)*(2/gammCO2i1) ;
Mach01 = sqrt(value2) % at max P0 = 1000 psi
% Minimum P0 affects minimum mach 0.4
value1min = ((65*6894.76)/P1)^(gammCO2i1/gammaCO2) ;
```

```

value2min = (value1min - 1)*(2/gammCO2i1) ;
Mach01min = sqrt(value2min) % at max P0 = 65 psi
% Density Ratio
% rho0/rho1 = (1 + ( (gammCO2i1/2)*Mach01^2 ) )^(1/gammCO2i1)
rho1 = rho0/(1 + ( (gammCO2i1/2)*Mach01^2 ) )^(1/gammCO2i1) ; % 419.6348 [g/m^3]
rho1 = rho0*(P1/P0)^(1/gammaCO2) % ^ value is the same
% but at P0 decreases how does rho1 change
T1 = P1/(rho1*R_CO2) % 5.2 K
T1 = 288 ;
v = Mach01*sqrt(gammaCO2*R_CO2*T1) % 87.5 m/s @ max P0
rho1min = rho0*(P1/P0min)^(1/gammaCO2) % 5188.1 [g/m^3]
T1min = P1/(rho1min*R_CO2) % .4 K
v = Mach01min*sqrt(gammaCO2*R_CO2*T1min) % 3.5885 m/s
%% Consider mixtures of air within the tube
% T_standard = 288.15 ; % [K] temp based off altitude
%
% rho_CO2 = 1.977 ; % [kg/m^3] CO2 density %1.98
% gammaCO2 = 1.28 ; % specific heat ratio of CO2
% R_CO2 = 188.92 ; % [J/kg*K] Gas constant for CO2
% M_CO2 = 44.01E-3 ; % [g/mol] molecular mass of CO2
%
% rho_air = 1.204 ; % [1.204 kg/m^3] air density
% R_air = 287 ;
% M_air = 28.96E-3 ; % [g/mol] molecular weight of air
%
% Rbar = 8.31 ; % [J/mol/K]
% % Dependent on a define temp
% Pg = rho_CO2*R_CO2*T_standard % 107790 Pa
% Pa = rho_air*R_air*T_standard % 99570 Pa
% P2tot = Pg + Pa % 207360 Pa
%
% Ng = Pg*V1/(Rbar*T_standard) % 1.6970e-04 # of moles
% Na = Pa*V1/(Rbar*T_standard) % 1.5676e-04 # of moles
% N = Ng*(P2tot/Pg) % 3.2646e-04
% N = Na*(P2tot/Pa) % total # of moles matches ^
%
% m_a = Na*M_air % 4.5398e-03 g
% m_g = Ng*M_CO2 % 7.4683e-03 g
% m = m_a + m_g % 1.2008e-02 g , mass of mixture gas
% Rmix = (P2tot*V1)/(m*T_standard) % .2259 , R const of mixture
% P2 = (m/V1)*Rmix*T_standard % verify Ptot with value found earlier, is good
%
% rho2_mix = m/V1
% %% conservation of momentum to find speed
% vel1 = a*Mach12 ; % assume speed is greater than 100 m/s due to compressibility
% rho1 = 1.98 ; % [1.96 g/L] CO2 density
% rho2_mix = m/V1 % density of gas mixture in tube
% A1 = pi*.002*.002 ; % cross area of regulator opening
% A2 = A1/2; % cross area of end of first tube
% vel2 = rho1*vel1*A1/(rho2_mix*A2)
%
% %Mach12 = gamma_air/sqrt(rho2_mix*vel2*T_standard)
% % A1 = pi*.005*.005 ; % cross-area of regulator tube
% % A2 = pi*.001*.001 ; % cross area of tube
%

```

```

%% ASSUME COMPRESSIBLE, rho is not the same, T2 = 273
%% P2/P1 = (1 + (M^2(gamma-1))/2)^(gamma/(gamma-1))
%% (P2/P1)^(1/gammaC02) = ((rho2/rho1)^gamma)^(1/gammaC02) = rho1/rho0
%% (P2/P1)^(1/gammaC02) = rho2/rho1
%% rho1 = rho0*(P1/P0)^(1/gammaC02)
%% gamm = 1.3 ;
%% gammi1 = gamm - 1 ;
%% value1 = (P1/P2)^(gammi1/gamm) ;
%% value2 = (value1 - 1)*(2/gammi1) ;
%% Mach12 = sqrt(value2)
%
% disp(['at this time calculations give us Mach . but disregard calcs' ...
%      'because the gas is a mixture gas, not purely CO2'])
%% Split first tube into the 6 solenoids
% 2 tubes, 1 to translational, 1 to rotational
mach_speed = 102.9001142533 ; %[m/s] 0.3 mach, > is compressible

```

## Appendix C - Pre-Test C++ Code

C++ code for initial testing for ItsyBitsy and IMU sensor BNO085, Andreana Aquino.

```
#include <Arduino.h>
#include <Wire.h>
#include <Adafruit_Sensor.h>

/*ASSIGNMENT TO HAVE THE IMU OUTPUT DATA TO SERIAL PORT*/
/*AA PROJECT*/

// Basic demo for readings from Adafruit BNO08x
#include <Adafruit_BNO08x.h>

// For SPI mode, we need a CS pin
#define BNO08X_CS 10
#define BNO08X_INT 9

// For SPI mode, we also need a RESET
// #define BNO08X_RESET 5
// but not for I2C or UART
#define BNO08X_RESET -1

// #define x1_left A1 //
// #define x2_right A2 //
// #define y_j A2 //

Adafruit_BNO08x bno08x(BNO08X_RESET);
sh2_SensorValue_t sensorValue;

void setup(void) {
  Serial.begin(115200);
  while (!Serial) delay(10); // will pause Zero, Leonardo, etc until serial
  console opens

  Serial.println("Adafruit BNO08x test!");

  // Try to initialize!
  if (!bno08x.begin_I2C()) {
```

```

    //if (!bno08x.begin_UART(&Serial1)) { // Requires a device with > 300 byte
UART buffer!
    //if (!bno08x.begin_SPI(BNO08X_CS, BNO08X_INT)) {
        Serial.println("Failed to find BNO08x chip");
        while (1) { delay(100); }
    }
    Serial.println("BNO08x Found!");

    for (int n = 0; n < bno08x.prodIds.numEntries; n++) {
        Serial.print("Part ");
        Serial.print(bno08x.prodIds.entry[n].swPartNumber);
        Serial.print(": Version :");
        Serial.print(bno08x.prodIds.entry[n].swVersionMajor);
        Serial.print(".");
        Serial.print(bno08x.prodIds.entry[n].swVersionMinor);
        Serial.print(".");
        Serial.print(bno08x.prodIds.entry[n].swVersionPatch);
        Serial.print(" Build ");
        Serial.println(bno08x.prodIds.entry[n].swBuildNumber);
    }

    //setReports();

    // Initialize digital pin 13 as an output
    //pinMode(13, OUTPUT); //

    Serial.println("Reading events");
    delay(100);
}

```

## Appendix D - Solenoid Verification C++ Code

C++ code for verifying the solenoids function as expected, Jason Nguyen.

```
#include <Arduino.h>

// constants won't change. They're used here to set pin numbers:
const int solbearingPin = 12;    // the number of the LED pin
const int solvalvePin = 11;     // the number of the LED pin
const int solroll1Pin = 10;     // the number of the LED pin
const int solroll2Pin = 9;      // the number of the LED pin
const int solx1Pin = 8;         // the number of the LED pin
const int solx2Pin = 7;         // the number of the LED pin
const int soly1Pin = 6;         // the number of the LED pin
const int soly2Pin = 5;         // the number of the LED pinn

void setup() {
    // initialize the LED pin as an output:
    //pinMode(ledPin, OUTPUT);
    // initialize the pushbutton pin as an input:
    //pinMode(buttonPin, INPUT);

    delay(2000);

    digitalWrite(solbearingPin, LOW);
    pinMode(solbearingPin, OUTPUT);

    digitalWrite(solvalvePin, LOW);
    pinMode(solvalvePin, OUTPUT);

    digitalWrite(solroll1Pin, LOW);
    pinMode(solroll1Pin, OUTPUT);

    digitalWrite(solroll2Pin, LOW);
    pinMode(solroll2Pin, OUTPUT);

    digitalWrite(solx1Pin, LOW);
    pinMode(solx1Pin, HIGH);
```

```

digitalWrite(solx2Pin, LOW);
pinMode(solx2Pin, OUTPUT);

digitalWrite(soly1Pin, LOW);
pinMode(soly1Pin, OUTPUT);

digitalWrite(soly2Pin, LOW);
pinMode(soly2Pin, OUTPUT);

}

void loop() {
  Serial.println('Off');
  digitalWrite(solbearingPin, HIGH);
  delay(1000/2);
  digitalWrite(solbearingPin, LOW);

  digitalWrite(solvalvePin, HIGH);
  delay(1000/2);
  digitalWrite(solvalvePin, LOW);

  digitalWrite(solroll1Pin, LOW);
  delay(1000/2);
  digitalWrite(solroll1Pin, HIGH);

  digitalWrite(solroll2Pin, LOW);
  delay(1000/2);
  digitalWrite(solroll2Pin, HIGH);

  digitalWrite(solx1Pin, LOW);
  delay(1000/2);
  digitalWrite(solx1Pin, HIGH);

  digitalWrite(solx2Pin, LOW);
  delay(1000/2);
  digitalWrite(solx2Pin, HIGH);

  digitalWrite(soly1Pin, LOW);
  delay(1000/2);
  digitalWrite(soly1Pin, HIGH);
}

```

```
digitalWrite(soly2Pin, LOW);  
delay(1000/2);  
digitalWrite(soly2Pin, HIGH);  
}
```

## Appendix E - ItsyBitsy C++ Code

C++ code for Adafruit ItsyBitsy M0 Express arduinos, Jason Nguyen.

```
/*ASSIGNMENT TO HAVE THE IMU OUTPUT DATA TO SERIAL PORT*/
/*AA PROJECT*/

#include <Arduino.h>
#include <ArduinoJson.h>
#include <Wire.h>
#include <Adafruit_Sensor.h>
#include "DS18B20.h"

// Basic demo for readings from Adafruit BNO08x
#include <Adafruit_BNO08x.h>
#include <stdio.h>

//Plotter Library
#include "Plotter.h"
#include <Filters.h>
#include <AH/Timing/MillisMicroTimer.hpp>

//Filter Library (Possible Uninstall later)
#include <Filters/Butterworth.hpp>

// For SPI mode, we need a CS pin
#define BNO08X_CS 10
#define BNO08X_INT 9

// define solenoid/nozzle pins
#define Translational1 A0 // pin that fires to west (negative x)
#define Translational2 A1 // pin that fires to north (negative y)
#define Translational3 A2 // pin that fires to east (positive x)
#define Translational4 A3 // pin that fires to south (positive y)

#define MIN_ANG_ROT 10.0F
#define MINUSZ1 A4 // pin that fires clockwise (-z)
#define MINUSZ2 A5 // clockwise z1
#define PLUSZ1 SCK // pin that fires counterclockwise (+z1)
#define PLUSZ2 MOSI // counterclockwise z2
```

```

#define airbearingON 2 // TURN ON AIRBEARING ON

#define DRXP          digitalWrite(XPLUS, HIGH)

// For SPI mode, we also need a RESET
//#define BNO08X_RESET 5
// but not for I2C or UART
#define BNO08X_RESET -1
#define ONE_WIRE_BUS 7

const int trigPin = 11;
const int echoPin = 12;

OneWire oneWire(ONE_WIRE_BUS);
DS18B20 sensor(&oneWire);

DeviceAddress da;

Adafruit_BNO08x bno08x(BNO08X_RESET);
sh2_SensorValue_t sensorValue;

Plotter p;

// defines variables (Important for Start-Up)
float zroll;
long duration;
int distance;

// Defining Conditions
float x;
float y;
float z;

// ----- Desired Control Values -----
// ----- //

float desired_rollangle = 0; //
float desired_x = 11; //

```

```

float desired_Y = 12;          //

//      -----                               Start           Up
-----                               //

void setup(void) {
  Serial.begin(115200);
  Serial1.begin(9600);        //NEW

  //while (!Serial) delay(10);    // will pause Zero, Leonardo, etc until
serial console opens
  delay(1000);
  // p.Begin();

  //Initalizing BNO08x
  Serial.println("Adafruit BNO08x test!");
  if (!bno08x.begin_I2C()) {
    //if (!bno08x.begin_UART(&Serial1)) { // Requires a device with > 300
byte UART buffer!
    //if (!bno08x.begin_SPI(BNO08X_CS, BNO08X_INT)) {
      Serial.println("Failed to find BNO08x chip");

  if (!bno08x.enableReport(SH2_GYROSCOPE_CALIBRATED)) {
    Serial.println("Could not enable gyroscope");
  }

  while (1) { delay(100); }
};
Serial.println("BNO08x Found!");

for (int n = 0; n < bno08x.prodIds.numEntries; n++) {
  Serial.print("Part ");
  Serial.print(bno08x.prodIds.entry[n].swPartNumber);
  Serial.print(": Version :");
  Serial.print(bno08x.prodIds.entry[n].swVersionMajor);
  Serial.print(".");
  Serial.print(bno08x.prodIds.entry[n].swVersionMinor);
  Serial.print(".");
  Serial.print(bno08x.prodIds.entry[n].swVersionPatch);
  Serial.print(" Build ");
  Serial.println(bno08x.prodIds.entry[n].swBuildNumber);
}

```

```

};

digitalWrite(airbearingON, HIGH);
Serial.println("Reading events");
delay(100);

// p.AddTimeGraph( "Time graph w/ 500 points", 500, "x label", x );
// p.AddTimeGraph( "Time graph w/ 200 points", 500, "x label", y );
// p.AddTimeGraph( "Time graph w/ 200 points", 500, "x label", z );
// p.AddTimeGraph( "Time graph w/ 200 points", 500, "x label", zroll );

//Initalizing DS18B20
//sensor.begin();

//Defining Pinmode for HC-BRO4
pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
pinMode(echoPin, INPUT); // Sets the echoPin as an Input
}

// ----- Define Conditions and Variables ----- //

// Timestamp
float timestamp_initalize = millis();
float previous_time = timestamp_initalize;
float current_time = millis();
float sample_time;

// Inital Condtions
float acceleration_initalx = 0;
float acceleration_initaly = 0;

float velocity_initalx = 0;
float velocity_initaly = 0;

float position_initalx = 0;
float position_initaly = 0;

```

```

float angle = 0;

// ----- Define STRUCT (JasonStruct)
----- //
struct JasonStruct {

    byte x_thruster; //0=nothing, off; -1: -x 1: +x
    byte y_thruster;
    int z_rot;        //0, -1, 1
    int x_trans;      //0, -1, 1
    int y_trans;      //0, -1, 1
    int on;
    byte dummy; //spacer

    float accelx = sensorValue.un.linearAcceleration.x;
    float accely = sensorValue.un.linearAcceleration.y;
    float gyroz = sensorValue.un.gyroscope.z;
    float array[3] = {accelx, accely, 0};

}; static JasonStruct js; // importing what Jason output

// Function to update Struct Variables
void updateStruct(){
    previous_time = current_time;
    current_time = millis();
    sample_time = (current_time - previous_time)/1000;

    js.accelx = sensorValue.un.linearAcceleration.x;
    js.accely = sensorValue.un.linearAcceleration.y;
    js.gyroz = sensorValue.un.gyroscope.z;
};

// ----- BNO08X Reports
----- //
void setReports(void) {
    Serial.println("Setting desired reports");
    if (! bno08x.enableReport(SH2_LINEAR_ACCELERATION)) {
        Serial.println("Could not enable game vector");
    }
}

```

```

}
if (!bno08x.enableReport(SH2_GYROSCOPE_CALIBRATED)) {
Serial.println("Could not enable gyroscope");
}
if (!bno08x.enableReport(SH2_ROTATION_VECTOR)) {
Serial.println("Could not enable rotation vector");
}
if (!bno08x.enableReport(SH2_GAME_ROTATION_VECTOR)) {
Serial.println("Could not enable game rotation vector");
}
}
}

// (POSSIBLE REMOVAL?)
float accel = 0;
float velocity = 0;
float position = 0;
float roll;

void moveEastWest(void); // "function prototype", introducing the x
movement function
void moveNorthSouth(void); // introducing the y movement function
void rotateCCWorCW(void); // introduce z rotation function

// ----- Plotter
----- //

uint32_t monitorRotation(void); // Recording time?

// ----- Filter Frequency
----- //

// Sampling frequency
const double f_s = 100; // Hz
// Cut-off frequency (-3 dB)
const double f_c = 30; // Hz
// Normalized cut-off frequency
const double f_n = 2 * f_c / f_s;

```

```

// Sample timer
Timer<micros> timer = std::round(1e6 / f_s);

// Sixth-order Butterworth filter
auto filter = butter<6>(f_n);

// ----- Control Function
// ----- //

double Kp_roll = 0.1;
double Ki_roll = 0.0;
double Kd_roll = 0;
double previous_error[3] = {0,0,0};

double error;
double u;

double updatePIDControl(double setpoint, double currentpoint, double
Kp, double Ki, double Kd, int PID_Control) {
error = setpoint - currentpoint;
u = Kp*error + Ki*error*sample_time +
Kd*((error-previous_error[PID_Control])/sample_time);
previous_error[PID_Control] = error;
return u;
};

// ----- LOOP
// ----- //

void loop(void) {

js.on = 1;

// NECESSARY FOR BN08X READING
if (bno08x.wasReset()) {
Serial.print("sensor was reset ");
setReports();
}
}

```

```

if (!bno08x.getSensorEvent(&sensorValue)) {
    return;
}

// Calling updated Struct and time
//float angle = angle + js.gyroz*((current_time - previous_time)/1000);
// float a = sensorValue.un.gameRotationVector.i;
//float b = sensorValue.un.gameRotationVector.j;
//float c = sensorValue.un.gameRotationVector.k;
// Serial.println(sensorValue.un.gameRotationVector.i);

// Switch (Updates only when IMU sensor senses linear/rotational movement)
switch (sensorValue.sensorId) {

    //case SH2_ACCELEROMETER:
    //Serial.print(js.accelx);
    //break;

    case SH2_GAME_ROTATION_VECTOR:

        float q[4] =
{sensorValue.un.gameRotationVector.real, sensorValue.un.gameRotationVector.
i, sensorValue.un.gameRotationVector.j, sensorValue.un.gameRotationVector.k}
;

        //Roll Angle (Z-axis) Quaternion To Euler Angles
//
<https://en.wikipedia.org/wiki/Conversion\_between\_quaternions\_and\_Euler\_angulars>
        float rollsin = 2 * (q[0] * q[3] + q[1] * q[2]);
        float rollcos = 1 - 2 * (q[2] * q[2] + q[3] * q[3]);
        float roll = atan2f(rollsin,rollcos);

        //Rad to Degrees
        zroll = roll*57.296;
        break;
}

```

```

updateStruct();
double                u_roll                =
updatePIDControl(desired_rollangle,zroll,Kp_roll,Ki_roll,Kd_roll,1);
//double                u_x                =
updatePIDControl(desired_rollangle,zroll,Kp_roll,Ki_roll,Kd_roll,2);
//double                u_y                =
updatePIDControl(desired_rollangle,zroll,Kp_roll,Ki_roll,Kd_roll,3);

// Attempts in Double Intergation for IMU Data
velocity = velocity + x*(sample_time);
position = position + velocity*(sample_time)+ 0.5*x*(pow(sample_time,2));
x = filter(js.accelx);
y = velocity;
z = position;

//Reading Ultrasonic Sensor 1
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
distance = duration * 0.034 / 2;

//Averaging ultrasonic sensor data
double readings[5];
int i;

for(i=0; i<5; i++){
readings[i] = distance;
}
int avgReading = (readings[0] + readings[1] + readings[2] + readings[3]
+ readings[4])/5;

int u_x = desired_X - avgReading;
int u_y = desired_Y - avgReading;
//Printing Radings

if (abs(desired_rollangle - zroll) > 3){
if (u_roll > 0){

```

```

    js.z_rot = 1;
}
else{
    js.z_rot = -1;
}
}
else{
    js.z_rot = 0;
}

if (abs(u_x) > 3){
if (u_x > 0){
    js.x_trans = 1;
}
else{
    js.x_trans = -1;
}
}
else{
    js.x_trans = 0;
}

if (abs(u_y) > 3){
if (u_y > 0){
    js.y_trans = 1;
}
else{
    js.y_trans = -1;
}
}
}
else{
    js.y_trans = 0;
}

//led
if(abs(zroll) > 3){
if(zroll > 0){
    digitalWrite(MINUSZ1, HIGH);
    digitalWrite(PLUSZ1, LOW);
    //Serial.print("clockwise");
}
}
}

```

```

}
else{
    digitalWrite(MINUSZ1, LOW);
    digitalWrite(PLUSZ1, HIGH);
    //Serial.print("counterclockwise");
}
}
else{
    digitalWrite(MINUSZ1, LOW);
    digitalWrite(PLUSZ1, LOW);
    //Serial.print("none");
}

//Serial.print("\t");

StaticJsonDocument<20> doc;
doc["roll"] = js.z_rot;
doc["xtrans"] = js.x_trans;
doc["ytrans"] = js.y_trans;
doc["on"] = js.on;
serializeJson(doc, Serial1);

//Serial.println(js.x_trans);
//Serial.println(js.y_trans);

Serial.print("\t");
Serial.print(u_x);
//Serial.print("\t");
//Serial.print(u_roll);
//Serial.print("\t");
//Serial.print(js.z_rot);
//Serial.print("\t");

//char mystr[6] = "hello";
//Serial1.write(mystr,6);

```

```
//Serial.print("\t");  
}
```

## Appendix F - Elegoo C++ Code

C++ code for Elegoo R3 Uno arduinos, Jason Nguyen.

```
#include <Arduino.h>
#include <ArduinoJson.h>

//Pin numbers
const int solbearingPin = 12;    // the number of the LED pin
const int solvalvePin = 11;     // the number of the LED pin
const int solroll1Pin = 10;     // the number of the LED pin
const int solroll2Pin = 9;      // the number of the LED pin
const int solx1Pin = 8;         // the number of the LED pin
const int solx2Pin = 7;         // the number of the LED pin
const int soly1Pin = 6;         // the number of the LED pin
const int soly2Pin = 5;         // the number of the LED pin

char datapacket[300];
StaticJsonDocument<40> doc;

const int LEVSH_ENABLE = 4;

void setup() {

    digitalWrite(LEVSH_ENABLE, HIGH);
    pinMode(LEVSH_ENABLE, OUTPUT);

    Serial.begin(9600);
    while (!Serial)
        continue;

    pinMode(solbearingPin, OUTPUT);
    digitalWrite(solbearingPin, LOW);
    //flip code
    digitalWrite(solvalvePin, LOW);
    pinMode(solvalvePin, OUTPUT);

    digitalWrite(solroll1Pin, LOW);
    pinMode(solroll1Pin, OUTPUT);
```

```

digitalWrite(solroll2Pin, LOW);
pinMode(solroll2Pin, OUTPUT);

digitalWrite(solx1Pin, LOW);
pinMode(solx1Pin, HIGH);

digitalWrite(solx2Pin, LOW);
pinMode(solx2Pin, OUTPUT);

digitalWrite(soly1Pin, LOW);
pinMode(soly1Pin, OUTPUT);

digitalWrite(soly2Pin, LOW);
pinMode(soly2Pin, OUTPUT);

}

void loop() {

int roll = 0;
int xtrans = 0;
int ytrans = 0;
int bearing = 1;
int valve = 1;

DeserializationError err = deserializeJson(doc, Serial);
if (err == DeserializationError::Ok)
{
    roll = doc["roll"].as<int>();
    xtrans = doc["xtrans"].as<int>();
    ytrans = doc["ytrans"].as<int>();
    bearing = doc["on"].as<int>();
    Serial.println(ytrans);
}
else
{
    Serial.print("deserializeJson() returned");

```

```

Serial.println(err.c_str());

while (Serial.available() > 0)
  Serial.read();
  //return;
}
// bearing actuation

if(bearing == 1){
  digitalWrite(solbearingPin, HIGH);
}

if(valve == 1){
  digitalWrite(solvalvePin, HIGH);
}

// roll actuation
if (roll == 0){
  digitalWrite(solroll1Pin, HIGH);
  digitalWrite(solroll2Pin, HIGH);
}
else
{
  if(roll == 1){
    digitalWrite(solroll1Pin, LOW);
    digitalWrite(solroll2Pin, HIGH);
    //have another for the extra sol
  }
  if(roll == -1){
    //digitalWrite(ledPin, HIGH);
    digitalWrite(solroll1Pin,HIGH);
    digitalWrite(solroll2Pin, LOW);
  }
}

// x-translation actuation
if (xtrans == 0){
  digitalWrite(solx1Pin, HIGH);
}

```

```

digitalWrite(solx2Pin, HIGH);

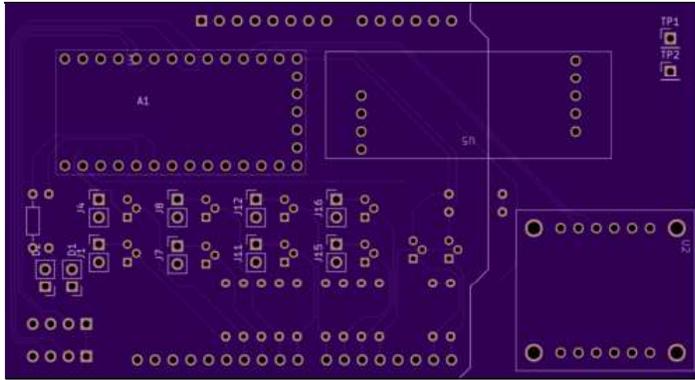
}
else
{
    if(xtrans == 1){
        digitalWrite(solx1Pin, LOW);
        digitalWrite(solx2Pin, HIGH);
    }
    if(xtrans == -1){
        digitalWrite(solx1Pin, HIGH);
        digitalWrite(solx2Pin, LOW);
    }
}

// y-translation actuation
if (ytrans == 0){
    digitalWrite(soly1Pin, HIGH);
    digitalWrite(soly2Pin, HIGH);
}
else
{
    if(ytrans == 1){
        digitalWrite(soly1Pin, LOW);
        digitalWrite(soly2Pin, HIGH);
    }
    if(ytrans == -1){
        digitalWrite(soly1Pin, HIGH);
        digitalWrite(soly2Pin, LOW);
    }
}
}
}

```

# Appendix G - PCB Order Design from OSHPARK.COM

PCB design assist from Stanley Krzesniak.



## Board Top

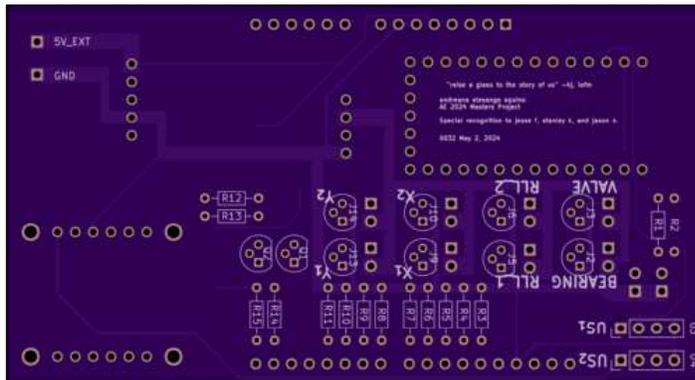
This shows the final manufactured board as if you held it in your hand.

Your design should show gold copper, purple mask, white silk, black drills, and the board outline.

Internal cutouts are indicated by a black outline but are not filled in.

If the image here is entirely white, you'll want to find and fix any gaps in the board outline.

There should be no dimension or measurement ruler



## Board Bottom

This shows the final manufactured board as if you held it in your hand.

Your design should show gold copper, purple mask, white silk, black drills, and the board outline.

Internal cutouts are indicated by a black outline but are not filled in.

If the image here is entirely white, you'll want to find and fix any gaps in the board outline.

There should be no dimension or measurement ruler



## Drills

Drills should show up as white circles or dots on a purple background.

Drill files should be NC Drill or Excellon format files. Multiple files will be accepted, and merged into one for fabrication.

Drill hits that pass through copper will be plated. All other drill hits will be non-plated.

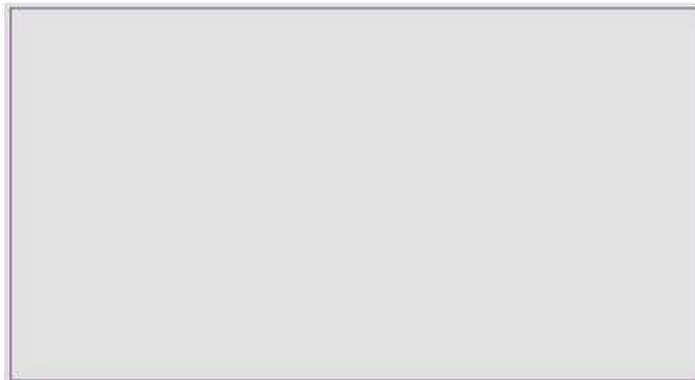
Most drill formats are detected and displayed as you'd see on the board. If your drills look incorrect, try exporting with INCH units and either No Zero Suppression or Leading Zero Suppression.

Drill slots and "oval" drills included as part of the drill file are supported. Most design tools do this when using the tool's native slot commands. Supported slots will appear on this preview. Note, it's possible to use this supported callout in an unsupported way. See our [Cutouts and Slots \(https://docs.oshpark.com/submitting-orders/cutouts-and-slots/\)](https://docs.oshpark.com/submitting-orders/cutouts-and-slots/) page for details regarding unsupported applications of slot drill commands.

Drills sizes below our minimums will be increased to the minimum size. See the [design rules \(https://docs.oshpark.com/services/\)](https://docs.oshpark.com/services/) or our [drills help page \(https://docs.oshpark.com/submitting-orders/drill-specs/\)](https://docs.oshpark.com/submitting-orders/drill-specs/) for additional details on drill specs.

Additionally, the following are not supported.

- **Overlapping drill hits**
- **Blind or buried vias**



Rendered from "AirBearingElectronic1.kicad\_pcb"

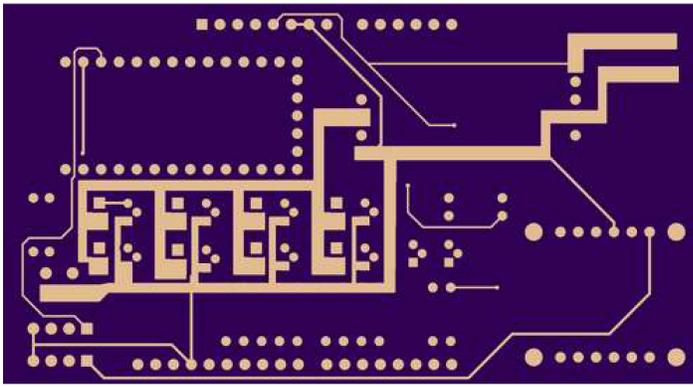
## Board Outline

The board outline should be a watertight purple outline showing at least the edge of the board with no gaps.

We will cut non-rectangular board shapes, but you will be billed for the smallest rectangle that will encompass the design.

As an example, a 2in diameter circle is billed the same as a 2in by 2in square.

Non-plated [Board Cutouts \(https://docs.oshpark.com/submitting-orders/board-outline/\)](https://docs.oshpark.com/submitting-orders/board-outline/) can be represented on the board outline layer, with some limitations. Slots are unsupported when indicated on the board outline layer, but usually work. To make slots with full support, use [Drill Slots \(https://docs.oshpark.com/submitting-orders/slots/\)](https://docs.oshpark.com/submitting-orders/slots/) on the drill layer.



Rendered from "AirBearingElectronic1.kicad\_pcb"

## Bottom Layer

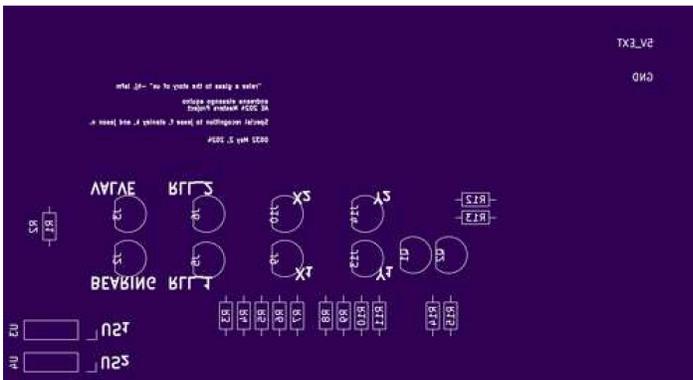
This layer should appear 'mirrored' as if you were looking down on it through the board from the top.

We will place copper everywhere we see gold color on this layer.

If you are using Altium Designer or Altium CircuitMaker, carefully examine the board to make sure there are no shorts from the mechanical layers being included on this layer. See [here \(https://docs.oshpark.com/design-tools/altium-designer/\)](https://docs.oshpark.com/design-tools/altium-designer/) for more.

If you are using Eagle, be aware that airwires are not the same as routed traces. If there are no copper links between pads showing on this layer, please review your .brd file for airwires.

See our [design tools pages \(https://docs.oshpark.com/design-tools/\)](https://docs.oshpark.com/design-tools/) for more.



Rendered from "AirBearingElectronic1.kicad\_pcb"

## Bottom Silk Screen

This layer should appear 'mirrored' as if you were looking down on it through the board from the top.

We will ignore the portion of the silkscreen that extends beyond the board outline.

We will automatically remove any silkscreen that crosses drilled holes or exposed copper.

If a logo isn't showing up on this layer, try changing your design tool import settings to create that silk image with 400 DPI or less, or check out our [Eagle-specific import-bmp script \(https://docs.oshpark.com/submitting-orders/import-bmp/\)](https://docs.oshpark.com/submitting-orders/import-bmp/) instructions.



Rendered from "AirBearingElectronic1.kicad\_pcb"

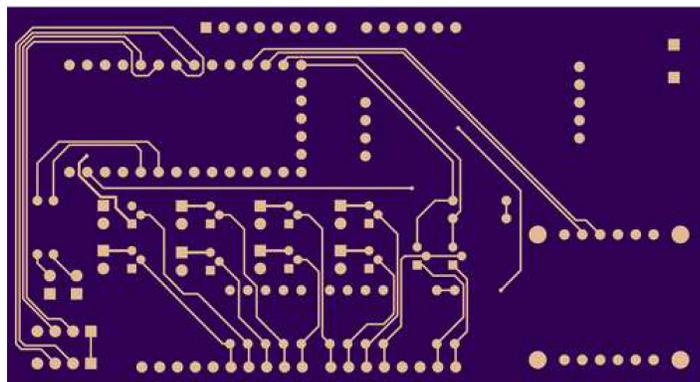
## Bottom Solder Mask

This layer should appear 'mirrored' as if you were looking down on it through the board from the top.

Soldermask layers show us where to remove the purple solder resist. The gold-colored areas will be exposed on the final board, and purple areas will be covered.

If you submitted an empty file, we won't remove any mask so this entire side of the board will be covered in purple soldermask

To expose the entire board, submit this file with a single polygon that covers the entire board. We will remove all mask everywhere and expose all the copper and board substrate.



Rendered from "AirBearingElectronic1.kicad\_pcb"

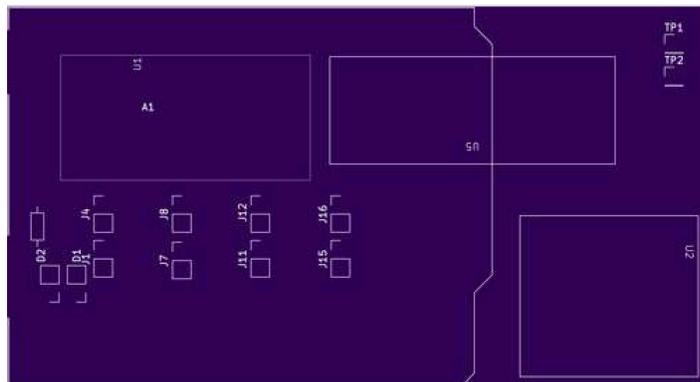
## Top Layer

We will place copper everywhere we see gold color on this layer.

If you are using Altium Designer or Altium CircuitMaker, carefully examine the board to make sure there are no shorts from the mechanical layers being included on this layer. See [here \(https://docs.oshpark.com/design-tools/altium-designer/\)](https://docs.oshpark.com/design-tools/altium-designer/) for more.

If you are using Eagle, be aware that airwires are not the same as routed traces. If there are no copper links between pads showing on this layer, please review your .brd file for airwires.

See our [design tools pages \(https://docs.oshpark.com/design-tools/\)](https://docs.oshpark.com/design-tools/) for more.



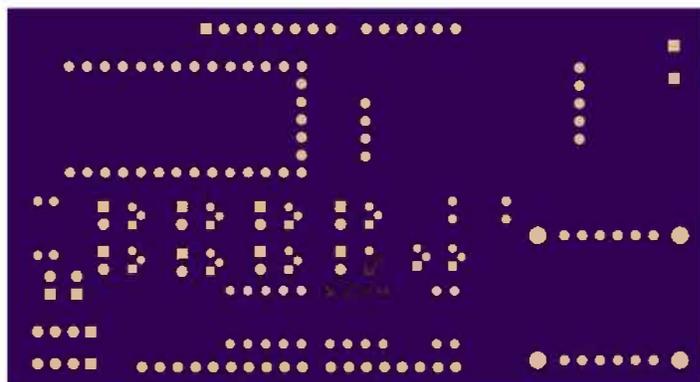
Rendered from "AirBearingElectronic1.kicad\_pcb"

## Top Silk Screen

We will ignore the portion of the silkscreen that extends beyond the board outline.

We will automatically remove any silkscreen that crosses drilled holes or exposed copper.

If a logo isn't showing up on this layer, try changing your design tool import settings to create that silk image with 400 DPI or less, or check out our [Eagle-specific import-bmp script \(https://docs.oshpark.com/submitting-orders/import-bmp/\)](https://docs.oshpark.com/submitting-orders/import-bmp/) instructions.



Rendered from "AirBearingElectronic1.kicad\_pcb"

## Top Solder Mask

Soldermask layers show us where to remove the purple solder resist. The gold-colored areas will be exposed on the final board, and purple areas will be covered.

If you submitted an empty file, we won't remove any mask so this entire side of the board will be covered in purple soldermask

To expose the entire board, submit this file with a single polygon that covers the entire board. We will remove all mask everywhere and expose all the copper and board substrate.

# **Appendix H - Gyroscopic MatLab Code and Gyroscopic Data Collection**

Part 1 - Matlab Code of Gyroscopic Data Analysis

Part 2 - Gyroscopic Data recorded onto an Excel spreadsheet.

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# Appendix H, Part 1 - MATLAB Code For Gyroscopic Plots

To observe the data seen in the results, the gyroscopic data collected was plotted and analyzed.

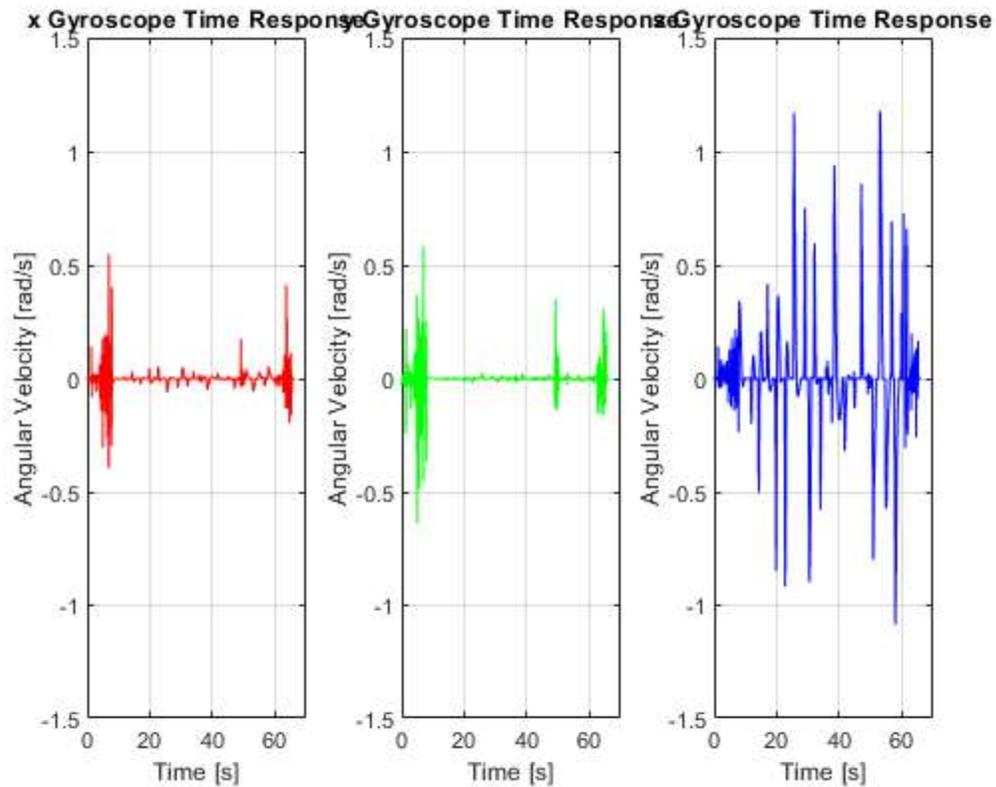
```
clc; clear all; close all;
load('gyro.mat')
```

## Individual Gyroscope Plots

```
figure,
subplot(1,3,1)
plot(gyro(:,1),gyro(:,2),'r')
grid on
axis([0 70 -1.5 1.5])
xlabel('Time [s]')
ylabel('Angular Velocity [rad/s]')
title('x Gyroscope Time Response')

subplot(1,3,2)
plot(gyro(:,1),gyro(:,3),'g')
grid on
axis([0 70 -1.5 1.5])
xlabel('Time [s]')
ylabel('Angular Velocity [rad/s]')
title('y Gyroscope Time Response')

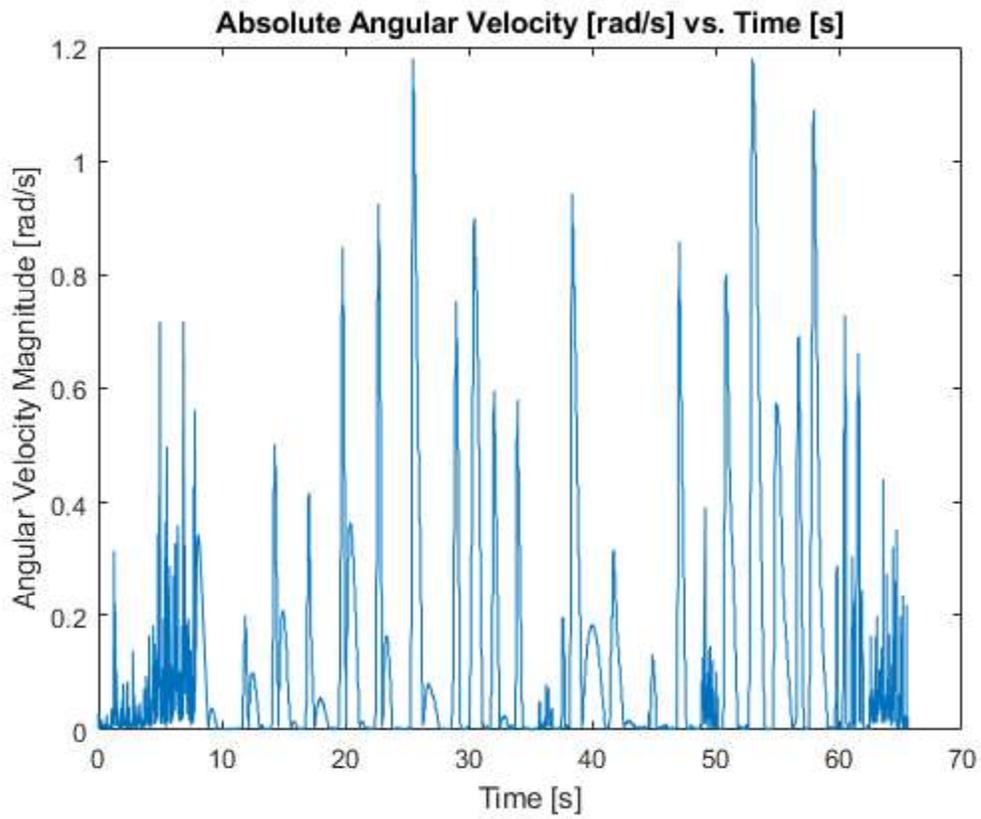
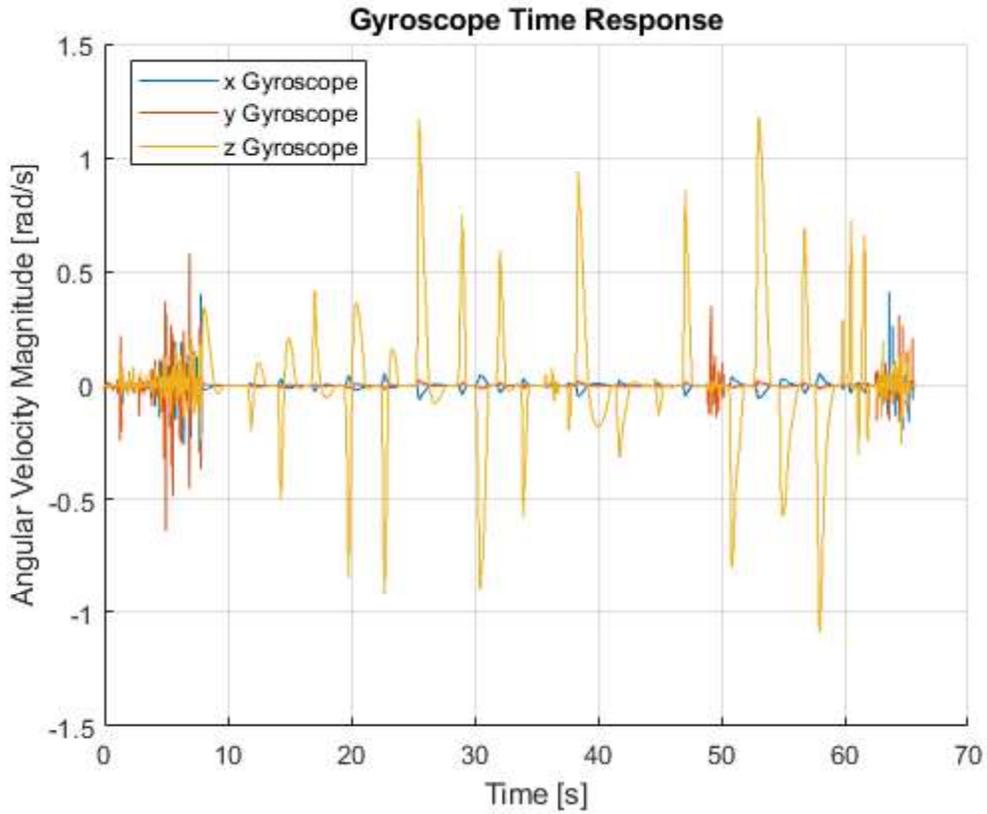
subplot(1,3,3)
grid on
plot(gyro(:,1),gyro(:,4),'b')
grid on
axis([0 70 -1.5 1.5])
xlabel('Time [s]')
ylabel('Angular Velocity [rad/s]')
title('z Gyroscope Time Response')
```



## Gyroscope Plots

```
figure,
hold all
plot(gyro(:,1),gyro(:,2))
plot(gyro(:,1),gyro(:,3))
plot(gyro(:,1),gyro(:,4))
grid on
xlabel('Time [s]')
ylabel('Angular Velocity Magnitude [rad/s]')
title('Gyroscope Time Response')
legend('x Gyroscope','y Gyroscope', 'z Gyroscope','location','best')
```

```
figure,
plot(gyro(:,1),gyro(:,5))
xlabel('Time [s]')
ylabel('Angular Velocity Magnitude [rad/s]')
title('Absolute Angular Velocity [rad/s] vs. Time [s]')
```



---

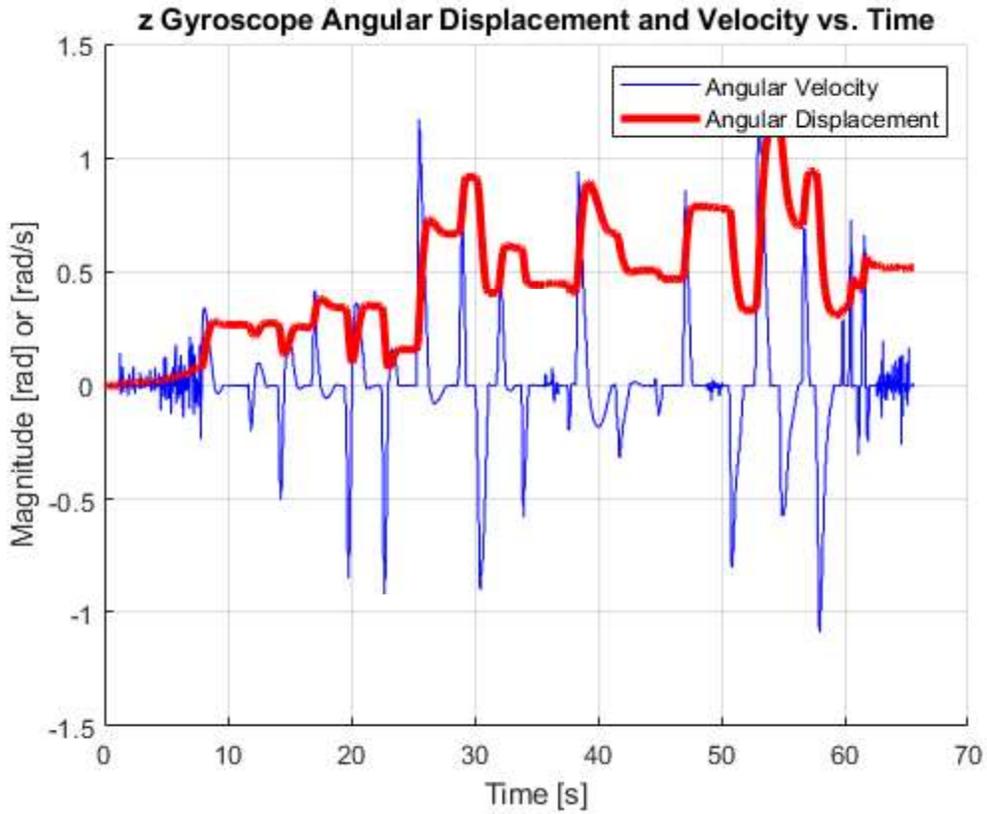
# Angular Displacement Plots

```
int = cumtrapz(gyro(:,1), gyro(:,4));
angulardisp = int(:,1);
figure,
hold all
plot(gyro(:,1),gyro(:,4), 'b')
plot(gyro(:,1),angulardisp, 'r-', 'linewidth',3)
grid on
xlabel('Time [s]');
ylabel('Magnitude [rad] or [rad/s]')
legend('Angular Velocity','Angular Displacement')
title('z Gyroscope Angular Displacement and Velocity vs. Time')

% tried to calculate and plot derivative but sharp changes in data make the
% values infinite

% for i = 1:length(gyro)
%     if i == length(gyro) - 1
%         ang_accel_z(i)=0;
%         continue
%     else
%         if i == length(gyro)
%             ang_accel_z(i)= 0;
%             break;
%         end
%         ang_accel_z(i) = (gyro(i+1,4)-gyro(i,4))/(gyro(i+1,1)-gyro(i,1));
%         if ang_accel_z(i) == Inf
%             ang_accel_z(i) = 0;
%         end
%     end
% end

% figure,
% plot(gyro(:,1),ang_accel_z)
```



*Published with MATLAB® R2023b*

Part 2 - Gyroscopic Data recorded onto an Excel spreadsheet.

| air bearing data page 1 |                     |                     |                     | air bearing data page 1    |          |           |           | air bearing data page 2 |          |          |           | air bearing data page 2 |           |          |          | air bearing data page 2 |           |           |           | air bearing data page 3 |           |           |           | air bearing data page 3 |           |           |           | air bearing data page 3 |           |          |  |
|-------------------------|---------------------|---------------------|---------------------|----------------------------|----------|-----------|-----------|-------------------------|----------|----------|-----------|-------------------------|-----------|----------|----------|-------------------------|-----------|-----------|-----------|-------------------------|-----------|-----------|-----------|-------------------------|-----------|-----------|-----------|-------------------------|-----------|----------|--|
| Time (s)                | Gyroscope x (rad/s) | Gyroscope y (rad/s) | Gyroscope z (rad/s) | Absolute/Magnitude (rad/s) | 4.24E-01 | 1.95E-03  | -2.06E-03 | 3.46E-03                | 4.47E-03 | 8.57E-01 | 2.76E-03  | -1.44E-03               | 1.41E-03  | 3.42E-03 | 2.04E-03 | -6.62E-04               | -2.12E-03 | 2.33E-03  | 3.29E-03  | 4.34E-01                | 4.86E-03  | -6.55E-03 | -7.66E-04 | 8.20E-03                | 8.67E-01  | -2.04E-03 | 2.59E-04  | 2.71E-03                | 3.40E-03  |          |  |
| 1.21E-02                | 2.64E-04            | -4.85E-03           | 9.17E-04            | 4.94E-03                   | 4.44E-01 | -1.25E-03 | -1.94E-03 | -5.67E-04               | 2.38E-03 | 8.77E-01 | -1.23E-03 | -2.11E-04               | 4.73E-04  | 1.34E-03 | 2.22E-02 | 7.19E-03                | 4.89E-03  | 2.87E-02  | 4.54E-02  | 4.54E-01                | 8.37E-04  | -2.29E-03 | -1.09E-03 | 2.94E-03                | 8.93E-01  | 1.04E-03  | 1.24E-03  | 1.24E-03                | -4.57E-03 | 5.88E-03 |  |
| 3.22E-02                | 2.28E-03            | -4.16E-03           | 2.13E-03            | 5.52E-03                   | 4.64E-01 | 1.31E-03  | -5.34E-03 | -3.04E-06               | 5.59E-03 | 8.97E-01 | 2.12E-03  | 5.41E-04                | -4.82E-03 | 5.53E-03 | 4.23E-02 | 3.00E-03                | -3.82E-03 | 5.89E-03  | 4.75E-01  | -4.04E-03               | -2.02E-03 | -1.17E-03 | 4.67E-03  | 9.07E-01                | -2.65E-03 | -4.76E-03 | -2.65E-03 | 5.87E-03                |           |          |  |
| 5.23E-02                | -4.28E-03           | -5.56E-03           | -3.88E-04           | 7.03E-03                   | 4.85E-01 | 3.30E-03  | 9.84E-04  | -1.63E-06               | 3.45E-03 | 9.17E-01 | -1.30E-03 | -8.45E-03               | 2.89E-04  | 8.66E-03 | 6.24E-02 | -3.16E-03               | 1.30E-03  | 9.84E-03  | 4.98E-01  | -3.04E-04               | 1.26E-03  | 2.01E-03  | 2.39E-04  | 9.27E-01                | -3.34E-04 | -6.21E-03 | -2.30E-03 | 3.49E-03                |           |          |  |
| 7.24E-02                | 4.72E-03            | 3.23E-03            | -2.32E-03           | 6.17E-03                   | 8.05E-01 | -1.82E-03 | -1.46E-03 | 1.49E-03                | 2.77E-03 | 8.37E-01 | 3.83E-03  | -2.03E-03               | -1.27E-03 | 4.55E-03 | 8.25E-02 | 2.60E-04                | -7.9E-04  | 4.13E-04  | 8.56E-04  | 5.15E-01                | -8.62E-03 | 4.05E-03  | -3.55E-03 | 1.03E-02                | 9.47E-01  | 4.07E-03  | -1.42E-03 | 1.73E-03                | 6.06E-03  |          |  |
| 9.25E-02                | 1.12E-03            | -8.97E-03           | 3.59E-03            | 1.07E-02                   | 5.25E-01 | 2.21E-03  | 7.93E-03  | -7.49E-04               | 8.29E-03 | 9.37E-01 | -7.39E-04 | -4.78E-03               | 2.48E-03  | 5.43E-03 | 1.09E-02 | 3.46E-03                | 2.22E-03  | 3.89E-03  | 3.89E-03  | 6.15E-01                | 3.19E-03  | 1.42E-03  | 3.54E-03  | 9.57E-01                | 3.37E-03  | 3.37E-03  | 1.04E-03  | 1.17E-03                | 4.12E-03  |          |  |
| 1.13E-01                | -5.39E-03           | 8.69E-03            | -3.88E-03           | 1.09E-02                   | 5.45E-01 | -3.27E-03 | 1.39E-03  | 6.86E-04                | 3.61E-03 | 8.77E-01 | 1.04E-03  | 2.08E-03                | 2.65E-03  | 1.23E-02 | 1.23E-01 | 1.63E-03                | 3.00E-03  | 1.46E-03  | 3.79E-03  | 5.55E-01                | 4.86E-03  | 7.18E-04  | -9.55E-04 | 5.00E-03                | 9.87E-01  | 1.00E-03  | 3.14E-04  | -2.58E-03               | 2.81E-03  |          |  |
| 1.33E-01                | 1.70E-03            | -3.05E-04           | 3.02E-03            | 3.48E-03                   | 5.65E-01 | -2.38E-03 | 9.03E-04  | 1.40E-04                | 2.55E-03 | 9.97E-01 | 4.43E-03  | 7.55E-03                | -2.85E-03 | 9.20E-03 | 1.43E-01 | -4.49E-03               | 1.34E-03  | 2.24E-03  | 5.18E-03  | 5.75E-01                | -4.35E-03 | -2.95E-03 | 1.04E-02  | 1.01E-01                | -3.47E-04 | 3.57E-03  | 3.36E-04  | 3.80E-03                |           |          |  |
| 1.53E-01                | -4.49E-03           | -1.34E-03           | 2.24E-03            | 5.18E-03                   | 5.85E-01 | -1.54E-03 | -1.92E-03 | -3.19E-04               | 2.48E-03 | 1.02E-01 | 1.04E-03  | 2.66E-03                | -6.17E-04 | 2.87E-03 | 1.63E-01 | -3.53E-03               | 5.39E-03  | 5.39E-03  | 1.15E-02  | 6.05E-01                | 3.83E-04  | 4.42E-04  | -7.85E-04 | 1.03E-01                | 6.36E-04  | 1.34E-03  | 4.76E-03  |                         |           |          |  |
| 1.73E-01                | -6.05E-03           | 8.90E-03            | 3.20E-03            | 1.15E-02                   | 6.05E-01 | 3.83E-04  | -3.22E-03 | 2.72E-03                | 4.24E-03 | 1.04E-01 | -1.33E-03 | -1.45E-03               | 6.81E-04  | 2.09E-03 | 1.83E-01 | -4.63E-03               | 1.19E-03  | 1.32E-03  | 4.86E-03  | 6.15E-01                | -1.59E-03 | -2.63E-03 | 3.29E-03  | 1.20E-01                | -5.94E-03 | -1.59E-02 | -2.63E-03 | 1.71E-02                |           |          |  |
| 1.93E-01                | 4.63E-03            | -3.36E-03           | 1.19E-03            | 4.33E-03                   | 6.15E-01 | 4.77E-04  | -4.80E-03 | 3.49E-04                | 3.84E-03 | 1.05E-01 | 1.23E-03  | -7.42E-03               | 2.88E-02  | 3.19E-02 | 2.03E-01 | -3.91E-03               | 1.32E-03  | 1.32E-03  | 4.86E-03  | 6.35E-01                | 1.22E-03  | -2.27E-02 | 2.03E-02  | 1.06E-01                | -7.42E-03 | 2.88E-02  | -2.21E-03 | 2.79E-02                |           |          |  |
| 2.03E-01                | 3.15E-03            | 3.85E-03            | -2.82E-03           | 5.72E-03                   | 6.35E-01 | -3.14E-03 | -5.55E-03 | 8.89E-04                | 6.44E-03 | 1.07E-01 | -1.02E-03 | -3.67E-02               | 7.15E-03  | 3.74E-02 | 2.13E-01 | -2.63E-04               | -4.43E-03 | 6.87E-03  | 5.51E-03  | 6.66E-01                | -4.37E-04 | -2.79E-03 | -1.62E-03 | 3.19E-03                | 1.19E-01  | -1.79E-02 | -1.95E-02 | -4.83E-03               | 2.69E-02  |          |  |
| 2.13E-01                | 2.63E-04            | 7.57E-03            | 2.80E-04            | 7.89E-03                   | 6.45E-01 | -3.97E-03 | -7.96E-03 | 1.44E-03                | 9.01E-03 | 1.08E-01 | 1.93E-04  | 1.28E-02                | -6.96E-03 | 1.46E-02 | 2.23E-01 | -1.34E-03               | 3.53E-03  | -1.17E-03 | 3.91E-03  | 6.66E-01                | -3.55E-03 | -1.74E-02 | -2.01E-03 | 1.83E-02                | 1.10E-01  | -4.52E-03 | 6.81E-04  | 3.92E-05                | 4.57E-03  |          |  |
| 2.23E-01                | -1.34E-05           | 7.18E-04            | 1.76E-03            | 1.90E-04                   | 6.56E-01 | -7.39E-04 | -1.53E-02 | -3.38E-03               | 1.59E-02 | 1.09E-01 | -3.62E-03 | 4.45E-03                | 9.03E-05  | 5.73E-03 | 2.33E-01 | -1.79E-03               | 3.53E-03  | -6.50E-04 | 4.01E-03  | 6.76E-01                | -7.33E-03 | -1.41E-02 | -5.54E-03 | 1.68E-02                | 1.11E-01  | -2.35E-03 | 2.96E-03  | 4.00E-03                |           |          |  |
| 2.33E-01                | -3.88E-03           | -1.46E-04           | -1.17E-04           | 3.89E-03                   | 6.86E-01 | -7.78E-03 | -2.11E-02 | -6.19E-04               | 2.25E-02 | 1.12E-01 | -7.31E-03 | 2.98E-03                | 1.81E-04  | 7.90E-03 | 2.43E-01 | -3.88E-03               | 2.69E-03  | 2.69E-03  | 1.19E-03  | 7.05E-01                | -4.23E-03 | -1.39E-02 | -1.18E-02 | 1.12E-01                | -1.13E-03 | -1.02E-03 | 1.81E-04  | 7.90E-03                |           |          |  |
| 2.43E-01                | -2.73E-02           | -2.41E-04           | 1.48E-03            | 5.14E-03                   | 7.05E-01 | -1.24E-03 | -1.27E-02 | 6.81E-03                | 2.99E-02 | 1.15E-01 | -1.45E-03 | -3.04E-03               | 7.51E-04  | 5.22E-03 | 2.54E-01 | -2.41E-04               | 1.81E-03  | 1.81E-03  | 1.81E-03  | 7.16E-01                | -4.86E-03 | -1.48E-02 | -1.48E-02 | 1.15E-01                | 1.15E-01  | 6.18E-04  | 4.51E-03  | 1.22E-02                |           |          |  |
| 2.64E-01                | -7.30E-03           | 1.73E-02            | -1.18E-03           | 1.88E-02                   | 7.16E-01 | -3.55E-03 | 3.22E-03  | -9.31E-04               | 4.88E-03 | 1.15E-01 | 6.18E-04  | -1.14E-02               | 4.51E-03  | 1.22E-02 | 2.84E-01 | 1.94E-03                | 3.09E-03  | -5.07E-03 | 6.25E-03  | 7.26E-01                | -1.37E-03 | 1.46E-03  | 2.19E-03  | 1.16E-01                | -3.96E-03 | -1.23E-02 | 1.16E-03  | 1.29E-02                |           |          |  |
| 2.94E-01                | 1.94E-03            | -2.97E-03           | -1.34E-04           | 3.89E-03                   | 7.36E-01 | -2.00E-03 | -8.55E-03 | 5.74E-03                | 1.13E-02 | 1.17E-01 | -5.49E-03 | -2.35E-02               | 1.51E-03  | 2.42E-02 | 3.04E-01 | -8.34E-04               | 7.80E-03  | 7.80E-03  | 7.80E-03  | 7.36E-01                | -1.75E-03 | -2.83E-03 | -1.11E-03 | 3.50E-03                | 1.18E-01  | -1.67E-02 | -1.43E-02 | 3.82E-02                |           |          |  |
| 3.24E-01                | 2.66E-03            | -4.43E-03           | 6.87E-03            | 6.87E-03                   | 7.36E-01 | 3.25E-03  | -1.10E-03 | 6.11E-03                | 6.11E-03 | 1.19E-01 | -1.79E-02 | -1.95E-02               | -4.83E-03 | 2.69E-02 | 3.34E-01 | 1.46E-03                | -2.49E-03 | -1.59E-02 | -2.63E-03 | 7.36E-01                | 4.37E-04  | -2.79E-03 | -1.62E-03 | 3.29E-03                | 1.20E-01  | -5.94E-03 | -1.59E-02 | -2.63E-03               | 1.71E-02  |          |  |
| 3.54E-01                | -4.31E-03           | -1.16E-02           | 1.32E-02            | 4.83E-03                   | 7.76E-01 | -3.72E-03 | -3.15E-02 | 3.89E-04                | 3.89E-04 | 1.21E-01 | -3.38E-03 | -1.02E-03               | 5.95E-03  | 9.59E-03 | 3.54E-01 | -4.77E-03               | 5.55E-03  | 1.05E-03  | 7.39E-03  | 7.76E-01                | 2.89E-03  | -4.58E-04 | -1.37E-03 | 2.89E-03                | 1.22E-01  | -1.27E-02 | -2.27E-02 | 2.03E-02                | 3.39E-02  |          |  |
| 3.64E-01                | -3.91E-04           | -5.55E-03           | 3.26E-03            | 4.83E-03                   | 7.96E-01 | -6.64E-04 | 1.76E-03  | 1.12E-03                | 2.19E-03 | 1.23E-01 | -6.66E-03 | 1.18E-02                | 2.02E-02  | 3.22E-02 | 3.74E-01 | -2.67E-04               | 3.08E-03  | -2.86E-03 | 3.21E-03  | 8.06E-01                | -1.12E-03 | 8.64E-04  | 1.70E-04  | 1.42E-03                | 1.24E-01  | -8.07E-03 | -8.17E-03 | 1.92E-02                | 2.24E-02  |          |  |
| 3.84E-01                | -7.52E-04           | 5.88E-03            | -2.08E-03           | 6.29E-03                   | 8.16E-01 | -6.83E-04 | 3.81E-04  | 2.49E-03                | 4.84E-03 | 1.25E-01 | 8.93E-02  | 6.28E-03                | 1.42E-02  | 2.16E-02 | 4.04E-01 | -7.52E-04               | 5.88E-03  | -2.08E-03 | 6.29E-03  | 8.16E-01                | -6.83E-04 | 3.81E-04  | 2.49E-03  | 4.84E-03                | 1.25E-01  | 8.93E-02  | 6.28E-03  | 1.42E-02                | 2.16E-02  |          |  |
| 3.94E-01                | -2.56E-03           | 1.40E-03            | 1.24E-03            | 3.18E-03                   | 8.26E-01 | -1.93E-03 | 1.93E-03  | 2.24E-05                | 2.73E-03 | 1.26E-01 | 6.01E-02  | 1.28E-01                | 2.65E-02  | 1.44E-01 | 4.04E-01 | -2.56E-03               | 1.40E-03  | 1.24E-03  | 3.18E-03  | 8.26E-01                | -1.93E-03 | 1.93E-03  | 2.24E-05  | 2.73E-03                | 1.26E-01  | 6.01E-02  | 1.28E-01  | 2.65E-02                | 1.44E-01  |          |  |
| 4.04E-01                | 2.88E-04            | -2.64E-03           | 8.65E-03            | 3.87E-03                   | 8.36E-01 | 2.55E-04  | -1.48E-03 | 6.82E-03                | 6.82E-03 | 1.27E-01 | -1.43E-01 | 1.63E-01                | 1.85E-02  | 3.16E-01 | 4.14E-01 | 2.88E-04                | -2.64E-03 | 8.65E-03  | 3.87E-03  | 8.36E-01                | 2.55E-04  | -1.48E-03 | 6.82E-03  | 6.82E-03                | 1.27E-01  | -1.43E-01 | 1.63E-01  | 1.85E-02                | 3.16E-01  |          |  |
| 4.14E-01                | 5.68E-04            | -3.10E-03           | 2.11E-03            | 3.80E-03                   | 8.47E-01 | 2.32E-03  | -6.40E-03 | -1.56E-04               | 6.80E-03 | 1.28E-01 | 6.41E-02  | 2.74E-02                | 9.24E-02  | 1.16E-01 |          |                         |           |           |           |                         |           |           |           |                         |           |           |           |                         |           |          |  |

| air bearing data page 4 |          |          |           | air bearing data page 4 |          |          |           | air bearing data page 4 |          |          |           | air bearing data page 5 |           |          |          | air bearing data page 5 |          |           |          | air bearing data page 5 |           |           |           | air bearing data page 6 |          |           |           | air bearing data page 6 |           |           |          | air bearing data page 6 |  |  |  |
|-------------------------|----------|----------|-----------|-------------------------|----------|----------|-----------|-------------------------|----------|----------|-----------|-------------------------|-----------|----------|----------|-------------------------|----------|-----------|----------|-------------------------|-----------|-----------|-----------|-------------------------|----------|-----------|-----------|-------------------------|-----------|-----------|----------|-------------------------|--|--|--|
| 1.26E+00                | 1.37E+02 | 4.90E+02 | 3.96E+02  | 6.45E+02                | 1.72E+00 | 1.45E+03 | -2.83E+03 | 5.79E+04                | 2.04E+03 | 2.15E+00 | -2.83E+03 | -1.67E+02               | 1.07E+02  | 2.00E+02 | 1.30E+00 | 1.57E+02                | 2.36E+02 | 1.30E+02  | 3.12E+02 | 1.73E+00                | -8.83E+04 | -2.50E+03 | 8.70E+04  | -4.47E+03               | 1.03E+02 | 1.30E+01  | -2.98E+02 | 6.99E+02                | -1.38E+02 | -6.19E+03 | 1.70E+02 |                         |  |  |  |
| 1.30E+00                | 1.47E+02 | 2.69E+02 | 2.09E+02  | 7.55E+02                | 1.74E+00 | 8.90E+04 | 9.14E+04  | 3.73E+04                | 1.33E+03 | 2.17E+00 | 3.90E+03  | -1.38E+02               | -4.19E+03 | 1.70E+02 | 1.30E+01 | 1.77E+02                | 2.69E+02 | 2.09E+02  | 7.55E+02 | 1.73E+00                | -8.83E+04 | -2.50E+03 | 8.70E+04  | -4.47E+03               | 1.03E+02 | 1.30E+01  | -2.98E+02 | 6.99E+02                | -1.38E+02 | -6.19E+03 | 1.70E+02 |                         |  |  |  |
| 1.33E+00                | 1.57E+02 | 4.16E+02 | 3.52E+02  | 2.22E+01                | 1.75E+00 | 1.75E+00 | -1.04E+03 | 1.20E+03                | 2.99E+03 | 2.18E+00 | -2.18E+03 | -4.30E+03               | 4.73E+03  | 1.93E+02 | 1.33E+01 | 1.93E+02                | 4.16E+02 | 3.52E+02  | 2.22E+01 | 1.75E+00                | 1.75E+00  | -1.04E+03 | 1.20E+03  | 2.99E+03                | 2.18E+00 | -2.18E+03 | -4.30E+03 | 4.73E+03                | 1.93E+02  |           |          |                         |  |  |  |
| 1.34E+00                | 2.24E+02 | 1.13E+01 | -3.86E+02 | 1.23E+01                | 1.77E+00 | 1.58E+03 | -1.48E+03 | -7.83E+04               | 2.29E+03 | 2.20E+00 | 4.41E+03  | -4.74E+04               | -1.76E+03 | 4.78E+03 | 1.35E+01 | 2.24E+02                | 1.13E+01 | -3.86E+02 | 1.23E+01 | 1.77E+00                | 1.58E+03  | -1.48E+03 | -7.83E+04 | 2.29E+03                | 2.20E+00 | 4.41E+03  | -         |                         |           |           |          |                         |  |  |  |



|                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |           |           |           |          |
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| air bearing data page 19 | air bearing data page 20 | air bearing data page 21 | air bearing data page 22 | air bearing data page 23 | air bearing data page 24 | air bearing data page 25 | air bearing data page 26 | air bearing data page 27 | air bearing data page 28 | air bearing data page 29 | air bearing data page 30 |           |           |           |          |
| 7.77E+00                 | 6.38E-02                 | -4.48E-02                | 1.60E-01                 | 1.78E-01                 | 8.21E+00                 | -1.95E-02                | 7.09E-03                 | 3.22E-01                 | 1.23E-01                 | 1.23E-01                 | 8.64E+00                 | -8.73E-03 | 4.45E-03  | 1.23E-01  | 1.23E-01 |
| 7.78E+00                 | 4.87E-02                 | 8.06E-02                 | 1.43E-01                 | 1.72E-01                 | 8.22E+00                 | -1.65E-02                | 7.72E-03                 | 3.17E-01                 | 1.21E-01                 | 1.21E-01                 | 8.65E+00                 | -8.25E-03 | 2.42E-03  | 1.16E-01  | 1.16E-01 |
| 7.79E+00                 | 5.17E-02                 | 4.71E-02                 | 7.15E-02                 | 1.00E-01                 | 8.23E+00                 | -1.60E-02                | 5.99E-03                 | 3.16E-01                 | 1.16E-01                 | 1.16E-01                 | 8.66E+00                 | -6.43E-03 | 4.98E-04  | 1.16E-01  | 1.16E-01 |
| 7.80E+00                 | -2.40E-02                | -1.41E-02                | -4.07E-02                | 2.98E-02                 | 8.24E+00                 | -1.53E-02                | 3.59E-03                 | 3.11E-01                 | 3.11E-01                 | 3.11E-01                 | 8.67E+00                 | -4.34E-03 | 2.14E-03  | 1.11E-01  | 1.11E-01 |
| 7.81E+00                 | -2.41E-02                | -2.46E-02                | -1.33E-01                | 1.37E-01                 | 8.25E+00                 | -1.46E-02                | 5.60E-03                 | 3.07E-01                 | 3.09E-01                 | 3.09E-01                 | 8.68E+00                 | -6.92E-03 | 2.25E-03  | 1.08E-01  | 1.08E-01 |
| 7.82E+00                 | 1.14E-01                 | -8.81E-02                | -2.36E-01                | 2.76E-01                 | 8.26E+00                 | -1.56E-02                | 5.25E-03                 | 3.04E-01                 | 3.04E-01                 | 3.04E-01                 | 8.69E+00                 | -5.36E-03 | 1.22E-04  | 1.01E-01  | 1.01E-01 |
| 7.83E+00                 | 4.02E-01                 | -3.68E-01                | -1.39E-01                | 5.62E-01                 | 8.27E+00                 | -1.32E-02                | 4.98E-03                 | 3.02E-01                 | 3.02E-01                 | 3.02E-01                 | 8.70E+00                 | -4.15E-03 | -1.03E-03 | 9.81E-02  | 9.82E-02 |
| 7.84E+00                 | 2.16E-01                 | -2.03E-01                | -8.01E-02                | 3.07E-01                 | 8.28E+00                 | -1.59E-02                | 2.66E-03                 | 2.96E-01                 | 2.96E-01                 | 2.96E-01                 | 8.71E+00                 | -3.96E-03 | 1.10E-03  | 9.22E-02  | 9.23E-02 |
| 7.85E+00                 | 4.09E-02                 | -4.33E-02                | 3.32E-02                 | 6.82E-02                 | 8.29E+00                 | -1.20E-02                | 7.64E-03                 | 2.89E-01                 | 2.90E-01                 | 2.90E-01                 | 8.72E+00                 | -6.09E-03 | 1.15E-03  | 8.77E-02  | 8.79E-02 |
| 7.86E+00                 | -8.97E-02                | 6.34E-02                 | 1.99E-02                 | 1.12E-01                 | 8.30E+00                 | -1.40E-02                | 1.96E-03                 | 2.88E-01                 | 2.87E-01                 | 2.87E-01                 | 8.73E+00                 | -5.48E-03 | 8.86E-04  | 8.33E-02  | 8.35E-02 |
| 7.87E+00                 | -2.02E-01                | 1.83E-01                 | -1.39E-02                | 2.73E-01                 | 8.31E+00                 | -1.74E-02                | 6.12E-03                 | 2.84E-01                 | 2.85E-01                 | 2.85E-01                 | 8.74E+00                 | -3.74E-03 | 1.73E-03  | 7.79E-02  | 7.80E-02 |
| 7.88E+00                 | -2.14E-01                | 1.34E-01                 | -3.19E-02                | 2.98E-01                 | 8.32E+00                 | -1.49E-02                | 3.35E-03                 | 2.79E-01                 | 2.79E-01                 | 2.79E-01                 | 8.75E+00                 | -2.59E-03 | 2.14E-03  | 7.35E-02  | 7.36E-02 |
| 7.89E+00                 | -1.52E-01                | 4.86E-02                 | -6.10E-02                | 1.70E-01                 | 8.33E+00                 | -1.57E-02                | 4.02E-03                 | 2.76E-01                 | 2.77E-01                 | 2.77E-01                 | 8.76E+00                 | -4.33E-03 | -1.02E-03 | 6.88E-02  | 6.89E-02 |
| 7.90E+00                 | 5.89E-02                 | -1.41E-01                | 2.25E-02                 | 1.54E-01                 | 8.34E+00                 | -1.24E-02                | 6.18E-03                 | 2.69E-01                 | 2.70E-01                 | 2.70E-01                 | 8.77E+00                 | -2.18E-03 | 2.95E-03  | 6.46E-02  | 6.51E-02 |
| 7.91E+00                 | -1.62E-02                | 6.62E-02                 | 1.20E-01                 | 1.38E-01                 | 8.35E+00                 | -1.39E-02                | 3.79E-03                 | 2.64E-01                 | 2.64E-01                 | 2.64E-01                 | 8.78E+00                 | -2.73E-03 | 6.65E-04  | 5.84E-02  | 5.84E-02 |
| 7.92E+00                 | 4.99E-02                 | -2.31E-02                | 1.48E-01                 | 1.57E-01                 | 8.36E+00                 | -1.42E-02                | 3.03E-03                 | 2.61E-01                 | 2.62E-01                 | 2.62E-01                 | 8.79E+00                 | -3.92E-03 | 5.36E-04  | 5.56E-02  | 5.57E-02 |
| 7.93E+00                 | -4.50E-02                | 2.20E-02                 | 2.14E-01                 | 2.20E-01                 | 8.37E+00                 | -1.25E-02                | 4.54E-03                 | 2.53E-01                 | 2.53E-01                 | 2.53E-01                 | 8.80E+00                 | -1.17E-03 | -4.72E-04 | 5.04E-02  | 5.06E-02 |
| 7.94E+00                 | -1.17E-02                | -2.56E-02                | 2.27E-01                 | 2.29E-01                 | 8.38E+00                 | -1.41E-02                | 5.15E-03                 | 2.52E-01                 | 2.52E-01                 | 2.52E-01                 | 8.81E+00                 | -3.03E-03 | 3.03E-03  | 4.38E-02  | 4.40E-02 |
| 7.95E+00                 | -2.71E-02                | 1.09E-02                 | 2.59E-01                 | 2.60E-01                 | 8.39E+00                 | -1.30E-02                | 6.24E-03                 | 2.46E-01                 | 2.47E-01                 | 2.47E-01                 | 8.82E+00                 | -3.80E-03 | 7.05E-04  | 4.13E-02  | 4.14E-02 |
| 7.96E+00                 | -8.14E-03                | 8.95E-03                 | 2.99E-01                 | 3.01E-01                 | 8.40E+00                 | -1.40E-02                | 3.65E-03                 | 2.41E-01                 | 2.41E-01                 | 2.41E-01                 | 8.83E+00                 | -5.94E-04 | 3.97E-04  | 3.97E-02  | 3.97E-02 |
| 7.97E+00                 | -1.93E-02                | 1.81E-02                 | 2.80E-01                 | 2.82E-01                 | 8.41E+00                 | -1.20E-02                | 3.32E-03                 | 2.39E-01                 | 2.39E-01                 | 2.39E-01                 | 8.84E+00                 | -1.51E-03 | -3.54E-04 | 3.52E-02  | 3.52E-02 |
| 7.98E+00                 | -1.23E-02                | -3.78E-03                | 2.96E-01                 | 2.97E-01                 | 8.42E+00                 | -1.00E-02                | 3.46E-03                 | 2.34E-01                 | 2.34E-01                 | 2.34E-01                 | 8.85E+00                 | -2.71E-03 | -6.61E-04 | 2.83E-02  | 2.84E-02 |
| 7.99E+00                 | -1.90E-02                | 4.33E-03                 | 3.06E-01                 | 3.07E-01                 | 8.43E+00                 | -1.20E-02                | 5.00E-03                 | 2.28E-01                 | 2.29E-01                 | 2.29E-01                 | 8.86E+00                 | -8.47E-04 | 1.57E-03  | 2.44E-02  | 2.44E-02 |
| 8.00E+00                 | -1.35E-02                | 5.58E-03                 | 3.11E-01                 | 3.11E-01                 | 8.44E+00                 | -8.60E-03                | 4.13E-03                 | 2.22E-01                 | 2.22E-01                 | 2.22E-01                 | 8.87E+00                 | -2.92E-04 | -8.88E-04 | 2.03E-02  | 2.03E-02 |
| 8.01E+00                 | -1.72E-02                | 8.16E-03                 | 3.16E-01                 | 3.17E-01                 | 8.45E+00                 | -1.06E-02                | 4.64E-03                 | 2.20E-01                 | 2.20E-01                 | 2.20E-01                 | 8.88E+00                 | -1.02E-03 | -2.39E-03 | 1.91E-02  | 1.93E-02 |
| 8.02E+00                 | -2.01E-02                | 6.88E-03                 | 3.22E-01                 | 3.22E-01                 | 8.46E+00                 | -1.09E-02                | 2.96E-03                 | 2.13E-01                 | 2.13E-01                 | 2.13E-01                 | 8.89E+00                 | -1.45E-03 | -3.08E-04 | 1.32E-02  | 1.33E-02 |
| 8.03E+00                 | -1.78E-02                | 1.85E-03                 | 3.32E-01                 | 3.32E-01                 | 8.47E+00                 | -1.18E-02                | 2.93E-03                 | 2.06E-01                 | 2.07E-01                 | 2.07E-01                 | 8.90E+00                 | 3.14E-05  | -1.51E-04 | 8.54E-03  | 8.54E-03 |
| 8.04E+00                 | -1.67E-02                | 6.10E-03                 | 3.37E-01                 | 3.37E-01                 | 8.48E+00                 | -1.46E-02                | 4.29E-03                 | 2.02E-01                 | 2.02E-01                 | 2.02E-01                 | 8.91E+00                 | -2.91E-03 | -1.19E-03 | 6.98E-03  | 6.98E-03 |
| 8.05E+00                 | -1.78E-02                | 6.30E-03                 | 3.32E-01                 | 3.32E-01                 | 8.49E+00                 | -1.10E-02                | 3.53E-03                 | 1.95E-01                 | 1.95E-01                 | 1.95E-01                 | 8.92E+00                 | -5.41E-04 | 1.07E-03  | 3.14E-03  | 3.14E-03 |
| 8.06E+00                 | -1.74E-02                | 6.72E-03                 | 3.36E-01                 | 3.36E-01                 | 8.50E+00                 | -7.39E-03                | 2.74E-03                 | 1.90E-01                 | 1.90E-01                 | 1.90E-01                 | 8.93E+00                 | 2.02E-04  | 1.37E-03  | -1.74E-03 | 2.22E-03 |
| 8.07E+00                 | -1.98E-02                | 4.94E-03                 | 3.42E-01                 | 3.43E-01                 | 8.51E+00                 | -1.22E-02                | 3.87E-03                 | 1.88E-01                 | 1.88E-01                 | 1.88E-01                 | 8.94E+00                 | -6.39E-04 | 3.14E-05  | -5.70E-03 | 5.73E-03 |
| 8.08E+00                 | -1.64E-02                | 7.40E-03                 | 3.43E-01                 | 3.43E-01                 | 8.52E+00                 | -1.13E-02                | 5.70E-03                 | 1.83E-01                 | 1.83E-01                 | 1.83E-01                 | 8.95E+00                 | 8.11E-04  | -2.14E-04 | -7.14E-03 | 7.19E-03 |
| 8.09E+00                 | -1.61E-02                | 7.41E-03                 | 3.41E-01                 | 3.41E-01                 | 8.53E+00                 | -8.22E-03                | 4.24E-03                 | 1.78E-01                 | 1.78E-01                 | 1.78E-01                 | 8.96E+00                 | 5.56E-05  | -1.78E-03 | -1.78E-03 | 7.79E-03 |
| 8.10E+00                 | -1.93E-02                | 4.41E-03                 | 3.41E-01                 | 3.42E-01                 | 8.54E+00                 | -7.48E-03                | 4.76E-03                 | 1.72E-01                 | 1.72E-01                 | 1.72E-01                 | 8.97E+00                 | 1.48E-03  | 1.48E-03  | 1.48E-02  | 1.48E-02 |
| 8.12E+00                 | -1.68E-02                | 4.75E-03                 | 3.42E-01                 | 3.43E-01                 | 8.55E+00                 | -7.29E-03                | 3.32E-03                 | 1.67E-01                 | 1.68E-01                 | 1.68E-01                 | 8.98E+00                 | 4.05E-03  | -1.08E-04 | -1.43E-02 | 1.49E-02 |
| 8.13E+00                 | -1.83E-02                | 3.62E-03                 | 3.43E-01                 | 3.44E-01                 | 8.56E+00                 | -7.80E-03                | 3.30E-03                 | 1.64E-01                 | 1.64E-01                 | 1.64E-01                 | 8.99E+00                 | -1.39E-03 | 1.39E-03  | 1.39E-02  | 1.39E-02 |
| 8.14E+00                 | -1.86E-02                | 4.81E-03                 | 3.37E-01                 | 3.38E-01                 | 8.57E+00                 | -1.05E-02                | 8.84E-04                 | 1.57E-01                 | 1.57E-01                 | 1.57E-01                 | 9.00E+00                 | 1.98E-03  | 1.26E-04  | -1.78E-02 | 1.79E-02 |
| 8.15E+00                 | -1.83E-02                | 6.26E-03                 | 3.38E-01                 | 3.39E-01                 | 8.58E+00                 | -8.20E-03                | 2.36E-03                 | 1.54E-01                 | 1.54E-01                 | 1.54E-01                 | 9.01E+00                 | 9.88E-04  | 1.47E-03  | -2.36E-02 | 2.37E-02 |
| 8.16E+00                 | -1.69E-02                | 6.46E-03                 | 3.36E-01                 | 3.36E-01                 | 8.59E+00                 | -6.56E-03                | 1.23E-03                 | 1.50E-01                 | 1.50E-01                 | 1.50E-01                 | 9.02E+00                 | 2.20E-03  | -1.37E-03 | -2.23E-02 | 2.24E-02 |
| 8.17E+00                 | -1.79E-02                | 6.07E-03                 | 3.32E-01                 | 3.33E-01                 | 8.60E+00                 | -5.76E-03                | 4.90E-03                 | 1.44E-01                 | 1.45E-01                 | 1.45E-01                 | 9.03E+00                 | 1.71E-03  | -1.86E-03 | -2.90E-02 | 2.51E-02 |
| 8.18E+00                 | -1.77E-02                | 6.50E-03                 | 3.30E-01                 | 3.30E-01                 | 8.61E+00                 | -6.46E-03                | 2.24E-03                 | 1.39E-01                 | 1.39E-01                 | 1.39E-01                 | 9.04E+00                 | 1.97E-03  | -1.19E-04 | -2.58E-02 | 2.59E-02 |
| 8.19E+00                 | -1.69E-02                | 4.31E-03                 | 3.27E-01                 | 3.27E-01                 | 8.62E+00                 | -6.42E-03                | 3.18E-03                 | 1.33E-01                 | 1.33E-01                 | 1.33E-01                 | 9.05E+00                 | 2.06E-04  | -2.87E-04 | -2.72E-02 | 2.72E-02 |
| 8.20E+00                 | -1.81E-02                | 7.13E-03                 | 3.26E-01                 | 3.26E-01                 | 8.63E+00                 | -6.42E-03                | 1.66E-03                 | 1.28E-01                 | 1.28E-01                 | 1.28E-01                 | 9.06E+00                 | 4.00E-03  | -2.36E-03 | -2.91E-02 | 2.95E-02 |

|                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |
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| 9.07E+00                 | 6.94E-04                 | -1.81E-04                | -2.89E-02                | 2.90E-02                 | 9.08E+00                 | 5.63E-04                 | 2.52E-03                 | -1.36E-02                | 1.38E-02                 | 1.38E-02                 | 9.09E+00                 | 3.35E-04                 | 1.05E-03                 | -1.43E-03                | 1.81E-03                 |
| 9.08E+00                 | 9.80E-05                 | -2.08E-03                | -3.14E-02                | 3.01E-02                 | 9.09E+00                 | -1.84E-03                | -3.91E-05                | -1.71E-02                | 1.72E-02                 | 1.72E-02                 | 9.10E+00                 | -1.62E-03                | 3.15E-03                 | 2.40E-03                 | 4.28E-03                 |
| 9.09E+00                 | -1.74E-03                | 3.48E-04                 | -3.05E-02                | 3.06E-02                 | 9.10E+00                 | 2.94E-04                 | -1.24E-03                | -1.05E-02                | 1.06E-02                 | 1.06E-02                 | 9.11E+00                 | -2.10E-04                | 6.86E-04                 | -1.50E-03                | 1.69E-03                 |
| 9.10E+00                 | 3.89E-03                 | -1.63E-04                | -3.13E-02                | 3.14E-02                 | 9.11E+00                 | -1.53E-02                | -4.45E-03                | -1.20E-02                | 1.21E-02                 | 1.21E-02                 | 9.12E+00                 | 1.02E-02                 | 1.02E-02                 | 1.02E-02                 | 1.02E-02                 |
| 9.11E+00                 | 2.70E-03                 | -8.88E-04                | -3.26E-02                | 3.27E-02                 | 9.12E+00                 | 5.54E-05                 | 2.32E-03                 | -7.85E-04                | -8.34E-03                | 9.28E-03                 | 9.13E+00                 | 5.15E-04                 | 1.35E-03                 | -1.92E-03                | 2.42E-03                 |
| 9.12E+00                 | 2.33E-03                 | -1.52E-03                | -3.51E-02                | 3.52E-02                 | 9.13E+00                 | -7.08E-04                | -2.77E-03                | -6.99E-03                | 7.55E-03                 | 7.55E-03                 | 9.14E+00                 | -1.43E-03                | -2.52E-03                | 3.15E-03                 | 3.15E-03                 |
| 9.13E+00                 | 3.19E-03                 | 1.00E-05                 | -3.32E-02                | 3.33E-02                 | 9.14E+00                 | 2.29E-03                 | -2.24E-03                | -8.39E-03                | 8.98E-03                 | 8.98E-03                 | 1.00E+01                 | -1.76E-03                | 1.29E-03                 | -3.26E-04                | 2.20E-03                 |
| 9.14E+00                 | 1.24E-03                 | 1.19E-05                 | -3.84E-02                | 3.85E-02                 | 9.15E+00                 | 1.74E-03                 | 1.20E-03                 | -6.53E-03                | 6.87E-03                 | 6.87E-03                 | 1.00E+01                 | 1.12E-03                 | 2.57E-03                 | -2.45E-03                | 3.73E-03                 |
| 9.15E+00                 | 2.44E-03                 | -1.07E-03                | -3.59E-02                | 3.60E-02                 | 9.16E+00                 | 9.83E-04                 | -1.48E-03                | -3.92E-03                | 4.31E-03                 | 4.31E-03                 | 1.00E+01                 | -4.15E-04                | 1.37E-03                 | 5.20E-04                 | 1.52E-03                 |
| 9.16E+00                 | 2.53E-03                 | -1.30E-03                | -3.48E-02                | 3.49E-02                 | 9.17E+00                 | -1.86E-03                | 1.66E-03                 | -2.05E-03                | 3.23E-03                 | 3.23E-03                 | 1.00E+01                 | 1.62E-03                 | 8.96E-05                 | -1.53E-03                | 2.23E-03                 |
| 9.17E+00                 | 2.33E-03                 | -2.20E-03                | -3.38E-02                | 3.39E-02                 | 9.18E+00                 | 1.08E-03                 | -1.38E-03                | -4.29E-03                | 4.63E-03                 | 4.63E-03                 | 1.00E+01                 | -1.34E-03                | -6.57E-05                | 3.79E-04                 | 1.39E-03                 |
| 9.18E+00                 | 7.02E-04                 | -2.24E-04                | -3.22E-02                | 3.23E-02                 | 9.19E+00                 | 8.49E-05                 | -2.78E-04                | -2.34E-04                | 4.14E-04                 | 4.14E-04                 | 1.00E+01                 | 2.91E-04                 | 4.21E-04                 | 1.57E-03                 | 1.57E-03                 |
| 9.19E+00                 | 3.46E-03                 | -2.11E-03                | -3.67E-02                | 3.68E-02                 | 9.20E+00                 | -1.29E-03                | -1.29E-03                | -4.88E-04                | 2.53E-03                 | 2.53E-03                 | 1.01E+01                 | -4.95E-04                | -1.13E-03                | -1.81E-04                | 1.24E-03                 |
| 9.20E+00                 | 2.83E-03                 | -7.58E-04                | -3.38E-02                | 3.40E-02                 | 9.21E+00                 | 1.21E-04                 | -1.08E-03                |                          |                          |                          |                          |                          |                          |                          |                          |

|                          |                          |                          |                          |                          |                          |                          |                          |                          |          |          |           |           |          |          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------|----------|-----------|-----------|----------|----------|
| air bearing data page 28 | air bearing data page 28 | air bearing data page 28 | air bearing data page 29 | air bearing data page 29 | air bearing data page 29 | air bearing data page 30 | air bearing data page 30 | air bearing data page 30 |          |          |           |           |          |          |
| 1.17E+01                 | 2.58E-03                 | 2.77E-03                 | 3.65E-03                 | 5.28E-03                 | 1.21E+01                 | 4.29E-03                 | 1.70E-03                 | -6.14E-02                | 6.18E-02 | 1.25E+01 | -4.84E-03 | 3.16E-03  | 9.96E-02 | 9.98E-02 |
| 1.17E+01                 | 9.40E-04                 | 1.18E-03                 | -2.22E-03                | 2.68E-03                 | 1.21E+01                 | 2.14E-03                 | -1.92E-03                | -5.33E-02                | 5.33E-02 | 1.25E+01 | -4.86E-03 | 3.10E-03  | 9.90E-02 | 9.81E-02 |
| 1.17E+01                 | -8.39E-04                | 3.55E-05                 | -7.67E-03                | 7.71E-03                 | 1.21E+01                 | 1.57E-03                 | -2.28E-03                | -4.69E-02                | 4.70E-02 | 1.25E+01 | -6.06E-03 | 3.65E-04  | 9.90E-02 | 9.92E-02 |
| 1.17E+01                 | 1.13E-03                 | -4.91E-04                | -4.30E-02                | 1.30E-02                 | 1.21E+01                 | 2.88E-03                 | -7.71E-05                | -3.77E-02                | 3.78E-02 | 1.25E+01 | -6.02E-03 | 3.47E-03  | 9.75E-02 | 9.77E-02 |
| 1.17E+01                 | 1.23E-03                 | -3.33E-03                | -2.29E-02                | 2.42E-02                 | 1.21E+01                 | 2.72E-03                 | -8.07E-04                | -3.11E-02                | 3.12E-02 | 1.25E+01 | -3.72E-03 | 5.73E-03  | 9.92E-02 | 9.95E-02 |
| 1.17E+01                 | 2.35E-03                 | -3.80E-04                | -4.03E-02                | 4.04E-02                 | 1.21E+01                 | 1.23E-03                 | 8.69E-04                 | -2.21E-02                | 2.22E-02 | 1.25E+01 | -6.38E-03 | 1.56E-03  | 9.46E-02 | 9.48E-02 |
| 1.17E+01                 | 6.90E-03                 | -5.10E-03                | -4.41E-02                | 4.48E-02                 | 1.22E+01                 | -2.68E-03                | -4.23E-04                | -1.36E-02                | 1.38E-02 | 1.26E+01 | -4.57E-03 | 2.32E-03  | 9.97E-02 | 9.98E-02 |
| 1.17E+01                 | 4.03E-03                 | -6.88E-03                | -4.69E-02                | 4.69E-02                 | 1.22E+01                 | 6.69E-04                 | 3.56E-03                 | -5.42E-03                | 6.59E-03 | 1.26E+01 | -6.89E-03 | 3.85E-03  | 9.05E-02 | 9.11E-02 |
| 1.17E+01                 | 3.30E-03                 | -3.54E-03                | -5.69E-02                | 5.71E-02                 | 1.22E+01                 | 2.36E-03                 | -1.88E-03                | 1.94E-03                 | 3.69E-03 | 1.26E+01 | -4.38E-03 | 1.74E-03  | 9.19E-02 | 9.20E-02 |
| 1.18E+01                 | 5.51E-03                 | 3.37E-03                 | -5.42E-02                | 6.45E-02                 | 1.22E+01                 | 3.10E-04                 | -4.90E-04                | 1.06E-02                 | 1.06E-02 | 1.26E+01 | -5.43E-03 | 3.01E-03  | 9.07E-02 | 9.09E-02 |
| 1.18E+01                 | 3.62E-03                 | 1.78E-03                 | -7.72E-02                | 7.73E-02                 | 1.22E+01                 | -1.38E-03                | 2.66E-03                 | 1.46E-02                 | 1.49E-02 | 1.26E+01 | -3.62E-03 | 1.22E-03  | 9.06E-02 | 9.07E-02 |
| 1.18E+01                 | 3.09E-03                 | 1.77E-02                 | -8.12E-02                | 8.13E-02                 | 1.22E+01                 | 1.07E-03                 | 9.96E-04                 | 2.01E-02                 | 2.01E-02 | 1.26E+01 | -4.54E-03 | 2.94E-03  | 8.95E-02 | 8.96E-02 |
| 1.18E+01                 | 2.85E-03                 | -3.76E-03                | -8.79E-02                | 8.80E-02                 | 1.22E+01                 | -8.24E-04                | -3.22E-03                | 2.51E-02                 | 2.54E-02 | 1.26E+01 | -6.28E-03 | 1.22E-03  | 8.84E-02 | 8.87E-02 |
| 1.18E+01                 | 5.34E-03                 | -2.45E-03                | -9.49E-02                | 9.51E-02                 | 1.22E+01                 | -2.66E-03                | 3.06E-04                 | 3.31E-02                 | 3.32E-02 | 1.27E+01 | -4.89E-03 | 3.69E-04  | 8.76E-02 | 8.78E-02 |
| 1.18E+01                 | 4.19E-03                 | -3.54E-03                | -1.03E-01                | 1.03E-01                 | 1.22E+01                 | -2.33E-03                | 1.23E-03                 | 3.87E-02                 | 3.88E-02 | 1.27E+01 | -3.39E-03 | 1.08E-03  | 8.40E-02 | 8.41E-02 |
| 1.18E+01                 | 4.66E-03                 | -1.50E-03                | -1.12E-01                | 1.12E-01                 | 1.22E+01                 | -1.53E-03                | 1.54E-03                 | 4.44E-02                 | 4.45E-02 | 1.27E+01 | -2.46E-03 | 3.15E-04  | 8.45E-02 | 8.46E-02 |
| 1.18E+01                 | 6.17E-03                 | -1.96E-03                | -1.24E-01                | 1.25E-01                 | 1.23E+01                 | -3.68E-03                | 1.43E-03                 | 4.83E-02                 | 4.85E-02 | 1.27E+01 | -8.73E-04 | 4.06E-03  | 8.22E-02 | 8.33E-02 |
| 1.18E+01                 | 8.52E-03                 | -1.51E-03                | -1.37E-01                | 1.38E-01                 | 1.23E+01                 | -2.98E-03                | 2.32E-04                 | 5.51E-02                 | 5.51E-02 | 1.27E+01 | -1.78E-03 | -1.07E-03 | 8.09E-02 | 8.10E-02 |
| 1.18E+01                 | 9.84E-03                 | -1.15E-03                | -1.49E-01                | 1.49E-01                 | 1.23E+01                 | -1.72E-03                | 1.08E-03                 | 5.91E-02                 | 5.91E-02 | 1.27E+01 | -4.78E-03 | 2.19E-03  | 7.78E-02 | 7.79E-02 |
| 1.18E+01                 | 1.07E-02                 | 1.07E-02                 | -1.61E-01                | 1.61E-01                 | 1.23E+01                 | -1.23E-03                | 1.23E-03                 | 6.20E-02                 | 6.21E-02 | 1.27E+01 | -1.77E-03 | 1.77E-03  | 7.40E-02 | 7.41E-02 |
| 1.19E+01                 | 1.14E-02                 | -3.03E-03                | -1.71E-01                | 1.72E-01                 | 1.23E+01                 | -8.75E-04                | 9.16E-04                 | 6.83E-02                 | 6.83E-02 | 1.27E+01 | -4.38E-03 | 2.80E-03  | 7.70E-02 | 7.72E-02 |
| 1.19E+01                 | 1.19E-02                 | -3.42E-03                | -1.80E-01                | 1.81E-01                 | 1.23E+01                 | -1.66E-03                | 2.74E-03                 | 7.21E-02                 | 7.22E-02 | 1.27E+01 | -2.81E-03 | 1.86E-03  | 7.19E-02 | 7.20E-02 |
| 1.19E+01                 | 9.98E-03                 | -2.66E-03                | -1.84E-01                | 1.84E-01                 | 1.23E+01                 | -2.47E-03                | 1.12E-03                 | 7.42E-02                 | 7.43E-02 | 1.27E+01 | -3.61E-03 | 4.19E-04  | 7.26E-02 | 7.27E-02 |
| 1.19E+01                 | 1.21E-02                 | -1.38E-03                | -1.91E-01                | 1.91E-01                 | 1.23E+01                 | -4.60E-03                | 1.08E-03                 | 7.70E-02                 | 7.72E-02 | 1.28E+01 | -5.10E-03 | 2.54E-04  | 6.89E-02 | 6.90E-02 |
| 1.19E+01                 | 1.31E-02                 | -3.46E-03                | -1.98E-01                | 1.98E-01                 | 1.23E+01                 | -3.64E-03                | 2.62E-03                 | 8.10E-02                 | 8.11E-02 | 1.28E+01 | -2.70E-03 | -1.20E-03 | 6.81E-02 | 6.82E-02 |
| 1.19E+01                 | 9.81E-03                 | -3.01E-03                | -2.00E-01                | 2.00E-01                 | 1.23E+01                 | -7.04E-03                | 4.92E-04                 | 9.49E-02                 | 9.49E-02 | 1.28E+01 | -4.41E-03 | -4.30E-05 | 6.50E-02 | 6.52E-02 |
| 1.19E+01                 | 1.01E-02                 | -2.63E-03                | -1.95E-01                | 1.95E-01                 | 1.24E+01                 | -3.53E-03                | 2.82E-03                 | 8.48E-02                 | 8.49E-02 | 1.28E+01 | -2.84E-03 | -4.85E-04 | 6.51E-02 | 6.51E-02 |
| 1.19E+01                 | -6.01E-02                | -4.91E-02                | -1.24E-01                | 1.24E-01                 | 1.24E+01                 | -4.07E-03                | -4.07E-03                | 8.39E-02                 | 8.39E-02 | 1.28E+01 | -4.34E-03 | 1.29E-03  | 6.19E-02 | 6.20E-02 |
| 1.19E+01                 | 6.10E-03                 | -2.55E-03                | -1.79E-01                | 1.80E-01                 | 1.24E+01                 | -5.33E-03                | 2.42E-03                 | 8.91E-02                 | 8.93E-02 | 1.28E+01 | -3.34E-03 | -3.53E-05 | 6.09E-02 | 6.10E-02 |
| 1.20E+01                 | 6.50E-03                 | -4.98E-03                | -1.69E-01                | 1.69E-01                 | 1.24E+01                 | -6.53E-03                | 3.69E-03                 | 8.99E-02                 | 9.01E-02 | 1.28E+01 | -2.14E-03 | 1.79E-03  | 5.83E-02 | 5.84E-02 |
| 1.20E+01                 | 7.90E-03                 | -6.60E-03                | -1.59E-01                | 1.59E-01                 | 1.24E+01                 | -3.55E-03                | 4.10E-03                 | 9.40E-02                 | 9.41E-02 | 1.28E+01 | -2.35E-03 | 2.22E-03  | 5.53E-02 | 5.54E-02 |
| 1.20E+01                 | 7.89E-03                 | -6.61E-03                | -1.59E-01                | 1.57E-01                 | 1.24E+01                 | -4.39E-03                | 3.34E-04                 | 9.47E-02                 | 9.48E-02 | 1.28E+01 | -1.47E-03 | 1.95E-03  | 5.42E-02 | 5.43E-02 |
| 1.20E+01                 | 1.01E-02                 | 2.45E-04                 | -1.49E-01                | 1.50E-01                 | 1.24E+01                 | -6.96E-03                | 7.95E-04                 | 9.53E-02                 | 9.55E-02 | 1.29E+01 | -3.16E-03 | 1.53E-03  | 5.15E-02 | 5.16E-02 |
| 1.20E+01                 | 7.76E-03                 | -6.69E-04                | -1.42E-01                | 1.42E-01                 | 1.24E+01                 | -6.45E-03                | 4.02E-03                 | 9.57E-02                 | 9.57E-02 | 1.29E+01 | -2.06E-04 | 4.37E-03  | 5.03E-02 | 5.05E-02 |
| 1.20E+01                 | 5.08E-03                 | -3.29E-04                | -1.34E-01                | 1.34E-01                 | 1.24E+01                 | -8.84E-03                | 4.60E-03                 | 9.89E-02                 | 9.89E-02 | 1.29E+01 | -5.25E-05 | 1.74E-04  | 4.67E-02 | 4.67E-02 |
| 1.20E+01                 | 6.39E-03                 | -3.17E-03                | -1.27E-01                | 1.27E-01                 | 1.24E+01                 | -3.89E-03                | 1.52E-03                 | 9.93E-02                 | 9.93E-02 | 1.29E+01 | -4.39E-03 | 3.79E-04  | 4.50E-02 | 4.51E-02 |
| 1.20E+01                 | 5.93E-03                 | -2.31E-03                | -1.17E-01                | 1.17E-01                 | 1.25E+01                 | -2.90E-03                | 6.46E-04                 | 9.81E-02                 | 9.82E-02 | 1.29E+01 | -3.01E-03 | 1.19E-04  | 4.20E-02 | 4.21E-02 |
| 1.20E+01                 | 5.11E-03                 | -1.81E-03                | -1.09E-01                | 1.09E-01                 | 1.25E+01                 | -6.98E-03                | 5.16E-03                 | 9.97E-02                 | 1.00E-01 | 1.29E+01 | -3.12E-04 | 5.30E-04  | 3.89E-02 | 3.89E-02 |
| 1.20E+01                 | 6.20E-03                 | 3.40E-04                 | -1.03E-01                | 1.04E-01                 | 1.25E+01                 | -2.98E-03                | 1.23E-03                 | 9.90E-02                 | 9.90E-02 | 1.29E+01 | -1.29E-03 | 3.99E-04  | 3.77E-02 | 3.77E-02 |
| 1.21E+01                 | 2.71E-03                 | -1.72E-03                | -9.29E-02                | 9.30E-02                 | 1.25E+01                 | -4.70E-03                | 9.80E-04                 | 9.92E-02                 | 9.94E-02 | 1.29E+01 | -3.80E-04 | 1.18E-03  | 3.70E-02 | 3.70E-02 |
| 1.21E+01                 | 4.29E-03                 | -1.15E-03                | -8.64E-02                | 8.65E-02                 | 1.25E+01                 | -2.97E-03                | 2.64E-03                 | 9.90E-02                 | 9.91E-02 | 1.29E+01 | -1.40E-03 | 1.74E-03  | 3.16E-02 | 3.17E-02 |
| 1.21E+01                 | 6.68E-03                 | -1.67E-03                | -7.76E-02                | 7.79E-02                 | 1.25E+01                 | -3.69E-03                | -3.08E-04                | 9.83E-02                 | 9.84E-02 | 1.29E+01 | -2.10E-03 | -3.09E-04 | 3.29E-02 | 3.30E-02 |
| 1.21E+01                 | 4.98E-03                 | -1.36E-03                | -7.17E-02                | 7.19E-02                 | 1.25E+01                 | -6.03E-03                | 1.63E-03                 | 1.00E-01                 | 1.01E-01 | 1.30E+01 | -8.70E-04 | -6.57E-04 | 2.70E-02 | 2.70E-02 |

|                          |                          |                          |                          |                          |                          |                          |                          |                          |          |          |           |           |           |          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------|----------|-----------|-----------|-----------|----------|
| air bearing data page 31 | air bearing data page 31 | air bearing data page 31 | air bearing data page 32 | air bearing data page 32 | air bearing data page 32 | air bearing data page 33 | air bearing data page 33 | air bearing data page 33 |          |          |           |           |           |          |
| 1.30E+01                 | -1.38E-03                | 2.37E-03                 | 2.48E-02                 | 2.50E-02                 | 1.34E+01                 | 1.75E-03                 | -1.40E-03                | -3.71E-03                | 4.34E-03 | 1.38E+01 | -1.91E-05 | -0.21E-03 | -1.62E-03 | 2.74E-03 |
| 1.30E+01                 | 1.79E-03                 | -5.86E-04                | 2.90E-02                 | 2.91E-02                 | 1.34E+01                 | 1.72E-03                 | 1.50E-03                 | -3.13E-03                | 3.87E-03 | 1.38E+01 | -3.08E-04 | -1.15E-04 | -2.48E-04 | 4.12E-04 |
| 1.30E+01                 | -3.14E-04                | -0.27E-02                | 2.51E-02                 | 2.52E-02                 | 1.34E+01                 | 1.60E-03                 | -4.47E-04                | -2.12E-03                | 2.42E-03 | 1.38E+01 | 3.28E-04  | -1.03E-03 | -9.06E-04 | 1.41E-03 |
| 1.30E+01                 | 3.99E-03                 | -1.89E-03                | 1.34E-01                 | 1.34E-01                 | 1.34E+01                 | -1.89E-03                | -2.29E-03                | -3.51E-03                | 3.39E-03 | 1.38E+01 | 2.43E-03  | 2.43E-03  | -5.41E-04 | 2.54E-03 |
| 1.30E+01                 | 1.19E-05                 | -1.93E-03                | 1.74E-02                 | 1.75E-02                 | 1.34E+01                 | 6.74E-04                 | 1.62E-03                 | -2.72E-03                | 3.24E-03 | 1.38E+01 | 6.68E-04  | 8.90E-04  | 1.24E-03  | 1.65E-03 |
| 1.30E+01                 | 4.62E-04                 | 5.44E-04                 | 1.49E-02                 | 1.50E-02                 | 1.34E+01                 | -1.12E-03                | 4.26E-04                 | 8.34E-04                 | 1.68E-03 | 1.38E+01 | 1.64E-03  | 5.29E-04  | 3.17E-04  | 1.75E-03 |
| 1.30E+01                 | -2.27E-03                | -1.79E-03                | 1.54E-02                 | 1.57E-02                 | 1.35E+01                 | 1.19E-03                 | 6.04E-04                 | -5.03E-04                | 1.42E-03 | 1.39E+01 | -6.26E-04 | 2.82E-04  | -6.56E-04 | 9.49E-04 |
| 1.30E+01                 | 4.31E-04                 | 8.24E-04                 | 1.22E-02                 | 1.22E-02                 | 1.35E+01                 | 3.96E-04                 | -1.15E-03                | 1.14E-04                 | 1.22E-03 | 1.39E+01 | -2.37E-05 | -2.05E-03 | -1.69E-03 | 2.78E-03 |
| 1.30E+01                 | 4.87E-04                 | -4.86E-04                | 8.02E-03                 | 8.05E-03                 | 1.35E+01                 | 5.03E-04                 | -0.27E-03                | 9.09E-04                 | 2.49E-03 | 1.39E+01 | 1.66E-04  | -4.20E-05 | -1.11E-03 | 1.12E-03 |
| 1.31E+01                 | -8.24E-04                | 3.46E-05                 | 8.40E-03                 | 8.44E-03                 | 1.35E+01                 | -6.57E-04                | 2.07E-03                 | -1.42E-03                | 2.59E-03 | 1.39E+01 | 1.95E-03  | 3.13E-04  | -6.05E-04 | 2.07E-03 |
| 1.31E+01                 | -8.54E-04                | 1.54E-04                 | 5.71E-03                 | 5.77E-03                 | 1.35E+01                 | -2.21E-03                | -1.42E-03                | -5.69E-04                | 2.69E-03 | 1.39E+01 | -3.59E-04 | 8.72E-05  | 4.76E-04  | 6.01E-04 |
| 1.31E+01                 | 2.43E-04                 | 1.76E-03                 | 2.39E-03                 | 2.39E-03                 | 1.35E+01                 | 4.62E-04                 | -1.46E-03                | 2.51E-03                 | 2.19E-03 | 1.39E+01 | 1.63E-03  | 1.11E-03  | -1.16E-03 | 2.02E-03 |
| 1.31E+01                 | 4.98E-04                 | -2.10E-03                | 1.79E-03                 | 2.81E-03                 | 1.35E+01                 | -2.64E-04                | 1.98E-04                 | -1.11E-03                | 1.18E-03 | 1.39E+01 | 4.85E-04  | -2.54E-04 | -1.26E-04 | 5.62E-04 |
| 1.31E+01                 | -2.35E-04                | 3.80E-04                 | 2.26E-06                 | 4.47E-04                 | 1.35E+01                 | -7.77E-04                | 2.01E-04                 | -8.37E-04                | 1.16E-03 | 1.40E+01 | -2.10E-03 | 1.64E-03  | -7.82E-06 | 2.67E-03 |
| 1.31E+01                 | 1.24E-03                 | -1.05E-03                | -1.72E-03                | 2.36E-03                 | 1.35E+01                 | 2.30E-04                 | 1.04E-03                 | -1.65E-04                | 1.09E-03 | 1.40E+01 | 8.03E-04  | 1.76E-04  | 1.78E-04  | 8.68E-04 |
| 1.31E+01                 | 6.98E-04                 | -3.47E-04                | -3.36E-03                | 3.51E-03                 | 1.35E+01                 | -2.87E-04                | -1.38E-04                | -1.42E-04                | 3.49E-04 | 1.40E+01 | 7.88E-04  | 7.08E-04  | 2.97E-04  | 1.10E-03 |
| 1.31E+01                 | -3.83E-04                | 7.86E-04                 | -4.25E-03                | 4.34E-03                 | 1.36E+01                 | -2.31E-04                | 1.04E-03                 | -6.86E-04                | 1.27E-03 | 1.40E+01 | -3.13E-03 | -1.40E-03 | 3.34E-04  | 3.45E-03 |
| 1.31E+01                 | 8.24E-04                 | -2.31E-03                | -6.46E-03                | 6.90E-03                 | 1.36E+01                 | 5.45E-04                 | 1.14E-03                 | -1.61E-03                | 2.05E-03 | 1.40E+01 | -3.13E-03 |           |           |          |

|                          |                          |                          |                          |                          |                          |                          |                          |                          |          |          |            |           |           |          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------|----------|------------|-----------|-----------|----------|
| air bearing data page 37 | air bearing data page 37 | air bearing data page 37 | air bearing data page 38 | air bearing data page 38 | air bearing data page 38 | air bearing data page 39 | air bearing data page 39 | air bearing data page 39 |          |          |            |           |           |          |
| 1.56E+01                 | -6.46E-04                | 8.29E-04                 | 1.13E-02                 | 1.34E-02                 | 1.60E+01                 | -7.03E-04                | -1.26E-04                | -1.11E-02                | 1.12E-02 | 1.64E+01 | -2.09E-03  | -7.99E-04 | 1.93E-03  | 2.96E-03 |
| 1.56E+01                 | -3.26E-03                | 1.05E-03                 | 1.16E-02                 | 1.21E-02                 | 1.60E+01                 | 2.34E-04                 | 9.37E-04                 | -1.14E-02                | 1.14E-02 | 1.64E+01 | 1.89E-03   | -0.27E-04 | -7.55E-04 | 2.04E-03 |
| 1.56E+01                 | 4.67E-04                 | 5.35E-04                 | 7.44E-03                 | 7.47E-03                 | 1.60E+01                 | 7.39E-04                 | 1.35E-03                 | -1.08E-02                | 1.09E-02 | 1.64E+01 | 1.83E-03   | 1.11E-04  | -1.02E-03 | 2.10E-03 |
| 1.56E+01                 | -1.10E-03                | 3.11E-03                 | 5.31E-03                 | 5.34E-03                 | 1.60E+01                 | 2.57E-05                 | 5.50E-04                 | -7.76E-03                | 7.79E-03 | 1.64E+01 | -1.03E-04  | -0.21E-03 | -1.15E-03 | 2.50E-03 |
| 1.56E+01                 | 2.57E-03                 | 5.18E-04                 | 1.82E-03                 | 3.19E-03                 | 1.60E+01                 | 1.89E-03                 | 2.05E-03                 | -7.82E-03                | 8.23E-03 | 1.65E+01 | -3.32E-04  | 2.36E-03  | -2.30E-03 | 3.31E-03 |
| 1.56E+01                 | -1.32E-03                | -4.69E-04                | -2.83E-04                | 1.34E-03                 | 1.60E+01                 | -8.38E-04                | -2.49E-03                | -7.70E-03                | 8.14E-03 | 1.65E+01 | 1.61E-04   | -2.40E-03 | 1.25E-03  | 2.71E-03 |
| 1.56E+01                 | -3.47E-05                | -1.15E-03                | -6.79E-04                | 1.34E-03                 | 1.60E+01                 | 1.17E-03                 | -6.30E-04                | -8.80E-03                | 8.90E-03 | 1.65E+01 | -6.51E-04  | -0.52E-03 | 3.32E-03  | 4.22E-03 |
| 1.56E+01                 | 1.72E-03                 | 6.02E-04                 | -1.20E-03                | 2.18E-03                 | 1.61E+01                 | 8.16E-04                 | 2.30E-03                 | -9.27E-03                | 9.59E-03 | 1.65E+01 | 4.28E-04   | 1.20E-03  | -1.20E-03 | 1.79E-03 |
| 1.56E+01                 | -2.15E-03                | 1.21E-03                 | -3.68E-03                | 4.43E-03                 | 1.61E+01                 | -1.01E-03                | 2.39E-03                 | -6.93E-03                | 7.40E-03 | 1.65E+01 | -1.80E-04  | 1.64E-04  | 2.26E-04  | 3.17E-04 |
| 1.56E+01                 | -1.32E-04                | -1.50E-03                | -4.74E-03                | 4.74E-03                 | 1.61E+01                 | -2.48E-04                | -1.45E-03                | -3.55E-03                | 3.85E-03 | 1.65E+01 | 5.95E-04   | 2.71E-04  | 5.19E-04  | 8.34E-04 |
| 1.57E+01                 | 7.90E-04                 | -8.47E-04                | -6.30E-03                | 6.40E-03                 | 1.61E+01                 | -2.80E-05                | -8.96E-04                | -4.34E-03                | 4.43E-03 | 1.65E+01 | 2.17E-04   | -4.25E-04 | -8.89E-04 | 1.01E-03 |
| 1.57E+01                 | -0.19E-04                | 1.12E-03                 | -8.14E-03                | 8.29E-03                 | 1.61E+01                 | -4.02E-04                | -1.03E-03                | 5.15E-03                 | 5.20E-03 | 1.65E+01 | 1.99E-03   | -0.01E-03 | -4.09E-04 | 2.35E-03 |
| 1.57E+01                 | 3.97E-04                 | 1.41E-04                 | -6.95E-03                | 6.97E-03                 | 1.61E+01                 | -8.81E-04                | -8.12E-04                | -6.82E-03                | 6.73E-03 | 1.65E+01 | 3.17E-04   | -4.35E-03 | -4.53E-03 | 4.69E-03 |
| 1.57E+01                 | 7.18E-04                 | -6.85E-04                | -1.02E-02                | 1.03E-02                 | 1.61E+01                 | -1.24E-03                | 6.72E-04                 | -5.59E-03                | 5.57E-03 | 1.65E+01 | -6.03E-04  | -1.49E-03 | -1.15E-03 | 2.20E-03 |
| 1.57E+01                 | 1.89E-03                 | -1.19E-03                | -6.43E-03                | 6.80E-03                 | 1.61E+01                 | 1.87E-03                 | -1.15E-03                | -3.87E-03                | 4.44E-03 | 1.66E+01 | -3.96E-04  | -2.98E-04 | 1.34E-03  | 1.42E-03 |
| 1.57E+01                 | -4.77E-04                | 4.31E-04                 | -1.07E-02                | 1.07E-02                 | 1.61E+01                 | -1.90E-03                | -1.11E-04                | -2.06E-03                | 2.80E-03 | 1.66E+01 | 8.01E-04   | 1.46E-04  | -9.26E-04 | 1.23E-03 |
| 1.57E+01                 | 1.62E-03                 | -8.29E-04                | -1.27E-02                | 1.28E-02                 | 1.61E+01                 | 1.18E-03                 | 3.80E-03                 | -2.26E-03                | 4.58E-03 | 1.66E+01 | -2.15E-03  | 4.62E-04  | -1.84E-03 | 2.87E-03 |
| 1.57E+01                 | -5.14E-04                | -3.20E-03                | -1.13E-02                | 1.16E-02                 | 1.62E+01                 | 8.44E-04                 | 1.83E-04                 | -1.34E-03                | 1.59E-03 | 1.66E+01 | 1.47E-03   | 2.52E-03  | -2.43E-03 | 2.92E-03 |
| 1.57E+01                 | 2.84E-03                 | 1.41E-03                 | -1.07E-02                | 1.12E-02                 | 1.62E+01                 | -1.02E-03                | -1.60E-03                | -3.58E-03                | 4.05E-03 | 1.66E+01 | 7.49E-05   | 1.92E-03  | 2.08E-04  | 1.93E-03 |
| 1.57E+01                 | 1.23E-03                 | 1.03E-02                 | -1.03E-02                | 1.03E-02                 | 1.62E+01                 | 1.02E-04                 | 2.08E-04                 | -2.92E-04                | 2.30E-03 | 1.66E+01 | 7.02E-04   | 4.32E-04  | 1.71E-03  | 1.90E-03 |
| 1.58E+01                 | 1.02E-03                 | 4.55E-04                 | -1.19E-02                | 1.20E-02                 | 1.62E+01                 | -8.00E-04                | -8.97E-04                | -1.30E-04                | 1.07E-03 | 1.66E+01 | -2.23E-03  | -1.28E-03 | -6.83E-04 | 2.63E-03 |
| 1.58E+01                 | 2.54E-04                 | 2.03E-03                 | -1.95E-02                | 1.67E-02                 | 1.62E+01                 | 8.98E-04                 | -2.50E-03                | -1.14E-03                | 2.89E-03 | 1.66E+01 | 1.94E-03   | 1.57E-03  | -3.24E-04 | 2.51E-03 |
| 1.58E+01                 | 1.78E-03                 | -8.75E-04                | -1.49E-02                | 1.50E-02                 | 1.62E+01                 | -1.01E-03                | -8.69E-05                | -3.02E-03                | 3.18E-03 | 1.66E+01 | -1.31E-03  | 4.88E-04  | 1.29E-03  | 1.90E-03 |
| 1.58E+01                 | -2.37E-04                | -1.46E-03                | -1.29E-02                | 1.30E-02                 | 1.62E+01                 | 1.55E-04                 | 1.14E-03                 | -1.15E-03                | 1.62E-03 | 1.67E+01 | -0.202E-03 | -2.40E-03 | -1.54E-03 | 3.49E-03 |
| 1.58E+01                 | -4.29E-04                | -2.30E-03                | -1.50E-02                | 1.52E-02                 | 1.62E+01                 | 1.90E-03                 | 1.14E-04                 | -5.13E-04                | 1.98E-03 | 1.67E+01 | -1.24E-03  | 3.01E-04  | -7.82E-05 | 1.28E-03 |
| 1.58E+01                 | 3.82E-03                 | -1.61E-03                | -1.47E-02                | 1.53E-02                 | 1.62E+01                 | 1.94E-03                 | 2.01E-03                 | 1.99E-04                 | 2.80E-03 | 1.67E+01 | 7.54E-04   | -9.25E-04 | -2.34E-04 | 1.22E-03 |
| 1.58E+01                 | 1.59E-03                 | 1.46E-03                 | -1.46E-02                | 1.48E-02                 | 1.62E+01                 | -3.24E-04                | -1.39E-03                | -2.36E-03                | 2.78E-03 | 1.67E+01 | -1.04E-03  | -3.02E-04 | -8.73E-04 | 1.39E-03 |
| 1.58E+01                 | -0.207E-04               | -0.240E-04               | -1.03E-02                | 1.03E-02                 | 1.63E+01                 | 1.63E-02                 | 8.30E-04                 | -1.69E-03                | 1.67E-03 | 1.67E+01 | -3.47E-03  | -2.16E-03 | -2.04E-03 | 3.89E-03 |
| 1.58E+01                 | -8.10E-04                | -1.28E-03                | -1.26E-02                | 1.27E-02                 | 1.63E+01                 | -1.25E-03                | -8.42E-04                | -1.57E-04                | 1.41E-03 | 1.67E+01 | 4.68E-04   | 1.55E-03  | 9.23E-04  | 1.95E-03 |
| 1.58E+01                 | -2.72E-04                | 6.91E-04                 | -1.35E-02                | 1.35E-02                 | 1.63E+01                 | -1.04E-03                | 8.67E-04                 | 1.24E-04                 | 1.36E-03 | 1.67E+01 | -4.33E-04  | 7.89E-05  | 9.39E-04  | 1.04E-03 |
| 1.59E+01                 | 3.41E-04                 | -0.27E-03                | -1.33E-02                | 1.35E-02                 | 1.63E+01                 | -2.15E-03                | 7.40E-05                 | -4.07E-04                | 2.19E-03 | 1.67E+01 | -4.44E-04  | 2.52E-03  | -1.69E-03 | 3.06E-03 |
| 1.59E+01                 | 8.60E-04                 | -2.19E-04                | -1.17E-02                | 1.17E-02                 | 1.63E+01                 | 5.67E-04                 | 1.22E-03                 | -2.42E-03                | 2.76E-03 | 1.67E+01 | 2.20E-04   | 1.46E-03  | 2.99E-04  | 1.50E-03 |
| 1.59E+01                 | 3.20E-03                 | 7.77E-04                 | -1.58E-02                | 1.62E-02                 | 1.63E+01                 | -1.69E-04                | 6.85E-04                 | 4.89E-04                 | 8.59E-04 | 1.67E+01 | 4.80E-04   | 2.02E-03  | 7.05E-04  | 2.19E-03 |
| 1.59E+01                 | 7.99E-04                 | 2.01E-03                 | -1.39E-02                | 1.40E-02                 | 1.63E+01                 | -4.92E-04                | -2.07E-03                | -1.27E-03                | 2.12E-03 | 1.68E+01 | -4.64E-04  | -7.98E-04 | 1.46E-03  | 1.73E-03 |
| 1.59E+01                 | -9.00E-04                | -1.29E-03                | -1.49E-02                | 1.49E-02                 | 1.63E+01                 | -7.94E-04                | -6.35E-04                | 1.29E-03                 | 1.62E-03 | 1.68E+01 | -1.09E-04  | 2.47E-03  | 1.33E-03  | 2.81E-03 |
| 1.59E+01                 | 1.39E-04                 | -0.207E-04               | -1.41E-02                | 1.41E-02                 | 1.63E+01                 | -1.03E-04                | -8.33E-04                | -2.33E-04                | 1.91E-03 | 1.68E+01 | 1.79E-03   | 3.85E-03  | -2.71E-04 | 4.94E-03 |
| 1.59E+01                 | -8.81E-04                | -1.47E-03                | -1.36E-02                | 1.37E-02                 | 1.63E+01                 | -5.75E-04                | -2.10E-03                | 2.19E-04                 | 2.28E-03 | 1.68E+01 | 1.05E-03   | -2.44E-03 | -1.52E-03 | 3.05E-03 |
| 1.59E+01                 | -7.33E-04                | 9.12E-04                 | -1.19E-02                | 1.20E-02                 | 1.64E+01                 | -2.00E-04                | 3.51E-04                 | 1.70E-04                 | 4.41E-04 | 1.68E+01 | -1.10E-03  | 1.90E-03  | 7.62E-04  | 2.40E-03 |
| 1.59E+01                 | -6.02E-05                | 5.19E-05                 | -1.11E-02                | 1.11E-02                 | 1.64E+01                 | 1.14E-03                 | 2.16E-03                 | 8.85E-04                 | 2.60E-03 | 1.68E+01 | -1.94E-03  | -1.64E-04 | 1.70E-03  | 2.58E-03 |
| 1.59E+01                 | 7.18E-04                 | -1.99E-03                | -1.20E-02                | 1.21E-02                 | 1.64E+01                 | 1.16E-03                 | -1.80E-03                | -3.54E-04                | 2.17E-03 | 1.68E+01 | -3.25E-03  | 3.77E-04  | 2.21E-03  | 3.95E-03 |
| 1.60E+01                 | 1.93E-04                 | -1.64E-03                | -1.02E-02                | 1.04E-02                 | 1.64E+01                 | -6.62E-04                | -1.12E-03                | 9.88E-04                 | 1.78E-03 | 1.68E+01 | -1.72E-03  | -8.97E-04 | 4.73E-03  | 5.11E-03 |
| 1.60E+01                 | -2.24E-04                | -7.97E-04                | -1.13E-02                | 1.13E-02                 | 1.64E+01                 | -3.12E-04                | -2.45E-03                | -1.26E-03                | 2.77E-03 | 1.68E+01 | -6.54E-04  | 2.96E-04  | 1.61E-02  | 1.62E-02 |
| 1.60E+01                 | 1.46E-03                 | -1.42E-03                | -1.08E-02                | 1.10E-02                 | 1.64E+01                 | -1.13E-03                | 4.82E-04                 | -2.74E-03                | 3.00E-03 | 1.68E+01 | -2.19E-05  | -1.43E-04 | 2.92E-02  | 2.92E-02 |

|                          |                          |                          |                          |                          |                          |                          |                          |                          |          |          |          |           |           |          |
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| 1.69E+01                 | -3.23E-03                | -7.79E-04                | 4.50E-02                 | 4.51E-02                 | 1.73E+01                 | -7.97E-03                | 2.13E-01                 | 1.32E-01                 | 1.32E-01 | 1.77E+01 | 3.13E-03 | -1.27E-03 | -3.84E-02 | 3.65E-02 |
| 1.69E+01                 | -1.58E-03                | -4.01E-04                | 6.42E-02                 | 6.42E-02                 | 1.73E+01                 | -8.32E-03                | 3.27E-04                 | 1.26E-01                 | 1.27E-01 | 1.77E+01 | 2.22E-03 | 3.17E-03  | -3.46E-02 | 3.48E-02 |
| 1.69E+01                 | -3.40E-03                | 2.53E-02                 | 8.39E-02                 | 8.39E-02                 | 1.73E+01                 | -6.42E-03                | 1.80E-02                 | 1.12E-01                 | 1.22E-01 | 1.77E+01 | 3.84E-04 | -3.02E-03 | -3.79E-02 | 3.79E-02 |
| 1.69E+01                 | -3.47E-03                | -1.02E-03                | 1.02E-02                 | 1.02E-02                 | 1.73E+01                 | -4.71E-03                | 1.89E-03                 | 1.77E-01                 | 1.77E-01 | 1.77E+01 | 3.76E-03 | 3.76E-03  | -3.94E-02 | 3.89E-02 |
| 1.69E+01                 | -4.00E-03                | 2.91E-04                 | 1.27E-01                 | 1.27E-01                 | 1.73E+01                 | -6.80E-03                | 2.88E-03                 | 1.10E-01                 | 1.10E-01 | 1.78E+01 | 3.74E-03 | 1.99E-03  | -4.28E-02 | 4.30E-02 |
| 1.69E+01                 | -8.40E-03                | 2.55E-03                 | 1.53E-01                 | 1.53E-01                 | 1.73E+01                 | -7.23E-03                | 1.60E-03                 | 1.06E-01                 | 1.07E-01 | 1.78E+01 | 2.56E-03 | -6.87E-04 | -4.42E-02 | 4.43E-02 |
| 1.69E+01                 | -8.14E-03                | 1.49E-03                 | 1.70E-01                 | 1.71E-01                 | 1.73E+01                 | -4.88E-03                | 4.92E-04                 | 1.01E-01                 | 1.02E-01 | 1.78E+01 | 3.03E-03 | -1.22E-03 | -4.12E-02 | 4.13E-02 |
| 1.69E+01                 | -6.00E-03                | -2.85E-03                | 1.83E-01                 | 1.83E-01                 | 1.74E+01                 | -5.27E-03                | -0.20E-04                | 9.44E-02                 | 9.49E-02 | 1.78E+01 | 3.59E-03 | 6.60E-04  | -6.50E-02 | 4.59E-02 |
| 1.69E+01                 | -1.16E-02                | 4.26E-04                 | 2.03E-01                 | 2.03E-01                 | 1.74E+01                 | -4.89E-03                | 3.61E-03                 | 8.97E-02                 | 8.98E-02 | 1.78E+01 | 2.73E-03 | -0.91E-03 | -3.94E-02 | 3.96E-02 |
| 1.69E+01                 | -1.24E-02                | 2.50E-03                 | 2.17E-01                 | 2.17E-01                 | 1.74E+01                 | -3.99E-03                | 1.59E-03                 | 8.35E-02                 | 8.36E-02 | 1.78E+01 | 1.45E-03 | 3.18E-03  | -4.57E-02 | 4.59E-02 |
| 1.70E+01                 | -1.34E-02                | 2.79E-03                 | 2.22E-01                 | 2.23E-01                 | 1.74E+01                 | -5.34E-03                | 1.47E-03                 | 7.60E-02                 | 7.62E-02 | 1.78E+01 | 1.30E-03 | -1.44E-03 | -4.72E-02 | 4.72E-02 |
| 1.70E+01                 | -1.30E-02                | 2.33E-03                 | 2.45E-01                 | 2.46E-01                 | 1.74E+01                 | -4.49E-03                | 8.80E-04                 | 7.37E-02                 | 7.38E-02 | 1.78E+01 | 2.53E-03 | 1.80E-03  | -4.87E-02 | 4.89E-02 |
| 1.70E+01                 | -1.34E-02                | 3.98E-03                 | 2.57E-01                 | 2.57E-01                 | 1.74E+01                 | -3.38E-03                | 3.89E-03                 | 6.87E-02                 | 6.87E-02 | 1.78E+01 | 1.68E-03 | 2.01E-03  | -5.04E-02 | 5.04E-02 |
| 1.70E+01                 | -1.56E-02                | 5.00E-03                 | 2.89E-01                 | 2.89E-01                 | 1.74E+01                 | -4.43E-03                | 8.84E-04                 | 6.10E-02                 | 6.12E-02 | 1.78E+01 | 4.01E-03 | -3.07E-03 | -5.14E-02 | 5.16E-02 |
| 1.70E+01                 | -1.63E-02                | 4.40E-03                 | 2.85E-01                 | 2.86E-01                 | 1.74E+01                 | -2.36E-03                | 4.51E-04                 | 5.54E-02                 | 5.55E-02 | 1.79E+01 | 2.33E-04 | -2.18E-03 | -4.78E-02 | 4.78E-02 |
| 1.70E+01                 | -1.45E-02                | 5.37E-03                 | 3.03E-01                 | 3.03E-01                 | 1.74E+01                 | -3.19E-03                | 1.45E-04                 | 5.32E-02                 | 5.33E-02 | 1.79E+01 | 2.67E-03 | 1.44E-03  | -4.97E-02 | 4.98E-02 |
| 1.70E+01                 | -1.67E-02                | 3.98E-03                 | 3.26E-01                 | 3.26E-01                 | 1.74E+01                 | -3.54E-03                | -1.04E-03                | 4.67E-02                 | 4.68E-02 | 1.79E+01 | 3.44E-03 | -2.48E-03 | -5.10E-02 | 5.12E-02 |
| 1.70E+01                 | -1.92E-02                | 3.58E-03                 | 3.55E-01                 | 3.55E-01                 | 1.75E+01                 | -1.99E-03                | 1.23E-04                 | 4.05E-02                 | 4.05E-02 | 1.79E+01 | 2.19E-03 |           |           |          |

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|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-----------|----------|----------|----------|
| 1.94E+01                 | 1.06E-03                 | 7.56E-04                 | -2.08E-03                | 2.45E-03                 | 1.99E+01                 | 3.36E-02                 | -6.76E-01                | -1.88E-02 | 8.20E-03 | 3.38E-01 | 3.39E-01 |
| 1.95E+01                 | 2.42E-03                 | 4.51E-03                 | -3.72E-03                | 4.51E-03                 | 1.99E+01                 | 3.66E-02                 | -7.71E-03                | -6.49E-01 | 6.50E-01 | 3.46E-01 | 3.46E-01 |
| 1.95E+01                 | 1.30E-03                 | 1.84E-03                 | -8.22E-03                | 8.52E-03                 | 1.99E+01                 | 3.15E-02                 | -7.29E-03                | -6.21E-01 | 6.22E-01 | 3.49E-01 | 3.50E-01 |
| 1.95E+01                 | 1.85E-04                 | 1.04E-02                 | -1.44E-02                | 1.89E-02                 | 1.99E+01                 | 2.83E-02                 | -1.23E-02                | -5.91E-01 | 5.93E-01 | 3.52E-01 | 3.52E-01 |
| 1.95E+01                 | 1.32E-03                 | 9.44E-04                 | -2.07E-02                | 2.08E-02                 | 1.99E+01                 | 2.91E-02                 | -8.08E-03                | -5.81E-01 | 5.82E-01 | 3.56E-01 | 3.56E-01 |
| 1.95E+01                 | 8.27E-04                 | -1.79E-03                | -2.84E-02                | 2.65E-02                 | 1.99E+01                 | 2.93E-02                 | -8.94E-03                | -5.31E-01 | 5.32E-01 | 3.69E-01 | 3.69E-01 |
| 1.95E+01                 | 5.09E-04                 | -2.08E-03                | -3.44E-02                | 3.44E-02                 | 1.99E+01                 | 2.92E-02                 | -8.82E-03                | -4.98E-01 | 4.99E-01 | 3.69E-01 | 3.69E-01 |
| 1.95E+01                 | 1.54E-03                 | 2.92E-04                 | -4.59E-02                | 4.59E-02                 | 1.99E+01                 | 2.44E-02                 | -5.93E-03                | -4.69E-01 | 4.70E-01 | 3.81E-01 | 3.82E-01 |
| 1.95E+01                 | 2.68E-03                 | 5.86E-04                 | -5.36E-02                | 5.37E-02                 | 2.00E+01                 | 2.31E-02                 | -8.27E-03                | -4.34E-01 | 4.35E-01 | 3.82E-01 | 3.83E-01 |
| 1.95E+01                 | 1.06E-03                 | -6.29E-03                | -5.28E-02                | 6.29E-02                 | 2.00E+01                 | 2.15E-02                 | -8.00E-03                | -4.01E-01 | 4.01E-01 | 3.84E-01 | 3.85E-01 |
| 1.95E+01                 | 3.42E-03                 | -6.57E-04                | -7.56E-02                | 7.57E-02                 | 2.00E+01                 | 1.96E-02                 | -7.09E-03                | -3.69E-01 | 3.67E-01 | 3.82E-01 | 3.82E-01 |
| 1.95E+01                 | 4.19E-03                 | 1.02E-05                 | -8.99E-02                | 8.99E-02                 | 2.00E+01                 | 2.01E-02                 | -8.15E-03                | -3.33E-01 | 3.33E-01 | 3.85E-01 | 3.85E-01 |
| 1.95E+01                 | 5.82E-03                 | -3.13E-03                | -1.01E-01                | 1.01E-01                 | 2.00E+01                 | 1.54E-02                 | -4.80E-03                | -3.00E-01 | 3.00E-01 | 3.87E-01 | 3.87E-01 |
| 1.95E+01                 | 4.86E-03                 | -7.50E-04                | -1.15E-01                | 1.15E-01                 | 2.00E+01                 | 1.43E-02                 | -4.99E-03                | -2.82E-01 | 2.82E-01 | 3.87E-01 | 3.87E-01 |
| 1.95E+01                 | 5.24E-03                 | -3.45E-03                | -1.35E-01                | 1.35E-01                 | 2.00E+01                 | 1.53E-02                 | -3.34E-03                | -2.27E-01 | 2.28E-01 | 3.86E-01 | 3.86E-01 |
| 1.95E+01                 | 8.99E-03                 | -3.26E-03                | -1.56E-01                | 1.56E-01                 | 2.00E+01                 | 7.92E-03                 | -3.81E-03                | -1.90E-01 | 1.91E-01 | 3.80E-01 | 3.80E-01 |
| 1.95E+01                 | 7.65E-03                 | -1.47E-03                | -1.77E-01                | 1.78E-01                 | 2.00E+01                 | 7.16E-03                 | -3.05E-03                | -1.52E-01 | 1.53E-01 | 3.81E-01 | 3.82E-01 |
| 1.95E+01                 | 8.60E-03                 | -3.75E-03                | -1.98E-01                | 1.98E-01                 | 2.00E+01                 | 7.28E-03                 | -3.57E-03                | -1.19E-01 | 1.19E-01 | 3.81E-01 | 3.81E-01 |
| 1.95E+01                 | 1.19E-02                 | -3.39E-03                | -2.26E-01                | 2.26E-01                 | 2.01E+01                 | 3.86E-03                 | -3.82E-03                | -8.46E-02 | 8.49E-02 | 3.67E-01 | 3.68E-01 |
| 1.95E+01                 | 1.33E-02                 | -1.33E-03                | -2.54E-01                | 2.54E-01                 | 2.01E+01                 | 1.89E-03                 | -4.83E-03                | -7.25E-02 | 7.25E-02 | 3.68E-01 | 3.69E-01 |
| 1.95E+01                 | 1.30E-02                 | -3.80E-03                | -2.88E-01                | 2.88E-01                 | 2.01E+01                 | -5.13E-05                | -1.26E-04                | -2.53E-02 | 2.53E-02 | 3.53E-01 | 3.54E-01 |
| 1.97E+01                 | 1.75E-02                 | -4.09E-03                | -3.25E-01                | 3.25E-01                 | 2.01E+01                 | 3.33E-03                 | 6.78E-04                 | -4.76E-03 | 5.85E-03 | 3.51E-01 | 3.51E-01 |
| 1.97E+01                 | 1.82E-02                 | -2.85E-03                | -3.58E-01                | 3.59E-01                 | 2.01E+01                 | -2.23E-03                | 3.54E-03                 | 3.44E-02  | 3.47E-02 | 3.48E-01 | 3.48E-01 |
| 1.97E+01                 | 2.21E-02                 | -7.12E-03                | -4.01E-01                | 4.01E-01                 | 2.01E+01                 | -5.97E-03                | 3.73E-03                 | 6.17E-02  | 6.21E-02 | 3.48E-01 | 3.48E-01 |
| 1.97E+01                 | 2.40E-02                 | -6.03E-03                | -4.41E-01                | 4.41E-01                 | 2.01E+01                 | -6.87E-03                | 6.16E-04                 | 8.78E-02  | 8.80E-02 | 3.47E-01 | 3.47E-01 |
| 1.97E+01                 | 2.21E-02                 | -9.37E-03                | -4.84E-01                | 4.85E-01                 | 2.01E+01                 | -6.62E-03                | 9.22E-04                 | 1.13E-01  | 1.13E-01 | 3.40E-01 | 3.40E-01 |
| 1.97E+01                 | 2.86E-02                 | -6.97E-03                | -5.31E-01                | 5.32E-01                 | 2.01E+01                 | -6.16E-03                | 2.46E-03                 | 1.34E-01  | 1.34E-01 | 3.36E-01 | 3.37E-01 |
| 1.97E+01                 | 3.37E-02                 | -6.52E-03                | -5.87E-01                | 5.87E-01                 | 2.01E+01                 | -4.37E-03                | 4.77E-03                 | 2.36E-01  | 2.36E-01 | 3.29E-01 | 3.29E-01 |
| 1.97E+01                 | 3.23E-02                 | -6.85E-03                | -6.31E-01                | 6.32E-01                 | 2.02E+01                 | -1.02E-02                | 1.48E-03                 | 1.74E-01  | 1.75E-01 | 3.26E-01 | 3.26E-01 |
| 1.97E+01                 | 3.60E-02                 | -1.25E-02                | -6.73E-01                | 6.74E-01                 | 2.02E+01                 | -1.28E-02                | 1.84E-03                 | 1.94E-01  | 1.94E-01 | 3.25E-01 | 3.25E-01 |
| 1.97E+01                 | 3.70E-02                 | -1.20E-02                | -7.19E-01                | 7.20E-01                 | 2.02E+01                 | -1.21E-02                | 3.50E-03                 | 2.11E-01  | 2.11E-01 | 3.20E-01 | 3.20E-01 |
| 1.98E+01                 | 4.09E-02                 | -7.82E-03                | -7.54E-01                | 7.55E-01                 | 2.02E+01                 | -1.09E-02                | 4.09E-03                 | 2.27E-01  | 2.27E-01 | 3.17E-01 | 3.17E-01 |
| 1.98E+01                 | 4.00E-02                 | -8.59E-03                | -7.92E-01                | 7.93E-01                 | 2.02E+01                 | -1.10E-02                | 7.37E-03                 | 2.44E-01  | 2.45E-01 | 3.11E-01 | 3.11E-01 |
| 1.98E+01                 | 4.54E-02                 | -8.19E-01                | 8.21E-01                 | 8.21E-01                 | 2.02E+01                 | -1.27E-02                | 5.21E-03                 | 2.59E-01  | 2.59E-01 | 3.07E-01 | 3.08E-01 |
| 1.98E+01                 | 4.50E-02                 | -1.24E-02                | -8.39E-01                | 8.40E-01                 | 2.02E+01                 | -1.83E-02                | 5.27E-03                 | 2.65E-01  | 2.66E-01 | 3.04E-01 | 3.04E-01 |
| 1.98E+01                 | 4.59E-02                 | -1.27E-02                | -8.99E-01                | 8.99E-01                 | 2.02E+01                 | -1.02E-02                | 6.19E-03                 | 2.71E-01  | 2.71E-01 | 2.97E-01 | 2.97E-01 |
| 1.98E+01                 | 4.62E-02                 | -1.23E-02                | -8.45E-01                | 8.46E-01                 | 2.02E+01                 | -1.68E-02                | 4.87E-03                 | 2.89E-01  | 2.90E-01 | 2.95E-01 | 2.95E-01 |
| 1.98E+01                 | 4.33E-02                 | -1.13E-02                | -8.24E-01                | 8.25E-01                 | 2.02E+01                 | -1.60E-02                | 4.24E-03                 | 2.96E-01  | 2.97E-01 | 2.88E-01 | 2.88E-01 |
| 1.98E+01                 | 4.90E-02                 | -1.28E-02                | -7.98E-01                | 8.00E-01                 | 2.03E+01                 | -1.71E-02                | 8.25E-03                 | 3.07E-01  | 3.07E-01 | 2.85E-01 | 2.85E-01 |
| 1.98E+01                 | 4.10E-02                 | -8.64E-03                | -7.75E-01                | 7.76E-01                 | 2.03E+01                 | -1.75E-02                | 7.82E-03                 | 3.14E-01  | 3.15E-01 | 2.79E-01 | 2.79E-01 |
| 1.98E+01                 | 3.96E-02                 | -9.38E-03                | -7.51E-01                | 7.52E-01                 | 2.03E+01                 | -1.69E-02                | 5.01E-03                 | 3.21E-01  | 3.21E-01 | 2.75E-01 | 2.75E-01 |
| 1.99E+01                 | 3.77E-02                 | -1.24E-02                | -7.29E-01                | 7.30E-01                 | 2.03E+01                 | -1.63E-02                | 4.15E-03                 | 3.28E-01  | 3.28E-01 | 2.68E-01 | 2.68E-01 |
| 1.99E+01                 | 3.67E-02                 | -1.32E-02                | -7.01E-01                | 7.02E-01                 | 2.03E+01                 | -1.59E-02                | 6.05E-03                 | 3.30E-01  | 3.30E-01 | 2.63E-01 | 2.63E-01 |

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|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------|----------|
| 2.07E+01                 | -1.28E-02                | 4.84E-03                 | 2.61E-01                 | 2.62E-01                 | 2.12E+01                 | 1.71E-03                 | 1.17E-04                 | -6.81E-03                | 4.92E-03 | 4.97E-03 |
| 2.08E+01                 | -1.41E-02                | 4.46E-03                 | 2.55E-01                 | 2.56E-01                 | 2.12E+01                 | -2.68E-04                | 6.04E-04                 | -6.25E-03                | 6.52E-03 | 6.88E-03 |
| 2.08E+01                 | -1.34E-02                | 3.71E-03                 | 2.49E-01                 | 2.49E-01                 | 2.12E+01                 | 2.58E-03                 | -2.63E-04                | -4.49E-03                | 4.98E-03 | 4.98E-03 |
| 2.08E+01                 | -1.30E-02                | 4.03E-03                 | 2.43E-01                 | 2.43E-01                 | 2.12E+01                 | 8.95E-04                 | -1.25E-03                | -8.16E-03                | 8.16E-03 | 6.34E-03 |
| 2.08E+01                 | -1.47E-02                | 5.74E-03                 | 2.39E-01                 | 2.40E-01                 | 2.12E+01                 | -1.73E-04                | 1.05E-03                 | -3.80E-03                | 3.95E-03 | 3.95E-03 |
| 2.08E+01                 | -1.00E-02                | 4.90E-03                 | 2.35E-01                 | 2.35E-01                 | 2.12E+01                 | -3.62E-03                | -1.19E-02                | -5.88E-03                | 6.16E-03 | 6.16E-03 |
| 2.08E+01                 | -1.23E-02                | 4.40E-03                 | 2.27E-01                 | 2.27E-01                 | 2.12E+01                 | 6.07E-03                 | 2.12E-03                 | -1.10E-02                | 1.28E-02 | 1.28E-02 |
| 2.08E+01                 | -8.39E-03                | 4.78E-03                 | 2.24E-01                 | 2.24E-01                 | 2.12E+01                 | -6.85E-05                | 3.49E-05                 | -1.23E-02                | 1.28E-02 | 1.28E-02 |
| 2.08E+01                 | -1.33E-02                | 4.15E-03                 | 2.20E-01                 | 2.20E-01                 | 2.13E+01                 | 1.01E-03                 | 2.52E-03                 | -1.09E-02                | 1.12E-02 | 1.12E-02 |
| 2.08E+01                 | -1.00E-02                | 4.93E-03                 | 2.09E-01                 | 2.10E-01                 | 2.13E+01                 | 1.02E-03                 | -2.52E-03                | -9.66E-03                | 1.00E-02 | 1.00E-02 |
| 2.08E+01                 | -8.91E-03                | 4.53E-03                 | 2.07E-01                 | 2.07E-01                 | 2.13E+01                 | -1.49E-03                | -1.06E-03                | -1.18E-02                | 1.19E-02 | 1.19E-02 |
| 2.08E+01                 | -3.07E-03                | 2.30E-01                 | 2.03E-01                 | 2.03E-01                 | 2.13E+01                 | -4.07E-03                | 1.04E-03                 | -4.26E-02                | 4.27E-02 | 4.27E-02 |
| 2.09E+01                 | -1.02E-02                | 2.57E-03                 | 1.90E-01                 | 1.91E-01                 | 2.13E+01                 | 1.55E-03                 | -2.01E-03                | -1.20E-02                | 1.23E-02 | 1.23E-02 |
| 2.09E+01                 | -1.17E-02                | 2.81E-03                 | 1.88E-01                 | 1.88E-01                 | 2.13E+01                 | 1.24E-03                 | -3.42E-04                | -1.38E-02                | 1.38E-02 | 1.38E-02 |
| 2.09E+01                 | -7.62E-03                | 3.26E-03                 | 1.81E-01                 | 1.81E-01                 | 2.13E+01                 | 1.03E-03                 | 8.21E-04                 | -1.27E-02                | 1.28E-02 | 1.28E-02 |
| 2.09E+01                 | -8.26E-03                | 2.57E-03                 | 1.73E-01                 | 1.73E-01                 | 2.13E+01                 | 1.28E-04                 | 1.24E-03                 | -1.39E-02                | 1.39E-02 | 1.39E-02 |
| 2.09E+01                 | -6.07E-03                | 1.45E-03                 | 1.69E-01                 | 1.69E-01                 | 2.13E+01                 | -1.90E-04                | -8.05E-04                | -1.41E-02                | 1.41E-02 | 1.41E-02 |
| 2.09E+01                 | -8.49E-03                | 2.20E-03                 | 1.65E-01                 | 1.65E-01                 | 2.13E+01                 | 1.93E-04                 | 8.11E-04                 | -1.39E-02                | 1.40E-02 | 1.40E-02 |
| 2.09E+01                 | -1.00E-02                | 3.21E-03                 | 1.59E-01                 | 1.60E-01                 | 2.14E+01                 | 1.32E-03                 | 1.47E-03                 | -1.36E-02                | 1.37E-02 | 1.37E-02 |
| 2.09E+01                 | -3.97E-03                | 1.70E-03                 | 1.54E-01                 | 1.54E-01                 | 2.14E+01                 | 1.46E-03                 | 8.96E-04                 | -1.36E-02                | 1.37E-02 | 1.37E-02 |
| 2.09E+01                 | -7.55E-03                | 1.46E-03                 | 1.47E-01                 | 1.47E-01                 | 2.14E+01                 | 1.04E-03                 | -1.36E-03                | -1.24E-02                | 1.25E-02 | 1.25E-02 |
| 2.10E+01                 | -7.75E-03                | 1.40E-03                 | 1.37E-01                 | 1.38E-01                 | 2.14E+01                 | 1.83E-04                 | -9.79E-05                | -1.30E-02                | 1.30E-02 | 1.30E-02 |
| 2.10E+01                 | -6.80E-03                | 1.29E-03                 | 1.31E-01                 | 1.31E-01                 | 2.14E+01                 | 1.84E-03                 | 2.12E-04                 | -1.48E-02                | 1.49E-02 | 1.49E-02 |
| 2.10E+01                 | -6.34E-03                | 5.09E-03                 | 1.25E-01                 | 1.25E-01                 | 2.14E+01                 | -6.78E-05                | 3.04E-04                 | -1.72E-02                | 1.72E-02 | 1.72E-02 |
| 2.10E+01                 | -1.59E-02                | -3.72E-03                | 1.15E-01                 | 1.17E-01                 | 2.14E+01                 | -1.27E-03                | 8.40E-04                 | -1.50E-02                | 1.51E-02 | 1.51E-02 |
| 2.10E+01                 | -8.01E-03                | 2.67E-03                 | 1.12E-01                 | 1.12E-01                 | 2.14E+01                 | 2.95E-03                 | 4.14E-04                 | -1.43E-02                | 1.46E-02 | 1.46E-02 |
| 2.10E+01                 | -4.49E-03                | 6.01E-04                 | 1.07E-01                 | 1.07E-01                 | 2.14E+01                 | 5.48E-04                 | 8.43E-04                 | -1.54E-02                | 1.54E-02 | 1.54E-02 |
| 2.10E+01                 | -1.67E-03                | 9.16E-03                 | 1.04E-01                 | 1.04E-01                 | 2.14E+01                 | -1.34E-03                | -1.63E-03                | -1.62E-02                | 1.63E-02 | 1.63E-02 |
| 2.10E+01                 | -5.81E-03                | 1.93E-03                 | 9.25E-02                 | 9.27E-02                 | 2.15E+01                 | 6.43E-04                 | 6.59E-03                 | -1.22E-02                | 1.23E-02 | 1.23E-02 |
| 2.10E+01                 | -4.91E-03                | -6.01E-04                | 8.50E-02                 | 8.51E-02                 | 2.15E+01                 | -1.04E-04                | 8.76E-04                 | -9.19E-03                | 9.23E-03 | 9.23E-03 |
| 2.10E+01                 | -5.02E-03                | -7.09E-04                | 8.03E-02                 | 8.05E-02                 | 2.15E+01                 | -7.88E-04                | -2.01E-03                | -1.22E-02                | 1.24E-02 | 1.24E-02 |
| 2.11E+01                 | -3.41E-03                | 3.72E-03                 | 7.10E-02                 | 7.12E-02                 | 2.15E+01                 | -2.21E-03                | -2.23E-03                | -1.40E-02                | 1.43E-02 | 1.43E-02 |
| 2.11E+01                 | -3.62E-03                | 1.91E-03                 | 6.35E-02                 | 6.37E-02                 | 2.15E+01                 | 2.07E-03                 | 3.06E-05                 | -1.11E-02                | 1.13E-02 | 1.13E-02 |
| 2.11E+01                 | -6.67E-03                | -2.06E-03                | 5.98E-02                 | 6.00E-02                 | 2.15E+01                 | 9.51E-04                 | 3.71E-03                 | -9.51E-03                | 1.03E-02 | 1.03E-02 |
| 2.11E+01                 | -4.21E-04                | 3.03E-03                 | 5.00E-02                 | 5.01E-02                 | 2.15E+01                 | 1.85E-03                 | -3.56E-04                | -9.89E-03                | 1.02E-02 | 1.02E-02 |
| 2.11E+01                 | -2.91E-03                | 8.74E-03                 | 4.35E-02                 | 4.36E-02                 | 2.1                      |                          |                          |                          |          |          |

|                          |                          |                          |                          |                          |                          |                          |                          |                          |          |          |           |           |           |          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------|----------|-----------|-----------|-----------|----------|
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| 2.33E+01                 | -8.59E-03                | 4.22E-03                 | 1.61E-01                 | 1.61E-01                 | 2.38E+01                 | -1.74E-03                | 2.19E-03                 | 3.35E-02                 | 3.38E-02 | 2.42E+01 | 5.89E-04  | -0.12E-05 | 1.58E-03  | 1.68E-03 |
| 2.33E+01                 | -8.03E-03                | 2.41E-03                 | 1.64E-01                 | 1.65E-01                 | 2.38E+01                 | -1.87E-03                | 5.10E-04                 | 2.96E-02                 | 2.97E-02 | 2.42E+01 | 3.02E-04  | 5.61E-04  | 6.84E-04  | 9.34E-04 |
| 2.34E+01                 | -7.41E-03                | 3.46E-03                 | 1.62E-01                 | 1.62E-01                 | 2.38E+01                 | 3.65E-04                 | 1.46E-03                 | 2.34E-02                 | 2.35E-02 | 2.42E+01 | 1.46E-03  | 1.78E-03  | 3.24E-03  | 3.98E-03 |
| 2.34E+01                 | -8.85E-03                | 1.93E-01                 | 1.94E-01                 | 1.94E-01                 | 2.38E+01                 | -2.44E-03                | 8.70E-05                 | 1.87E-02                 | 1.88E-02 | 2.43E+01 | -3.93E-04 | -1.25E-03 | -8.11E-04 | 1.53E-03 |
| 2.34E+01                 | -9.04E-03                | 3.75E-03                 | 1.80E-01                 | 1.80E-01                 | 2.38E+01                 | -1.11E-03                | 1.72E-03                 | 1.50E-02                 | 1.51E-02 | 2.43E+01 | -1.26E-03 | -8.17E-04 | -7.17E-04 | 1.54E-03 |
| 2.34E+01                 | -8.12E-03                | 1.27E-03                 | 1.90E-01                 | 1.90E-01                 | 2.38E+01                 | -8.89E-04                | 1.48E-03                 | 7.37E-03                 | 7.57E-03 | 2.43E+01 | -1.52E-03 | 2.16E-03  | 1.59E-03  | 3.08E-03 |
| 2.34E+01                 | -8.19E-03                | 5.10E-03                 | 1.61E-01                 | 1.61E-01                 | 2.38E+01                 | -3.72E-04                | 1.87E-03                 | 5.44E-03                 | 5.77E-03 | 2.43E+01 | 1.55E-03  | 1.55E-03  | 1.72E-03  | 2.79E-03 |
| 2.34E+01                 | -8.49E-03                | 1.86E-03                 | 1.59E-01                 | 1.59E-01                 | 2.38E+01                 | 1.37E-03                 | -1.01E-03                | 2.06E-03                 | 2.67E-03 | 2.43E+01 | 1.39E-03  | -7.17E-04 | 2.20E-04  | 1.59E-03 |
| 2.34E+01                 | -9.38E-03                | 1.73E-03                 | 1.56E-01                 | 1.56E-01                 | 2.38E+01                 | -1.47E-03                | -1.82E-03                | 2.13E-03                 | 3.18E-03 | 2.43E+01 | -1.13E-03 | 5.86E-04  | -9.90E-05 | 1.28E-03 |
| 2.34E+01                 | -8.58E-03                | 1.36E-03                 | 1.54E-01                 | 1.54E-01                 | 2.39E+01                 | 4.96E-04                 | -1.05E-04                | -1.11E-03                | 1.22E-03 | 2.43E+01 | 3.04E-04  | -0.26E-03 | -8.61E-04 | 2.23E-03 |
| 2.34E+01                 | -1.10E-02                | 1.49E-03                 | 1.54E-01                 | 1.54E-01                 | 2.39E+01                 | 1.10E-03                 | 1.21E-03                 | -2.75E-03                | 3.20E-03 | 2.43E+01 | 8.79E-04  | -8.44E-04 | 3.28E-04  | 1.29E-03 |
| 2.34E+01                 | -8.89E-03                | 3.91E-01                 | 1.93E-01                 | 1.93E-01                 | 2.39E+01                 | -4.83E-03                | 2.41E-03                 | 7.49E-04                 | 2.95E-03 | 2.43E+01 | 7.09E-04  | 1.13E-03  | -9.42E-04 | 1.93E-03 |
| 2.35E+01                 | -8.45E-03                | 1.22E-03                 | 1.52E-01                 | 1.52E-01                 | 2.39E+01                 | -2.84E-03                | 4.46E-04                 | 1.03E-03                 | 2.87E-03 | 2.43E+01 | -1.97E-03 | -1.59E-04 | 2.19E-03  | 2.95E-03 |
| 2.35E+01                 | -8.41E-03                | 5.00E-03                 | 1.48E-01                 | 1.48E-01                 | 2.39E+01                 | -3.14E-03                | -1.30E-03                | -3.23E-04                | 3.41E-03 | 2.43E+01 | 2.80E-04  | 3.73E-04  | 1.71E-03  | 1.88E-03 |
| 2.35E+01                 | -8.39E-03                | 1.28E-03                 | 1.47E-01                 | 1.48E-01                 | 2.39E+01                 | 7.92E-04                 | 2.44E-03                 | -1.98E-03                | 3.25E-03 | 2.43E+01 | 2.01E-03  | 1.63E-04  | -1.42E-03 | 2.48E-03 |
| 2.35E+01                 | -7.90E-03                | 2.32E-03                 | 1.41E-01                 | 1.42E-01                 | 2.39E+01                 | 1.70E-04                 | -1.26E-03                | -8.18E-04                | 1.51E-03 | 2.44E+01 | -1.78E-03 | -0.28E-03 | 5.83E-04  | 2.94E-03 |
| 2.35E+01                 | -6.02E-03                | 2.78E-03                 | 1.39E-01                 | 1.39E-01                 | 2.39E+01                 | -1.53E-03                | 3.25E-04                 | 1.46E-03                 | 2.74E-03 | 2.44E+01 | 7.13E-05  | -0.23E-03 | 7.03E-04  | 2.24E-03 |
| 2.35E+01                 | -8.77E-03                | 1.37E-01                 | 1.38E-01                 | 1.38E-01                 | 2.39E+01                 | 2.01E-03                 | 6.54E-05                 | 5.83E-04                 | 2.09E-03 | 2.44E+01 | -0.42E-03 | -1.03E-03 | 4.67E-03  | 4.86E-03 |
| 2.35E+01                 | -8.67E-03                | 5.18E-03                 | 1.33E-01                 | 1.33E-01                 | 2.39E+01                 | 1.09E-03                 | -3.90E-04                | 4.05E-04                 | 1.23E-03 | 2.44E+01 | -3.02E-04 | -1.68E-04 | 1.27E-03  | 1.32E-03 |
| 2.35E+01                 | -7.77E-03                | 2.61E-01                 | 1.33E-01                 | 1.33E-01                 | 2.40E+01                 | -1.43E-04                | -2.39E-04                | -2.39E-04                | 2.92E-03 | 2.44E+01 | -1.04E-03 | -4.25E-04 | -1.32E-03 | 4.93E-03 |
| 2.35E+01                 | -7.41E-03                | 2.85E-03                 | 1.29E-01                 | 1.30E-01                 | 2.40E+01                 | -1.95E-03                | 3.01E-04                 | -4.58E-05                | 1.99E-03 | 2.44E+01 | -7.28E-04 | -1.30E-03 | -8.61E-04 | 1.77E-03 |
| 2.35E+01                 | -7.90E-03                | 2.24E-03                 | 1.28E-01                 | 1.28E-01                 | 2.40E+01                 | -1.54E-03                | 5.75E-04                 | 4.71E-04                 | 1.71E-03 | 2.44E+01 | -7.21E-04 | -5.96E-04 | -9.96E-04 | 1.03E-03 |
| 2.36E+01                 | -8.14E-03                | 7.32E-04                 | 1.26E-01                 | 1.26E-01                 | 2.40E+01                 | 8.12E-04                 | 1.84E-03                 | 4.85E-04                 | 1.89E-03 | 2.44E+01 | 4.79E-04  | -0.28E-03 | -1.10E-03 | 2.66E-03 |
| 2.36E+01                 | -4.20E-03                | 4.04E-03                 | 1.22E-01                 | 1.22E-01                 | 2.40E+01                 | 2.06E-04                 | -6.61E-04                | -8.29E-04                | 1.08E-03 | 2.44E+01 | 5.38E-04  | 1.06E-03  | 5.88E-04  | 1.49E-03 |
| 2.36E+01                 | -7.38E-03                | 4.82E-04                 | 1.19E-01                 | 1.19E-01                 | 2.40E+01                 | -1.60E-03                | 2.17E-03                 | 6.76E-04                 | 2.78E-03 | 2.44E+01 | -1.01E-03 | -1.14E-03 | 1.16E-03  | 1.92E-03 |
| 2.36E+01                 | -9.30E-03                | 1.14E-01                 | 1.15E-01                 | 1.15E-01                 | 2.40E+01                 | -1.59E-05                | -0.20E-03                | -1.87E-04                | 2.09E-03 | 2.44E+01 | 6.92E-04  | -4.71E-04 | -1.39E-03 | 1.62E-03 |
| 2.36E+01                 | -7.67E-03                | 1.46E-03                 | 1.11E-01                 | 1.11E-01                 | 2.40E+01                 | 1.64E-03                 | -8.58E-04                | -5.02E-04                | 1.80E-03 | 2.45E+01 | 1.69E-03  | -8.36E-04 | -1.22E-03 | 2.24E-03 |
| 2.36E+01                 | -2.11E-03                | 2.11E-03                 | 1.08E-01                 | 1.08E-01                 | 2.40E+01                 | 2.40E-01                 | 8.71E-04                 | -8.71E-04                | 1.09E-03 | 2.45E+01 | -2.45E-01 | -4.56E-04 | 1.94E-03  | 3.25E-03 |
| 2.36E+01                 | -3.99E-03                | 2.01E-03                 | 1.05E-01                 | 1.05E-01                 | 2.40E+01                 | -1.05E-03                | -1.25E-03                | 1.75E-03                 | 2.15E-03 | 2.45E+01 | -6.08E-04 | 8.88E-05  | -1.79E-03 | 1.79E-03 |
| 2.36E+01                 | -4.06E-03                | 1.12E-03                 | 1.04E-01                 | 1.04E-01                 | 2.41E+01                 | -6.93E-04                | 1.97E-04                 | 7.20E-04                 | 9.53E-04 | 2.45E+01 | -1.14E-03 | 3.83E-03  | 1.45E-04  | 4.00E-03 |
| 2.36E+01                 | -7.49E-03                | 8.92E-02                 | 9.65E-02                 | 9.65E-02                 | 2.41E+01                 | -4.23E-04                | 2.27E-03                 | 2.22E-03                 | 3.21E-03 | 2.45E+01 | -2.92E-04 | 2.56E-03  | -1.51E-03 | 2.98E-03 |
| 2.36E+01                 | -4.60E-03                | 1.44E-03                 | 9.20E-02                 | 9.22E-02                 | 2.41E+01                 | -1.65E-03                | -5.18E-04                | 2.47E-03                 | 3.01E-03 | 2.45E+01 | -3.31E-05 | 4.52E-04  | -1.90E-03 | 1.95E-03 |
| 2.37E+01                 | -4.99E-03                | 3.39E-03                 | 8.82E-02                 | 8.84E-02                 | 2.41E+01                 | 3.16E-04                 | 2.28E-03                 | 1.33E-04                 | 2.31E-03 | 2.45E+01 | -1.46E-03 | -1.46E-03 | -1.80E-03 | 2.93E-03 |
| 2.37E+01                 | -3.52E-03                | 4.70E-03                 | 8.14E-02                 | 8.16E-02                 | 2.41E+01                 | -1.13E-03                | 1.94E-04                 | 1.19E-03                 | 2.12E-03 | 2.45E+01 | 1.27E-03  | 1.27E-03  | 1.76E-03  | 1.76E-03 |
| 2.37E+01                 | -1.39E-03                | 9.73E-04                 | 8.03E-02                 | 8.03E-02                 | 2.41E+01                 | 1.43E-03                 | -3.95E-04                | -1.25E-03                | 1.93E-03 | 2.45E+01 | 2.57E-03  | -2.09E-03 | 2.12E-03  | 3.73E-03 |
| 2.37E+01                 | -2.72E-03                | 7.69E-04                 | 7.53E-02                 | 7.53E-02                 | 2.41E+01                 | -8.14E-04                | 8.77E-05                 | 1.89E-03                 | 2.99E-03 | 2.45E+01 | -2.95E-03 | 1.24E-02  | 1.92E-03  | 1.92E-03 |
| 2.37E+01                 | -2.29E-03                | 1.83E-03                 | 6.92E-02                 | 6.92E-02                 | 2.41E+01                 | -1.39E-03                | 2.27E-03                 | 1.76E-03                 | 3.19E-03 | 2.45E+01 | -8.95E-04 | 4.95E-05  | -3.58E-03 | 3.72E-03 |
| 2.37E+01                 | -2.62E-03                | 1.22E-03                 | 6.54E-02                 | 6.55E-02                 | 2.41E+01                 | -1.33E-03                | 1.68E-03                 | -5.55E-04                | 2.21E-03 | 2.45E+01 | -1.12E-03 | -0.61E-04 | -1.10E-03 | 1.59E-03 |
| 2.37E+01                 | -3.49E-03                | -4.13E-05                | 6.08E-02                 | 6.09E-02                 | 2.41E+01                 | -3.94E-04                | -0.21E-03                | -2.30E-04                | 2.16E-03 | 2.46E+01 | 7.65E-04  | 4.49E-04  | -4.11E-04 | 9.70E-04 |
| 2.37E+01                 | -2.41E-03                | -8.45E-05                | 5.32E-02                 | 5.32E-02                 | 2.42E+01                 | 9.84E-04                 | -0.43E-03                | 2.47E-05                 | 2.62E-03 | 2.46E+01 | 2.30E-04  | 1.77E-05  | 1.21E-03  | 1.23E-03 |
| 2.37E+01                 | -1.70E-03                | -8.99E-04                | 5.00E-02                 | 5.00E-02                 | 2.42E+01                 | -4.01E-03                | 4.26E-03                 | 2.76E-03                 | 6.47E-03 | 2.46E+01 | 2.43E-03  | -0.14E-04 | -1.57E-03 | 2.90E-03 |
| 2.37E+01                 | -2.62E-03                | 4.41E-02                 | 4.43E-02                 | 4.43E-02                 | 2.42E+01                 | 4.90E-04                 | 1.34E-04                 | 2.00E-03                 | 2.08E-03 | 2.46E+01 | -2.90E-03 | -2.19E-04 | -2.96E-04 | 2.24E-03 |
| 2.38E+01                 | -3.93E-03                | -1.24E-02                | 3.84E-02                 | 3.88E-02                 | 2.42E+01                 | 1.55E-03                 | 2.73E-03                 | -1.28E-03                | 3.40E-03 | 2.46E+01 | -8.79E-04 | 3.00E-05  | 1.13E-03  | 1.43E-03 |

|                          |                          |                          |                          |                          |                          |                          |                          |                          |          |          |           |          |          |          |
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| 2.46E+01                 | -2.79E-03                | -1.98E-03                | 1.29E-03                 | 3.65E-03                 | 2.51E+01                 | 1.15E-03                 | -8.36E-04                | 2.14E-03                 | 2.60E-03 | 2.55E+01 | -8.82E-02 | 2.71E-02 | 1.15E+00 | 1.16E+00 |
| 2.46E+01                 | 1.21E-03                 | 7.22E-04                 | -1.70E-03                | 2.25E-03                 | 2.51E+01                 | -8.53E-04                | -0.32E-03                | 1.16E-03                 | 2.73E-03 | 2.55E+01 | -6.23E-02 | 2.64E-02 | 1.17E+00 | 1.17E+00 |
| 2.47E+01                 | 4.81E-04                 | 7.34E-04                 | 2.00E-03                 | 2.19E-03                 | 2.51E+01                 | 8.00E-04                 | 2.36E-03                 | 5.49E-04                 | 2.59E-03 | 2.55E+01 | -6.03E-02 | 2.05E-02 | 1.17E+00 | 1.17E+00 |
| 2.47E+01                 | -2.92E-05                | 8.47E-04                 | 1.05E-03                 | 2.67E-03                 | 2.51E+01                 | 1.51E-03                 | -8.38E-05                | 4.40E-04                 | 7.82E-04 | 2.55E+01 | -4.25E-02 | 4.56E-02 | 1.16E+00 | 1.16E+00 |
| 2.47E+01                 | 1.27E-03                 | 2.34E-03                 | 1.99E-04                 | 2.67E-03                 | 2.51E+01                 | 1.66E-03                 | 9.10E-04                 | -8.80E-05                | 1.89E-03 | 2.55E+01 | -5.87E-02 | 1.77E-02 | 1.15E+00 | 1.15E+00 |
| 2.47E+01                 | -2.67E-04                | 2.70E-03                 | 1.89E-03                 | 3.20E-03                 | 2.51E+01                 | 2.32E-04                 | 4.31E-04                 | -7.24E-04                | 8.74E-04 | 2.55E+01 | -5.90E-02 | 2.00E-02 | 1.13E+00 | 1.13E+00 |
| 2.47E+01                 | -7.21E-04                | -1.04E-03                | 1.36E-03                 | 1.86E-03                 | 2.51E+01                 | 1.73E-03                 | -3.52E-05                | 1.27E-03                 | 2.15E-03 | 2.56E+01 | -8.84E-02 | 1.82E-02 | 1.12E+00 | 1.12E+00 |
| 2.47E+01                 | -4.46E-04                | 6.24E-04                 | -1.56E-03                | 1.74E-03                 | 2.51E+01                 | 7.61E-04                 | 1.49E-03                 | -1.49E-03                | 2.24E-03 | 2.56E+01 | -6.15E-02 | 1.66E-02 | 1.11E+00 | 1.11E+00 |
| 2.47E+01                 | 1.11E-03                 | 5.16E-04                 | -1.12E-03                | 1.68E-03                 | 2.51E+01                 | -1.46E-03                | 1.48E-03                 | 9.58E-04                 | 2.29E-03 | 2.56E+01 | -5.68E-02 | 2.02E-02 | 1.09E+00 | 1.09E+00 |
| 2.47E+01                 | 8.97E-04                 | -1.30E-03                | 1.43E-03                 | 2.13E-03                 | 2.52E+01                 | 5.26E-04                 | -2.03E-03                | 6.63E-04                 | 2.19E-03 | 2.56E+01 | -5.74E-02 | 2.22E-02 | 1.08E+00 | 1.08E+00 |
| 2.47E+01                 | 4.30E-05                 | 2.71E-03                 | -3.85E-04                | 2.74E-03                 | 2.52E+01                 | -2.74E-05                | -2.35E-03                | 1.19E-03                 | 2.63E-03 | 2.56E+01 | -6.69E-02 | 2.09E-02 | 1.06E+00 | 1.06E+00 |
| 2.47E+01                 | 2.27E-04                 | 9.90E-05                 | 3.17E-04                 | 3.17E-04                 | 2.52E+01                 | -1.99E-04                | -1.87E-04                | -5.33E-04                | 9.99E-04 | 2.56E+01 | -5.86E-02 | 1.24E-02 | 1.05E+00 | 1.05E+00 |
| 2.48E+01                 | 7.92E-04                 | 1.14E-03                 | -7.78E-04                | 1.70E-03                 | 2.52E+01                 | -2.41E-03                | -2.18E-03                | 1.43E-03                 | 3.55E-03 | 2.56E+01 | -5.70E-02 | 1.55E-02 | 1.03E+00 | 1.03E+00 |
| 2.48E+01                 | 5.12E-04                 | -2.58E-04                | -0.26E-03                | 2.62E-03                 | 2.52E+01                 | 3.44E-03                 | -0.63E-03                | 1.03E-03                 | 4.45E-03 | 2.56E+01 | -5.47E-02 | 1.72E-02 | 1.02E+00 | 1.02E+00 |
| 2.48E+01                 | -1.50E-03                | 6.54E-04                 | 2.17E-03                 | 2.72E-03                 | 2.52E+01                 | -8.75E-04                | 5.32E-05                 | -1.84E-04                | 5.99E-03 | 2.56E+01 | -5.40E-02 | 1.70E-02 | 9.98E-01 | 1.00E+00 |
| 2.48E+01                 | 4.20E-04                 | 2.63E-03                 | 2.11E-03                 | 3.40E-03                 | 2.52E+01                 | 8.29E-04                 | 5.65E-04                 | 8.23E-05                 | 1.01E-03 | 2.56E+01 | -5.34E-02 | 1.56E-02 | 9.82E-01 | 9.84E-01 |
| 2.48E+01                 | 4.96E-04                 | -1.89E-03                | -2.12E-03                | 2.89E-03                 | 2.52E+01                 | -6.63E-05                | 1.80E-03                 | -9.84E-04                | 2.04E-03 | 2.57E+01 | -4.92E-02 | 1.41E-02 | 9.68E-01 | 9.70E-01 |
| 2.48E+01                 | -1.99E-03                | 1.40E-03                 | -1.25E-03                | 2.74E-03                 | 2.52E+01                 | 1.90E-03                 | 7.94E-04                 | 2.62E-03                 | 2.62E-03 | 2.57E+01 | -4.89E-02 |          |          |          |

|                          |                          |                          |                          |                          |                          |                          |                          |                          |           |          |           |           |           |          |
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| air bearing data page 64 | air bearing data page 64 | air bearing data page 64 | air bearing data page 65 | air bearing data page 65 | air bearing data page 65 | air bearing data page 66 | air bearing data page 66 | air bearing data page 66 |           |          |           |           |           |          |
| 2.72E+01                 | 5.96E-03                 | -3.94E-04                | -5.18E-02                | 5.21E-02                 | 2.77E+01                 | -1.53E-03                | 4.89E-04                 | -2.76E-03                | 3.19E-03  | 2.81E+01 | -0.02E-03 | 1.07E-03  | 4.98E-04  | 2.40E-03 |
| 2.72E+01                 | 1.80E-03                 | 2.33E-04                 | -4.88E-02                | 4.98E-02                 | 2.77E+01                 | 7.88E-05                 | -4.36E-04                | -4.38E-03                | 4.40E-03  | 2.81E+01 | -2.10E-04 | 9.14E-04  | -8.99E-04 | 1.28E-03 |
| 2.72E+01                 | 2.99E-03                 | -8.47E-04                | -5.06E-02                | 5.08E-02                 | 2.77E+01                 | 5.59E-04                 | -1.45E-03                | -3.55E-03                | 3.87E-03  | 2.81E+01 | 1.13E-04  | -8.32E-04 | 8.14E-04  | 1.17E-03 |
| 2.73E+01                 | 3.02E-04                 | -3.12E-03                | -5.19E-02                | 5.17E-02                 | 2.77E+01                 | -1.38E-03                | -8.02E-04                | 6.15E-04                 | 1.71E-03  | 2.81E+01 | 1.72E-04  | -1.21E-03 | 7.71E-04  | 1.65E-03 |
| 2.73E+01                 | 2.18E-03                 | 7.67E-04                 | -4.90E-02                | 4.90E-02                 | 2.77E+01                 | -3.74E-04                | 1.78E-03                 | -7.86E-05                | 1.82E-03  | 2.81E+01 | -4.61E-04 | 2.90E-04  | 2.56E-03  | 2.61E-03 |
| 2.73E+01                 | 2.70E-03                 | -1.77E-03                | -4.57E-02                | 4.58E-02                 | 2.77E+01                 | -2.00E-03                | 3.60E-04                 | 8.46E-04                 | 2.21E-03  | 2.81E+01 | -6.28E-04 | 5.54E-04  | -1.02E-03 | 1.27E-03 |
| 2.73E+01                 | 2.04E-03                 | -1.30E-03                | -4.70E-02                | 4.71E-02                 | 2.77E+01                 | 1.60E-03                 | 1.39E-04                 | -1.04E-03                | 1.92E-03  | 2.82E+01 | -3.54E-04 | -8.82E-04 | -7.05E-04 | 8.78E-04 |
| 2.73E+01                 | 1.03E-03                 | 7.88E-04                 | -4.69E-02                | 4.69E-02                 | 2.77E+01                 | -3.28E-03                | 2.94E-03                 | -3.74E-04                | 4.42E-03  | 2.82E+01 | -3.59E-04 | 2.22E-04  | 6.63E-04  | 7.88E-04 |
| 2.73E+01                 | 2.90E-03                 | -1.69E-03                | -4.52E-02                | 4.53E-02                 | 2.77E+01                 | -4.19E-04                | 1.30E-03                 | 1.06E-03                 | 1.73E-03  | 2.82E+01 | -3.65E-04 | -1.67E-03 | 1.44E-03  | 2.23E-03 |
| 2.73E+01                 | 2.45E-03                 | 2.68E-04                 | -4.44E-02                | 4.44E-02                 | 2.77E+01                 | 3.02E-06                 | 1.58E-03                 | -3.14E-03                | 3.51E-03  | 2.82E+01 | 1.12E-03  | 3.34E-03  | -5.43E-03 | 3.52E-03 |
| 2.73E+01                 | 2.88E-03                 | -8.70E-04                | -3.87E-02                | 3.88E-02                 | 2.78E+01                 | -2.19E-04                | 1.47E-03                 | -1.29E-03                | 1.97E-03  | 2.82E+01 | -2.51E-03 | -2.71E-03 | 1.08E-03  | 3.89E-03 |
| 2.73E+01                 | 3.91E-03                 | 3.39E-02                 | -3.99E-02                | 4.01E-02                 | 2.78E+01                 | -2.89E-04                | 4.18E-04                 | -4.51E-03                | 1.03E-03  | 2.82E+01 | -1.32E-03 | 3.31E-04  | 5.52E-04  | 1.09E-03 |
| 2.73E+01                 | 2.81E-03                 | 3.83E-06                 | -3.75E-02                | 3.75E-02                 | 2.78E+01                 | -1.56E-03                | -3.99E-04                | 2.29E-03                 | 2.89E-03  | 2.82E+01 | -2.11E-03 | -1.74E-03 | 1.49E-03  | 3.11E-03 |
| 2.74E+01                 | 4.00E-03                 | -8.73E-04                | -3.89E-02                | 3.71E-02                 | 2.78E+01                 | -2.36E-03                | 6.07E-05                 | 9.38E-04                 | 2.54E-03  | 2.82E+01 | -4.53E-04 | 4.91E-04  | 2.09E-03  | 2.19E-03 |
| 2.74E+01                 | 7.21E-04                 | -3.19E-05                | -3.88E-02                | 3.88E-02                 | 2.78E+01                 | 2.98E-04                 | -1.72E-03                | -3.12E-04                | 1.77E-03  | 2.82E+01 | 2.20E-03  | 6.99E-04  | 1.06E-03  | 2.54E-03 |
| 2.74E+01                 | -3.07E-06                | 7.01E-05                 | -3.63E-02                | 3.63E-02                 | 2.78E+01                 | -3.64E-04                | 1.23E-04                 | -1.35E-03                | 1.40E-03  | 2.82E+01 | 3.09E-04  | 5.33E-04  | 1.58E-04  | 6.39E-04 |
| 2.74E+01                 | 1.80E-03                 | 1.86E-03                 | -3.86E-02                | 3.87E-02                 | 2.78E+01                 | -6.37E-04                | 1.17E-03                 | -1.57E-05                | 1.33E-03  | 2.83E+01 | -2.56E-04 | -4.39E-04 | 2.77E-03  | 2.82E-03 |
| 2.74E+01                 | 1.48E-03                 | 9.20E-04                 | 3.39E-02                 | 3.39E-02                 | 2.78E+01                 | -1.71E-03                | 7.81E-04                 | 9.29E-04                 | 2.10E-03  | 2.83E+01 | 1.35E-03  | 1.14E-03  | -2.49E-03 | 3.05E-03 |
| 2.74E+01                 | 2.90E-04                 | -1.17E-03                | -3.35E-02                | 3.36E-02                 | 2.78E+01                 | -1.59E-03                | 6.99E-04                 | 2.23E-04                 | 1.75E-03  | 2.83E+01 | 4.10E-04  | 1.16E-03  | 9.75E-04  | 1.57E-03 |
| 2.74E+01                 | 7.64E-04                 | -8.85E-04                | -3.21E-02                | 3.21E-02                 | 2.78E+01                 | 2.78E+01                 | 7.71E-04                 | 8.19E-04                 | -2.39E-03 | 2.83E+01 | 2.83E+01  | -3.31E-04 | -1.12E-03 | 4.96E-04 |
| 2.74E+01                 | 3.81E-04                 | -9.30E-04                | -3.15E-02                | 3.15E-02                 | 2.78E+01                 | 1.48E-03                 | -1.29E-03                | -5.79E-04                | 2.05E-03  | 2.83E+01 | -1.91E-03 | -4.11E-03 | 2.47E-03  | 3.31E-03 |
| 2.74E+01                 | 2.73E-03                 | -9.35E-04                | -2.80E-02                | 2.81E-02                 | 2.78E+01                 | 3.18E-04                 | -3.38E-04                | -7.77E-04                | 8.05E-04  | 2.83E+01 | -8.46E-04 | -5.44E-05 | 5.44E-05  | 1.08E-03 |
| 2.74E+01                 | 1.79E-03                 | 4.58E-04                 | -2.84E-02                | 2.85E-02                 | 2.79E+01                 | -1.77E-03                | -1.12E-03                | -2.39E-04                | 2.11E-03  | 2.83E+01 | 5.93E-04  | 2.88E-03  | 9.87E-05  | 2.94E-03 |
| 2.75E+01                 | 1.64E-03                 | -8.80E-04                | -2.62E-02                | 2.63E-02                 | 2.79E+01                 | -3.48E-04                | -2.71E-04                | 8.85E-04                 | 9.89E-04  | 2.83E+01 | 3.38E-04  | -5.50E-04 | -2.76E-04 | 7.83E-04 |
| 2.75E+01                 | 3.51E-04                 | -3.19E-03                | -2.74E-02                | 2.78E-02                 | 2.79E+01                 | 3.55E-04                 | 1.38E-03                 | -4.54E-04                | 1.49E-03  | 2.83E+01 | 1.11E-04  | -1.52E-03 | 3.14E-04  | 1.55E-03 |
| 2.75E+01                 | 1.30E-03                 | 6.60E-04                 | -2.42E-02                | 2.43E-02                 | 2.79E+01                 | 1.41E-03                 | 1.72E-03                 | 3.75E-04                 | 2.28E-03  | 2.83E+01 | 3.29E-04  | -9.56E-04 | 2.18E-03  | 2.40E-03 |
| 2.75E+01                 | 5.04E-05                 | 8.96E-04                 | -2.18E-02                | 2.19E-02                 | 2.79E+01                 | 2.62E-04                 | 1.39E-03                 | 7.09E-04                 | 1.59E-03  | 2.84E+01 | -5.57E-04 | 1.64E-03  | 1.83E-04  | 1.74E-03 |
| 2.75E+01                 | 2.38E-03                 | 2.38E-03                 | -2.79E-02                | 2.79E-02                 | 2.79E+01                 | 2.79E+01                 | 8.16E-03                 | 8.16E-03                 | 2.79E-02  | 2.84E+01 | 2.84E+01  | 2.84E+01  | 2.84E+01  | 2.84E+01 |
| 2.75E+01                 | -2.45E-04                | -1.23E-03                | -2.12E-02                | 2.13E-02                 | 2.79E+01                 | -2.12E-04                | 2.39E-03                 | -5.99E-04                | 4.39E-04  | 2.84E+01 | 3.51E-04  | -1.51E-03 | 4.93E-04  | 1.62E-03 |
| 2.75E+01                 | 8.00E-04                 | 2.16E-04                 | -1.92E-02                | 1.92E-02                 | 2.80E+01                 | 8.31E-04                 | 1.52E-03                 | -1.14E-03                | 2.07E-03  | 2.84E+01 | -4.36E-04 | -1.12E-03 | 7.55E-04  | 1.42E-03 |
| 2.75E+01                 | 1.99E-03                 | -9.88E-04                | -1.94E-02                | 1.95E-02                 | 2.80E+01                 | -2.17E-04                | 1.88E-03                 | 1.49E-03                 | 2.39E-03  | 2.84E+01 | -3.51E-04 | -1.99E-03 | 1.82E-03  | 2.58E-03 |
| 2.75E+01                 | 1.15E-04                 | -1.34E-04                | -1.60E-02                | 1.60E-02                 | 2.80E+01                 | 7.46E-05                 | 1.49E-04                 | 2.06E-03                 | 2.07E-03  | 2.84E+01 | -2.86E-04 | 2.37E-03  | -1.31E-03 | 2.72E-03 |
| 2.75E+01                 | -6.94E-04                | 1.86E-03                 | -1.50E-02                | 1.51E-02                 | 2.80E+01                 | 1.42E-04                 | 1.78E-04                 | -1.16E-03                | 1.87E-03  | 2.84E+01 | 1.58E-03  | -3.24E-03 | 5.26E-04  | 2.87E-03 |
| 2.76E+01                 | 4.85E-04                 | 5.15E-04                 | -1.25E-02                | 1.25E-02                 | 2.80E+01                 | -1.10E-03                | 3.97E-04                 | -1.02E-05                | 1.17E-03  | 2.84E+01 | -2.99E-04 | -2.86E-03 | -9.24E-04 | 3.04E-03 |
| 2.76E+01                 | 3.10E-03                 | 5.41E-04                 | -1.13E-02                | 1.17E-02                 | 2.80E+01                 | 1.16E-03                 | -1.30E-03                | -3.25E-03                | 2.02E-03  | 2.84E+01 | 3.13E-03  | 5.60E-04  | 1.49E-03  | 3.52E-03 |
| 2.76E+01                 | -1.59E-03                | -4.15E-03                | 1.07E-02                 | 1.07E-02                 | 2.80E+01                 | -3.91E-04                | 1.92E-03                 | 8.19E-04                 | 1.94E-03  | 2.84E+01 | 2.94E+01  | 2.94E+01  | 2.94E+01  | 2.94E+01 |
| 2.76E+01                 | 3.02E-04                 | 2.34E-03                 | -1.23E-02                | 1.28E-02                 | 2.80E+01                 | 5.05E-04                 | -1.33E-03                | 2.08E-03                 | 2.51E-03  | 2.85E+01 | -1.67E-04 | -2.42E-03 | -1.49E-03 | 2.84E-03 |
| 2.76E+01                 | 4.40E-04                 | 8.00E-04                 | -8.89E-03                | 8.98E-03                 | 2.80E+01                 | -2.68E-03                | 6.98E-04                 | -3.42E-04                | 2.79E-03  | 2.85E+01 | -4.57E-04 | 1.00E-03  | 1.72E-04  | 1.12E-03 |
| 2.76E+01                 | -3.27E-03                | 5.67E-04                 | -9.41E-03                | 9.98E-03                 | 2.80E+01                 | -2.30E-04                | -8.08E-04                | 1.42E-03                 | 1.65E-03  | 2.85E+01 | -4.72E-04 | 8.47E-04  | 2.86E-03  | 2.83E-03 |
| 2.76E+01                 | -2.51E-03                | -1.26E-03                | -5.69E-03                | 6.30E-03                 | 2.81E+01                 | -6.65E-04                | 2.22E-04                 | 2.52E-03                 | 2.62E-03  | 2.85E+01 | -1.37E-03 | 4.32E-04  | 2.72E-04  | 1.53E-03 |
| 2.76E+01                 | -3.75E-04                | 5.88E-05                 | -4.27E-03                | 4.29E-03                 | 2.81E+01                 | 2.81E-04                 | 1.13E-03                 | -1.36E-03                | 1.78E-03  | 2.85E+01 | 2.25E-04  | -3.23E-03 | 1.17E-03  | 3.44E-03 |
| 2.76E+01                 | 9.83E-04                 | 9.79E-04                 | -3.82E-03                | 4.06E-03                 | 2.81E+01                 | 1.13E-03                 | -2.91E-04                | 1.05E-04                 | 1.17E-03  | 2.85E+01 | 6.24E-04  | 3.68E-04  | 3.46E-04  | 1.00E-03 |
| 2.76E+01                 | 4.62E-04                 | -6.41E-04                | -4.84E-03                | 4.91E-03                 | 2.81E+01                 | -1.03E-03                | 6.20E-04                 | -3.38E-03                | 3.59E-03  | 2.85E+01 | 2.42E-04  | 2.06E-03  | 1.51E-05  | 2.07E-03 |

|                          |                          |                          |                          |                          |                          |                          |                          |                          |          |          |           |           |           |          |
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| 2.85E+01                 | -4.19E-04                | 2.03E-04                 | 3.10E-04                 | 5.99E-04                 | 2.90E+01                 | -3.38E-02                | 1.18E-02                 | 6.48E-01                 | 6.49E-01 | 2.94E+01 | 1.38E-03  | 8.12E-04  | 2.25E-04  | 1.62E-03 |
| 2.85E+01                 | 9.65E-04                 | -6.13E-04                | 3.27E-04                 | 1.14E-03                 | 2.90E+01                 | -3.61E-02                | 7.14E-03                 | 6.80E-01                 | 6.80E-01 | 2.94E+01 | 1.24E-03  | 6.77E-05  | -1.37E-03 | 1.85E-03 |
| 2.85E+01                 | -1.52E-03                | -7.58E-04                | 3.02E-04                 | 1.73E-03                 | 2.90E+01                 | -4.17E-02                | 9.02E-03                 | 7.08E-01                 | 7.10E-01 | 2.94E+01 | -2.28E-03 | -4.07E-04 | -5.27E-04 | 2.37E-03 |
| 2.86E+01                 | 1.82E-03                 | -8.77E-04                | -2.81E-03                | 2.46E-03                 | 2.90E+01                 | -3.93E-02                | 8.04E-03                 | 7.34E-01                 | 7.34E-01 | 2.94E+01 | 1.96E-03  | 1.03E-03  | 1.20E-04  | 3.29E-03 |
| 2.86E+01                 | -1.48E-03                | 1.18E-03                 | 1.58E-03                 | 2.46E-03                 | 2.90E+01                 | -3.98E-02                | 1.04E-02                 | 7.47E-01                 | 7.48E-01 | 2.94E+01 | 5.72E-04  | 1.17E-03  | 1.14E-03  | 1.73E-03 |
| 2.86E+01                 | -2.16E-03                | 7.10E-04                 | 2.00E-03                 | 3.16E-03                 | 2.90E+01                 | -3.89E-02                | 9.03E-03                 | 7.52E-01                 | 7.53E-01 | 2.94E+01 | -1.26E-03 | -1.25E-03 | -1.06E-03 | 1.65E-03 |
| 2.86E+01                 | -1.79E-03                | -8.91E-04                | 4.27E-04                 | 2.05E-03                 | 2.90E+01                 | -3.96E-02                | 9.69E-03                 | 7.52E-01                 | 7.53E-01 | 2.94E+01 | -2.03E-03 | -9.13E-05 | 3.79E-04  | 2.07E-03 |
| 2.86E+01                 | -3.28E-03                | 1.12E-03                 | -2.58E-03                | 4.31E-03                 | 2.90E+01                 | -4.16E-02                | 7.14E-03                 | 7.40E-01                 | 7.41E-01 | 2.95E+01 | -1.47E-03 | -1.82E-03 | 6.66E-04  | 2.44E-03 |
| 2.86E+01                 | -1.19E-03                | 9.25E-04                 | 2.21E-03                 | 2.67E-03                 | 2.90E+01                 | -3.51E-02                | 1.43E-02                 | 7.12E-01                 | 7.13E-01 | 2.95E+01 | 1.54E-03  | -1.33E-03 | 1.43E-03  | 2.49E-03 |
| 2.86E+01                 | -1.94E-03                | 1.98E-03                 | 5.45E-03                 | 6.11E-03                 | 2.90E+01                 | -3.50E-02                | 1.58E-02                 | 6.93E-01                 | 6.94E-01 | 2.95E+01 | -1.28E-03 | 2.92E-03  | 1.32E-03  | 3.45E-03 |
| 2.86E+01                 | 1.96E-03                 | 1.57E-03                 | 1.10E-02                 | 1.13E-02                 | 2.91E+01                 | -3.62E-02                | 1.10E-02                 | 6.72E-01                 | 6.73E-01 | 2.95E+01 | -6.02E-04 | 5.70E-04  | 4.25E-04  | 9.32E-04 |
| 2.86E+01                 | -1.02E-03                | 1.19E-02                 | 1.19E-02                 | 1.20E-02                 | 2.91E+01                 | -3.97E-02                | 1.09E-02                 | 6.55E-01                 | 6.56E-01 | 2.95E+01 | -1.89E-04 | -4.33E-04 | -7.81E-05 | 4.34E-04 |
| 2.86E+01                 | 1.02E-03                 | 2.93E-03                 | 1.98E-02                 | 2.01E-02                 | 2.91E+01                 | -3.27E-02                | 1.11E-02                 | 6.37E-01                 | 6.38E-01 | 2.95E+01 | 8.62E-04  | 6.54E-04  | 1.51E-04  | 1.09E-03 |
| 2.87E+01                 | -1.89E-03                | -2.50E-03                | 2.57E-02                 | 2.59E-02                 | 2.91E+01                 | -3.00E-02                | 6.40E-03                 | 6.18E-01                 | 6.19E-01 | 2.95E+01 | -1.84E-03 | 1.24E-03  | -2.19E-05 | 2.22E-03 |
| 2.87E+01                 | -2.90E-04                | 3.80E-03                 | 2.78E-02                 | 2.80E-02                 | 2.91E+01                 | -2.89E-02                | 1.01E-02                 | 5.99E-01                 | 6.00E-01 | 2.95E+01 | 5.41E-04  | -1.17E-03 | -1.57E-04 | 1.30E-03 |
| 2.87E+01                 | 4.30E-04                 | 2.14E-03                 | 3.09E-02                 | 3.10E-02                 | 2.91E+01                 | -3.15E-02                | 8.09E-03                 | 5.80E-01                 | 5.81E-01 | 2.95E+01 | -1.35E-03 | 3.18E-05  | 4.47E-04  | 1.42E-03 |
| 2.87E+01                 | -2.35E-03                | -2.36E-03                | 3.58E-02                 | 3.60E-02                 | 2.91E+01                 | -3.00E-02                | 5.30E-03                 | 5.65E-01                 | 5.66E-01 | 2.95E+01 | 1.43E-03  | -1.13E-04 | -4.06E-03 | 2.51E-03 |
| 2.87E+01                 | -3.62E-03                | -2.08E-03                | 4.04E-02                 | 4.06E-02                 | 2.91E+01                 | -2.57E-02                | 1.02E-02                 | 5.43E-01                 | 5.44E-01 | 2.96E+01 | 6.11E-04  |           |           |          |

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|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------|-----------|----------|----------|----------|
| 3.11E+01                 | 6.02E-04                 | 1.50E-03                 | -2.80E-02                | 2.80E-02                 | 3.15E+01                 | 6.19E-04                 | -3.09E-04                | 9.93E-04                 | 1.21E-03                 | 3.20E+01 | -1.78E-02 | 2.98E-03 | 3.36E-01 | 3.37E-01 |
| 3.11E+01                 | 5.60E-04                 | 7.47E-04                 | -1.12E-02                | 1.19E-02                 | 3.16E+01                 | 2.61E-03                 | 1.79E-03                 | 6.15E-04                 | 3.32E-03                 | 3.20E+01 | -0.07E-02 | 3.24E-03 | 3.70E-01 | 3.70E-01 |
| 3.11E+01                 | -0.01E-03                | 1.78E-03                 | 4.70E-03                 | 5.12E-03                 | 3.16E+01                 | -0.22E-03                | -0.28E-03                | 6.28E-04                 | 3.23E-03                 | 3.20E+01 | -1.84E-02 | 1.02E-02 | 4.11E-01 | 4.12E-01 |
| 3.12E+01                 | -3.93E-04                | -1.88E-04                | 7.01E-03                 | 7.08E-03                 | 3.16E+01                 | -7.78E-04                | -8.48E-04                | 1.39E-03                 | 1.89E-03                 | 3.20E+01 | -2.89E-02 | 1.65E-02 | 4.47E-01 | 4.49E-01 |
| 3.12E+01                 | -1.43E-03                | +1.89E-03                | 5.79E-03                 | 6.29E-03                 | 3.16E+01                 | 6.89E-04                 | +1.54E-03                | -8.51E-04                | 1.89E-03                 | 3.20E+01 | -2.74E-02 | 1.43E-02 | 4.86E-01 | 4.87E-01 |
| 3.12E+01                 | -1.28E-04                | -1.18E-04                | 7.71E-03                 | 7.71E-03                 | 3.16E+01                 | 4.46E-04                 | 1.80E-03                 | -8.80E-05                | 1.88E-03                 | 3.20E+01 | -2.96E-02 | 5.22E-01 | 5.22E-01 | 5.23E-01 |
| 3.12E+01                 | -6.93E-04                | -1.26E-03                | 5.14E-03                 | 5.32E-03                 | 3.16E+01                 | -1.23E-03                | 3.49E-05                 | 3.07E-03                 | 3.30E-03                 | 3.20E+01 | -3.13E-02 | 1.36E-02 | 5.51E-01 | 5.52E-01 |
| 3.12E+01                 | 1.91E-04                 | -0.01E-03                | 8.85E-03                 | 8.94E-03                 | 3.16E+01                 | -6.12E-04                | -1.28E-04                | 1.86E-03                 | 1.99E-03                 | 3.21E+01 | -2.79E-02 | 8.10E-03 | 5.78E-01 | 5.79E-01 |
| 3.12E+01                 | -2.89E-03                | 2.12E-03                 | 6.48E-03                 | 7.29E-03                 | 3.16E+01                 | -3.22E-04                | 2.94E-04                 | -9.31E-04                | 1.03E-03                 | 3.21E+01 | -3.47E-02 | 1.57E-02 | 5.87E-01 | 5.89E-01 |
| 3.12E+01                 | -1.75E-03                | 1.76E-03                 | 7.38E-03                 | 7.67E-03                 | 3.16E+01                 | 5.72E-05                 | 4.66E-04                 | -1.10E-04                | 4.82E-04                 | 3.21E+01 | -3.22E-02 | 8.70E-03 | 5.67E-01 | 5.69E-01 |
| 3.12E+01                 | 5.40E-03                 | -1.58E-02                | 1.07E-02                 | 1.27E-02                 | 3.16E+01                 | 2.71E-03                 | -0.291E-04               | -1.24E-04                | 2.73E-03                 | 3.21E+01 | -3.26E-02 | 1.01E-02 | 5.89E-01 | 5.90E-01 |
| 3.12E+01                 | -4.33E-03                | 3.51E-03                 | 4.69E-03                 | 7.09E-03                 | 3.17E+01                 | 9.87E-04                 | 1.03E-04                 | 2.97E-03                 | 2.89E-03                 | 3.21E+01 | -3.33E-02 | 1.11E-02 | 5.85E-01 | 5.91E-01 |
| 3.12E+01                 | -1.35E-04                | 3.20E-03                 | 3.21E-03                 | 4.54E-03                 | 3.17E+01                 | -1.14E-03                | -1.14E-04                | 6.85E-05                 | 1.18E-03                 | 3.21E+01 | -3.05E-02 | 5.75E-01 | 5.75E-01 | 5.76E-01 |
| 3.12E+01                 | -3.54E-03                | 2.20E-03                 | 3.44E-03                 | 5.41E-03                 | 3.17E+01                 | 1.78E-03                 | 1.62E-03                 | -1.05E-04                | 2.41E-03                 | 3.21E+01 | -2.87E-02 | 8.52E-03 | 5.88E-01 | 5.89E-01 |
| 3.13E+01                 | -1.32E-03                | -0.87E-03                | 5.53E-03                 | 6.37E-03                 | 3.17E+01                 | -0.31E-03                | 3.42E-05                 | 1.33E-03                 | 2.66E-03                 | 3.21E+01 | -3.44E-02 | 1.12E-02 | 5.17E-01 | 5.88E-01 |
| 3.13E+01                 | 3.83E-03                 | -1.49E-04                | 1.84E-03                 | 4.25E-03                 | 3.17E+01                 | -0.77E-04                | 1.24E-03                 | -0.25E-03                | 2.85E-03                 | 3.21E+01 | -2.70E-02 | 9.86E-03 | 5.46E-01 | 5.46E-01 |
| 3.13E+01                 | 2.52E-03                 | -1.27E-03                | 1.88E-03                 | 3.39E-03                 | 3.17E+01                 | -6.45E-04                | -1.44E-03                | 2.65E-03                 | 3.18E-03                 | 3.21E+01 | -1.27E-02 | 1.21E-02 | 5.29E-01 | 5.29E-01 |
| 3.13E+01                 | 2.25E-04                 | -1.64E-03                | 3.03E-03                 | 3.45E-03                 | 3.17E+01                 | 1.60E-03                 | -0.20E-03                | 1.91E-03                 | 3.24E-03                 | 3.22E+01 | -2.67E-02 | 6.66E-03 | 5.02E-01 | 5.13E-01 |
| 3.13E+01                 | -1.28E-03                | 9.07E-04                 | 2.19E-03                 | 2.89E-03                 | 3.17E+01                 | 8.04E-04                 | 3.94E-04                 | 1.63E-03                 | 2.11E-03                 | 3.22E+01 | -2.49E-02 | 7.07E-03 | 5.15E-01 | 5.62E-01 |
| 3.13E+01                 | -4.33E-03                | -0.26E-03                | 4.59E-03                 | 4.59E-03                 | 3.17E+01                 | -1.17E-03                | 3.99E-05                 | -4.53E-05                | 3.00E-03                 | 3.22E+01 | -2.89E-02 | 1.26E-02 | 4.87E-01 | 4.96E-01 |
| 3.13E+01                 | 2.29E-03                 | 9.45E-05                 | -3.45E-05                | 2.30E-03                 | 3.18E+01                 | 4.39E-04                 | -1.38E-03                | 3.79E-03                 | 4.09E-03                 | 3.22E+01 | -2.71E-02 | 7.40E-03 | 4.70E-01 | 4.71E-01 |
| 3.13E+01                 | 8.41E-04                 | -9.73E-04                | 2.30E-03                 | 2.64E-03                 | 3.18E+01                 | -1.32E-03                | 2.48E-03                 | 3.86E-03                 | 4.78E-03                 | 3.22E+01 | -2.23E-02 | 1.07E-02 | 4.56E-01 | 4.57E-01 |
| 3.13E+01                 | -1.61E-03                | 1.91E-03                 | 8.92E-04                 | 2.65E-03                 | 3.18E+01                 | -5.77E-04                | 1.66E-04                 | 5.43E-03                 | 5.47E-03                 | 3.22E+01 | -2.95E-02 | 6.22E-03 | 4.41E-01 | 4.42E-01 |
| 3.13E+01                 | 1.31E-03                 | 1.44E-03                 | 2.08E-03                 | 2.85E-03                 | 3.18E+01                 | 7.41E-05                 | 3.50E-03                 | 8.60E-03                 | 9.29E-03                 | 3.22E+01 | -2.30E-02 | 3.97E-03 | 4.30E-01 | 4.30E-01 |
| 3.14E+01                 | 2.15E-03                 | 6.49E-04                 | 7.55E-06                 | 2.25E-03                 | 3.18E+01                 | -1.13E-03                | 6.93E-04                 | 1.14E-02                 | 1.15E-02                 | 3.22E+01 | -2.29E-02 | 7.22E-03 | 4.14E-01 | 4.15E-01 |
| 3.14E+01                 | -2.37E-03                | -0.20E-03                | 3.95E-05                 | 3.10E-03                 | 3.18E+01                 | -1.17E-03                | -1.02E-03                | 1.68E-02                 | 1.68E-02                 | 3.22E+01 | -2.13E-02 | 4.34E-03 | 3.99E-01 | 3.99E-01 |
| 3.14E+01                 | -6.23E-03                | -1.30E-03                | -1.38E-03                | 5.99E-03                 | 3.18E+01                 | -1.52E-03                | -4.66E-05                | 2.73E-02                 | 2.73E-02                 | 3.22E+01 | -1.62E-02 | 3.32E-03 | 3.83E-01 | 3.84E-01 |
| 3.14E+01                 | -5.54E-03                | -1.49E-03                | 1.28E-01                 | 1.28E-01                 | 3.18E+01                 | -3.16E-03                | 2.39E-03                 | 1.39E-02                 | 1.39E-02                 | 3.22E+01 | -1.32E-02 | 3.23E-02 | 3.76E-01 | 3.76E-01 |
| 3.14E+01                 | -1.15E-04                | -1.42E-03                | -1.73E-05                | 1.42E-03                 | 3.18E+01                 | -6.99E-04                | -4.54E-02                | 4.54E-02                 | 4.55E-02                 | 3.22E+01 | -1.88E-02 | 6.04E-03 | 3.56E-01 | 3.56E-01 |
| 3.14E+01                 | -0.77E-04                | -1.84E-03                | 1.37E-03                 | 2.49E-03                 | 3.18E+01                 | -2.50E-03                | 4.47E-03                 | 5.69E-02                 | 5.71E-02                 | 3.23E+01 | -1.64E-02 | 5.53E-03 | 3.42E-01 | 3.42E-01 |
| 3.14E+01                 | -1.52E-03                | -4.91E-05                | 4.88E-04                 | 1.59E-03                 | 3.19E+01                 | -4.41E-03                | 6.47E-02                 | 6.48E-02                 | 6.48E-02                 | 3.23E+01 | -1.69E-02 | 6.72E-03 | 3.25E-01 | 3.26E-01 |
| 3.14E+01                 | -2.10E-03                | 2.40E-03                 | 1.38E-03                 | 3.47E-03                 | 3.19E+01                 | -4.38E-03                | -1.28E-03                | 7.94E-02                 | 7.96E-02                 | 3.23E+01 | -1.37E-02 | 3.97E-03 | 3.15E-01 | 3.15E-01 |
| 3.14E+01                 | 2.43E-03                 | 1.72E-03                 | 6.65E-04                 | 3.05E-03                 | 3.19E+01                 | -6.82E-03                | -2.12E-03                | 9.08E-02                 | 9.09E-02                 | 3.23E+01 | -1.38E-02 | 9.38E-04 | 3.98E-01 | 3.00E-01 |
| 3.14E+01                 | -1.42E-03                | 3.75E-03                 | -1.09E-03                | 4.16E-03                 | 3.19E+01                 | -3.52E-03                | -0.26E-03                | 1.03E-01                 | 1.03E-01                 | 3.23E+01 | -1.34E-02 | 2.84E-01 | 2.84E-01 | 2.84E-01 |
| 3.15E+01                 | -1.02E-04                | 8.74E-04                 | 1.07E-03                 | 1.63E-03                 | 3.19E+01                 | -6.40E-03                | -2.71E-03                | 1.16E-01                 | 1.16E-01                 | 3.23E+01 | -1.48E-02 | 5.90E-03 | 2.72E-01 | 2.73E-01 |
| 3.15E+01                 | 1.35E+01                 | 1.35E+01                 | 8.32E-04                 | 8.32E-04                 | 3.19E+01                 | -1.19E-03                | -1.19E-03                | 1.33E-01                 | 1.33E-01                 | 3.23E+01 | -1.23E-02 | 2.11E-02 | 2.57E-01 | 2.57E-01 |
| 3.15E+01                 | 9.77E-04                 | 4.05E-04                 | 1.25E-03                 | 1.64E-03                 | 3.19E+01                 | -8.80E-03                | 4.48E-03                 | 1.51E-01                 | 1.52E-01                 | 3.23E+01 | -1.15E-02 | 6.80E-04 | 2.44E-01 | 2.44E-01 |
| 3.15E+01                 | -3.32E-04                | 1.33E-03                 | -0.57E-03                | 2.91E-03                 | 3.19E+01                 | -8.78E-03                | 4.35E-04                 | 1.72E-01                 | 1.72E-01                 | 3.24E+01 | -8.86E-03 | 2.90E-03 | 2.90E-01 | 2.90E-01 |
| 3.15E+01                 | 1.29E-03                 | -1.08E-03                | 9.81E-04                 | 1.95E-03                 | 3.19E+01                 | -8.95E-03                | 3.21E-03                 | 1.92E-01                 | 1.92E-01                 | 3.24E+01 | -1.43E-02 | 3.85E-03 | 2.18E-01 | 2.19E-01 |
| 3.15E+01                 | -3.16E-03                | -0.60E-03                | -1.44E-03                | 4.34E-03                 | 3.19E+01                 | -1.30E-02                | 2.10E-03                 | 2.17E-01                 | 2.17E-01                 | 3.24E+01 | -6.32E-03 | 2.02E-01 | 2.02E-01 | 2.03E-01 |
| 3.15E+01                 | 3.61E-03                 | 8.50E-03                 | -5.28E-04                | 9.25E-03                 | 3.20E+01                 | -1.35E-02                | -0.22E-03                | 2.39E-01                 | 2.39E-01                 | 3.24E+01 | -1.07E-02 | 1.37E-01 | 1.91E-01 | 1.91E-01 |
| 3.15E+01                 | 4.10E-04                 | 4.33E-03                 | 6.70E-04                 | 4.40E-03                 | 3.20E+01                 | -1.33E-02                | 3.37E-03                 | 2.63E-01                 | 2.64E-01                 | 3.24E+01 | -1.03E-02 | 1.60E-01 | 1.75E-01 | 1.75E-01 |
| 3.15E+01                 | 1.73E-03                 | 1.03E-03                 | -1.39E-03                | 2.49E-03                 | 3.20E+01                 | -1.60E-02                | 6.25E-03                 | 2.97E-01                 | 2.97E-01                 | 3.24E+01 | -6.70E-03 | 2.84E-01 | 1.65E-01 | 1.66E-01 |

| air bearing data page 76 | air bearing data page 76 | air bearing data page 76 | air bearing data page 77 | air bearing data page 77 | air bearing data page 77 | air bearing data page 78 |          |           |           |           |          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------|-----------|-----------|-----------|----------|
| 3.24E+01                 | -6.83E-03                | 1.48E-03                 | 1.49E-01                 | 1.49E-01                 | 3.28E+01                 | -7.42E-04                | -1.04E-04                | -0.27E-02                | 2.37E-02                 | 3.33E+01 | -1.51E-04 | -4.20E-04 | 3.10E-03  | 3.15E-03 |
| 3.24E+01                 | -6.83E-03                | 9.52E-04                 | 1.40E-01                 | 1.40E-01                 | 3.29E+01                 | 2.07E-03                 | -3.46E-05                | -0.21E-02                | 2.15E-02                 | 3.33E+01 | -4.91E-03 | -3.80E-03 | 2.47E-03  | 2.47E-03 |
| 3.24E+01                 | -4.52E-03                | 2.19E-03                 | 1.28E-01                 | 1.28E-01                 | 3.29E+01                 | 1.98E-03                 | -8.29E-04                | -0.31E-02                | 2.32E-02                 | 3.33E+01 | -1.73E-03 | 5.82E-03  | -0.52E-03 | 6.02E-03 |
| 3.25E+01                 | -1.05E-03                | 1.32E-03                 | 1.13E-01                 | 1.13E-01                 | 3.29E+01                 | -4.58E-03                | -1.64E-03                | -2.83E-02                | 2.33E-02                 | 3.33E+01 | -2.03E-02 | -2.03E-04 | 2.33E-03  | 2.33E-03 |
| 3.25E+01                 | -2.43E-03                | 1.73E-03                 | 1.00E-01                 | 1.00E-01                 | 3.29E+01                 | 4.10E-05                 | 1.48E-04                 | -2.25E-02                | 2.25E-02                 | 3.33E+01 | -1.04E-03 | 3.48E-03  | 1.94E-04  | 3.64E-03 |
| 3.25E+01                 | -4.32E-03                | 5.17E-04                 | 9.05E-02                 | 9.06E-02                 | 3.29E+01                 | 3.32E-03                 | 3.71E-04                 | -0.14E-02                | 2.16E-02                 | 3.34E+01 | -4.13E-03 | -8.54E-04 | 1.86E-03  | 4.61E-03 |
| 3.25E+01                 | -6.06E-03                | 2.20E-03                 | 8.00E-02                 | 8.03E-02                 | 3.29E+01                 | 2.70E-03                 | -0.08E-04                | -0.24E-02                | 2.46E-02                 | 3.33E+01 | -1.34E-03 | 3.30E-04  | -1.53E-03 | 2.06E-03 |
| 3.25E+01                 | -3.91E-03                | -6.40E-05                | 6.78E-02                 | 6.79E-02                 | 3.29E+01                 | 8.77E-04                 | 6.63E-04                 | -0.16E-02                | 2.16E-02                 | 3.33E+01 | -4.96E-05 | -1.41E-03 | -1.71E-04 | 1.58E-03 |
| 3.25E+01                 | -3.84E-03                | -8.82E-04                | 5.56E-02                 | 5.57E-02                 | 3.29E+01                 | 2.08E-03                 | 2.58E-03                 | -1.96E-02                | 1.99E-02                 | 3.34E+01 | -2.21E-03 | 1.02E-03  | -2.55E-04 | 2.44E-03 |
| 3.25E+01                 | -7.70E-04                | 4.28E-02                 | 4.29E-02                 | 4.29E-02                 | 3.29E+01                 | 2.87E-03                 | -1.22E-02                | -0.23E-02                | 2.28E-02                 | 3.34E+01 | 2.02E-04  | 1.06E-02  | -8.28E-03 | 1.08E-02 |
| 3.25E+01                 | -3.19E-04                | 2.28E-03                 | 3.35E-02                 | 3.36E-02                 | 3.29E+01                 | 6.27E-04                 | 1.44E-03                 | -0.22E-02                | 2.23E-02                 | 3.34E+01 | -1.99E-03 | -3.68E-03 | -3.45E-03 | 5.43E-03 |
| 3.25E+01                 | 1.35E+01                 | 1.35E+01                 | 8.32E-04                 | 8.32E-04                 | 3.30E+01                 | 1.92E-03                 | -4.22E-03                | -0.27E-02                | 2.39E-02                 | 3.34E+01 | -1.44E-03 | -0.11E-03 | 7.35E-04  | 2.91E-03 |
| 3.25E+01                 | -1.85E-03                | -3.04E-04                | 1.24E-02                 | 1.24E-02                 | 3.30E+01                 | -1.05E-03                | 3.76E-04                 | -2.31E-02                | 2.31E-02                 | 3.34E+01 | -6.43E-04 | +1.54E-03 | -0.51E-04 | 1.92E-03 |
| 3.25E+01                 | 1.00E-03                 | -1.82E-04                | 2.35E-03                 | 2.60E-03                 | 3.30E+01                 | 2.39E-03                 | -4.41E-04                | -0.21E-02                | 2.23E-02                 | 3.34E+01 | 5.04E-04  | -0.28E-03 | 3.27E-04  | 2.16E-03 |
| 3.26E+01                 | -1.22E-03                | 8.18E-04                 | -3.91E-03                | 4.18E-03                 | 3.30E+01                 | 2.99E-03                 | 3.43E-04                 | -0.54E-02                | 2.56E-02                 | 3.34E+01 | -6.49E-04 | -0.25E-03 | 6.25E-03  | 2.79E-03 |
| 3.26E+01                 | -1.99E-03                | -1.10E-03                | -6.30E-03                | 6.70E-03                 | 3.30E+01                 | 2.10E-05                 | 1.05E-03                 | -0.26E-02                | 2.27E-02                 | 3.34E+01 | -5.89E-04 | -1.97E-03 | 1.66E-04  | 2.05E-03 |
| 3.26E+01                 | -1.85E-03                | -3.13E-04                | -6.78E-03                | 7.04E-03                 | 3.30E+01                 | 3.33E-03                 | 8.06E-05                 | -0.55E-02                | 2.57E-02                 | 3.34E+01 | 6.10E-04  | -1.51E-03 | -0.61E-04 | 1.42E-03 |
| 3.26E+01                 | 1.44E-03                 | -1.26E-03                | -1.00E-02                | 1.02E-02                 | 3.30E+01                 | -8.18E-04                | 1.81E-03                 | -0.26E-02                |                          |          |           |           |           |          |

| air bearing data page 82 | air bearing data page 82 | air bearing data page 82 | air bearing data page 83 | air bearing data page 83 | air bearing data page 83 | air bearing data page 84 | air bearing data page 84 | air bearing data page 84 |          |          |            |           |           |          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------|----------|------------|-----------|-----------|----------|
| 3.50E+01                 | -5.74E-05                | 1.95E-03                 | -5.84E-04                | 2.07E-03                 | 3.54E+01                 | -2.87E-04                | 8.10E-05                 | 9.55E-04                 | 1.00E-03 | 3.59E+01 | -1.64E-03  | 3.84E-03  | 1.09E-03  | 4.31E-03 |
| 3.50E+01                 | 2.29E-03                 | -2.12E-03                | 2.78E-04                 | 3.14E-03                 | 3.54E+01                 | -2.23E-03                | -4.28E-04                | -3.96E-04                | 1.39E-03 | 3.59E+01 | 6.93E-03   | 1.25E-03  | -8.33E-04 | 7.09E-03 |
| 3.50E+01                 | 2.31E-05                 | -8.10E-04                | 1.51E-03                 | 1.78E-03                 | 3.55E+01                 | -4.98E-04                | 4.51E-04                 | 1.17E-03                 | 2.31E-03 | 3.59E+01 | -46.49E-05 | 2.48E-03  | 1.42E-03  | 2.88E-03 |
| 3.50E+01                 | 3.03E-04                 | 1.70E-03                 | -4.91E-04                | 1.83E-03                 | 3.55E+01                 | 1.41E-04                 | 1.50E-03                 | -2.49E-03                | 2.91E-03 | 3.59E+01 | -4.91E-03  | -8.91E-03 | -2.51E-03 | 9.65E-03 |
| 3.50E+01                 | 1.70E-04                 | 5.84E-04                 | -2.13E-04                | 6.44E-04                 | 3.55E+01                 | 4.50E-04                 | 1.57E-03                 | 9.25E-04                 | 1.88E-03 | 3.59E+01 | -1.20E-03  | -1.04E-03 | 1.32E-03  | 2.09E-03 |
| 3.51E+01                 | -2.96E-04                | -7.00E-04                | -7.25E-04                | 1.05E-03                 | 3.55E+01                 | -1.35E-03                | 2.80E-04                 | 1.29E-03                 | 1.89E-03 | 3.59E+01 | 3.20E-03   | -8.70E-04 | -3.88E-03 | 5.10E-03 |
| 3.51E+01                 | 2.03E-05                 | -4.02E-04                | 1.10E-03                 | 1.17E-03                 | 3.55E+01                 | 1.19E-03                 | -7.86E-04                | -4.75E-05                | 1.95E-03 | 3.59E+01 | 1.54E-03   | -1.00E-03 | -8.89E-04 | 2.03E-03 |
| 3.51E+01                 | -8.28E-04                | 8.90E-04                 | 1.10E-03                 | 1.84E-03                 | 3.55E+01                 | 4.85E-04                 | -1.10E-03                | 1.30E-04                 | 1.21E-03 | 3.59E+01 | -2.91E-03  | -8.93E-04 | 1.46E-03  | 3.37E-03 |
| 3.51E+01                 | 3.01E-04                 | 1.58E-03                 | -4.27E-04                | 1.67E-03                 | 3.55E+01                 | -2.00E-04                | 1.60E-03                 | -2.27E-03                | 2.78E-03 | 3.60E+01 | -3.28E-05  | 2.75E-05  | -3.15E-04 | 3.18E-04 |
| 3.51E+01                 | -3.50E-04                | -1.27E-03                | -1.84E-03                | 2.28E-03                 | 3.55E+01                 | -2.56E-04                | -1.28E-03                | 5.60E-04                 | 1.42E-03 | 3.60E+01 | 4.99E-06   | 6.22E-06  | 4.89E-06  | 4.76E-03 |
| 3.51E+01                 | 5.88E-04                 | 2.55E-04                 | 1.13E-04                 | 6.51E-04                 | 3.55E+01                 | 2.25E-03                 | 5.08E-04                 | 3.73E-04                 | 2.34E-03 | 3.60E+01 | -2.33E-03  | 1.57E-03  | 6.32E-03  | 6.52E-03 |
| 3.51E+01                 | -4.07E-04                | 48.99E-04                | 7.79E-04                 | 1.91E-03                 | 3.55E+01                 | -1.89E-04                | -2.27E-03                | 1.04E-03                 | 2.79E-03 | 3.60E+01 | 3.30E-03   | 3.38E-03  | 2.15E-03  | 5.93E-03 |
| 3.51E+01                 | -1.18E-03                | -1.18E-03                | 1.27E-03                 | 2.08E-03                 | 3.55E+01                 | 2.02E-03                 | -5.30E-04                | -7.09E-04                | 2.29E-03 | 3.60E+01 | 3.54E-03   | 3.65E-03  | 2.84E-03  | 5.73E-03 |
| 3.51E+01                 | 4.60E-04                 | -1.80E-03                | 4.73E-04                 | 1.92E-03                 | 3.55E+01                 | 6.00E-04                 | 2.18E-03                 | -8.37E-04                | 2.41E-03 | 3.60E+01 | -1.53E-03  | -8.45E-03 | 1.10E-02  | 1.16E-02 |
| 3.51E+01                 | 5.77E-04                 | -4.28E-04                | -8.91E-04                | 1.21E-03                 | 3.55E+01                 | 1.01E-03                 | 7.95E-04                 | -6.73E-04                | 1.45E-03 | 3.60E+01 | -6.59E-03  | -1.72E-03 | 1.39E-02  | 1.51E-02 |
| 3.52E+01                 | -2.99E-04                | -7.90E-04                | 1.48E-03                 | 1.89E-03                 | 3.56E+01                 | 5.31E-04                 | -2.00E-03                | -1.06E-03                | 2.32E-03 | 3.60E+01 | 1.41E-03   | 7.74E-04  | 9.40E-03  | 9.54E-03 |
| 3.52E+01                 | -1.15E-03                | -1.74E-03                | 1.50E-03                 | 2.57E-03                 | 3.56E+01                 | -2.60E-04                | 4.78E-05                 | -1.02E-03                | 1.05E-03 | 3.60E+01 | 1.18E-03   | 4.94E-03  | 8.18E-03  | 9.62E-03 |
| 3.52E+01                 | 6.69E-04                 | -1.05E-03                | 6.81E-04                 | 1.42E-03                 | 3.56E+01                 | -8.19E-04                | -1.28E-03                | -2.75E-04                | 8.64E-04 | 3.60E+01 | -8.49E-03  | -8.42E-03 | -3.02E-03 | 1.05E-02 |
| 3.52E+01                 | 1.98E-03                 | 5.81E-04                 | -3.45E-04                | 1.70E-03                 | 3.56E+01                 | -1.18E-04                | 1.71E-03                 | -1.24E-03                | 2.12E-03 | 3.61E+01 | -3.11E-03  | -2.67E-04 | 9.10E-03  | 9.62E-03 |
| 3.52E+01                 | -4.99E-04                | -1.22E-05                | -2.28E-05                | 1.97E-03                 | 3.56E+01                 | 2.89E-03                 | 2.87E-02                 | 1.67E-02                 | 4.63E-03 | 3.61E+01 | 2.53E-03   | 2.53E-03  | 7.29E-03  | 7.93E-03 |
| 3.52E+01                 | -8.09E-04                | -2.40E-03                | -1.19E-03                | 2.83E-03                 | 3.56E+01                 | 1.33E-03                 | -2.38E-03                | -2.26E-04                | 2.74E-03 | 3.61E+01 | -3.74E-03  | 2.60E-04  | 1.67E-03  | 4.10E-03 |
| 3.52E+01                 | -2.21E-03                | -8.46E-04                | 2.17E-04                 | 2.31E-03                 | 3.57E+01                 | 8.17E-04                 | -2.12E-03                | -2.57E-03                | 3.43E-03 | 3.61E+01 | -3.34E-03  | -8.03E-03 | -3.09E-03 | 5.80E-03 |
| 3.52E+01                 | 1.15E-05                 | -8.89E-04                | -7.99E-04                | 8.53E-04                 | 3.57E+01                 | -6.06E-04                | -8.89E-04                | -1.27E-07                | 1.06E-03 | 3.61E+01 | 6.66E-04   | -3.06E-03 | -3.32E-03 | 4.56E-03 |
| 3.52E+01                 | 1.93E-03                 | 1.63E-03                 | -2.10E-03                | 3.28E-03                 | 3.57E+01                 | -1.36E-03                | -6.78E-03                | -6.43E-03                | 1.17E-02 | 3.61E+01 | -1.59E-03  | 2.31E-03  | -3.33E-03 | 4.35E-03 |
| 3.52E+01                 | 3.49E-04                 | -1.25E-03                | -3.76E-04                | 1.35E-03                 | 3.57E+01                 | 1.94E-02                 | 4.97E-03                 | -5.20E-03                | 2.07E-02 | 3.61E+01 | 1.94E-03   | 4.99E-03  | -5.38E-04 | 5.38E-03 |
| 3.53E+01                 | -2.23E-03                | -1.41E-03                | 1.60E-06                 | 2.64E-03                 | 3.57E+01                 | -3.60E-03                | -1.05E-04                | 1.91E-03                 | 3.16E-03 | 3.61E+01 | -1.16E-04  | 2.53E-03  | 1.59E-03  | 2.99E-03 |
| 3.53E+01                 | -7.09E-04                | -1.37E-03                | 3.93E-04                 | 4.12E-03                 | 3.57E+01                 | 9.17E-03                 | -8.99E-03                | 7.02E-03                 | 1.27E-02 | 3.61E+01 | -3.56E-03  | 7.15E-04  | 5.47E-04  | 3.88E-03 |
| 3.53E+01                 | 2.00E-03                 | -1.07E-03                | 1.88E-03                 | 3.49E-03                 | 3.57E+01                 | -5.44E-02                | -3.38E-02                | -2.39E-02                | 2.32E-02 | 3.61E+01 | 3.81E-02   | 1.44E-02  | 1.08E-02  | 3.09E-02 |
| 3.53E+01                 | 8.54E-04                 | -7.33E-04                | 1.89E-04                 | 1.14E-03                 | 3.57E+01                 | 8.14E-03                 | -8.57E-03                | 2.91E-02                 | 2.97E-02 | 3.62E+01 | -6.08E-04  | 2.40E-03  | 4.04E-03  | 4.79E-03 |
| 3.53E+01                 | -1.30E-03                | -2.33E-03                | 8.88E-04                 | 2.81E-03                 | 3.57E+01                 | 9.49E-05                 | 2.48E-03                 | 3.72E-02                 | 3.73E-02 | 3.62E+01 | -1.28E-03  | -8.42E-05 | 4.85E-03  | 4.83E-03 |
| 3.53E+01                 | 1.12E-03                 | 2.74E-03                 | 2.55E-03                 | 3.91E-03                 | 3.57E+01                 | 4.87E-03                 | -4.95E-02                | 4.76E-02                 | 4.81E-02 | 3.62E+01 | -2.67E-03  | -2.21E-03 | 1.12E-02  | 1.17E-02 |
| 3.53E+01                 | -1.01E-03                | 4.46E-04                 | -1.33E-03                | 1.73E-03                 | 3.58E+01                 | 4.97E-03                 | -3.44E-03                | 4.85E-02                 | 4.89E-02 | 3.62E+01 | 2.04E-03   | 1.46E-03  | 1.53E-02  | 1.55E-02 |
| 3.53E+01                 | -1.11E-03                | -1.18E-03                | 1.05E-03                 | 1.93E-03                 | 3.58E+01                 | -1.44E-03                | 9.66E-05                 | 4.97E-02                 | 4.97E-02 | 3.62E+01 | 4.40E-04   | 1.94E-03  | 1.87E-02  | 1.88E-02 |
| 3.53E+01                 | -6.94E-04                | 6.54E-06                 | -1.53E-03                | 1.82E-03                 | 3.58E+01                 | -1.13E-03                | 3.01E-03                 | 4.32E-02                 | 4.33E-02 | 3.62E+01 | -1.56E-03  | 1.93E-03  | 2.21E-02  | 2.22E-02 |
| 3.53E+01                 | -8.59E-04                | -4.03E-04                | -2.07E-05                | 9.49E-04                 | 3.58E+01                 | -5.18E-03                | 1.68E-02                 | 3.10E-02                 | 3.17E-02 | 3.62E+01 | -3.80E-03  | 1.17E-04  | 2.08E-02  | 2.11E-02 |
| 3.54E+01                 | -2.89E-04                | -1.00E-03                | 2.99E-04                 | 1.07E-03                 | 3.58E+01                 | -7.91E-03                | 6.57E-02                 | 1.87E-02                 | 1.92E-02 | 3.62E+01 | -3.32E-02  | -1.44E-02 | 2.15E-02  | 2.16E-02 |
| 3.54E+01                 | -1.98E-05                | 1.46E-04                 | 1.10E-03                 | 1.19E-03                 | 3.58E+01                 | -1.33E-02                | 5.47E-03                 | 1.10E-02                 | 1.81E-02 | 3.62E+01 | 2.30E-03   | 5.91E-04  | 2.21E-02  | 2.22E-02 |
| 3.54E+01                 | -8.40E-04                | -4.48E-04                | -1.73E-03                | 1.98E-03                 | 3.58E+01                 | -1.82E-03                | -8.89E-03                | 4.44E-03                 | 7.60E-03 | 3.63E+01 | 5.40E-03   | -1.41E-05 | 1.92E-02  | 1.99E-02 |
| 3.54E+01                 | 7.01E-05                 | 4.02E-05                 | 1.36E-03                 | 1.36E-03                 | 3.58E+01                 | -1.59E-03                | 3.23E-03                 | 2.77E-03                 | 4.54E-03 | 3.63E+01 | 2.66E-03   | -2.04E-03 | 2.23E-02  | 2.25E-02 |
| 3.54E+01                 | -7.89E-04                | -1.54E-03                | 2.60E-03                 | 3.12E-03                 | 3.58E+01                 | -5.27E-05                | 6.01E-04                 | 3.85E-03                 | 3.90E-03 | 3.63E+01 | 1.53E-04   | 1.11E-03  | 2.45E-02  | 2.45E-02 |
| 3.54E+01                 | -6.31E-04                | 2.03E-03                 | 8.21E-04                 | 2.38E-03                 | 3.58E+01                 | 2.75E-03                 | 2.81E-03                 | 6.88E-03                 | 7.93E-03 | 3.63E+01 | 4.17E-03   | -3.74E-04 | 3.22E-02  | 3.25E-02 |
| 3.54E+01                 | 1.32E-03                 | -6.13E-04                | -3.04E-04                | 1.49E-03                 | 3.59E+01                 | 2.21E-03                 | 3.40E-03                 | -3.98E-04                | 4.07E-03 | 3.63E+01 | 1.27E-03   | 3.28E-03  | 3.96E-02  | 3.97E-02 |
| 3.54E+01                 | -2.27E-03                | 1.55E-03                 | -1.08E-03                | 2.99E-03                 | 3.59E+01                 | 7.35E-04                 | -3.26E-03                | 7.23E-04                 | 3.42E-03 | 3.63E+01 | 3.05E-04   | 2.55E-02  | 5.99E-02  | 5.99E-02 |

| air bearing data page 85 | air bearing data page 85 | air bearing data page 85 | air bearing data page 86 | air bearing data page 86 | air bearing data page 86 | air bearing data page 87 | air bearing data page 87 | air bearing data page 87 |          |           |           |           |           |            |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------|-----------|-----------|-----------|-----------|------------|
| 3.63E+01                 | -3.57E-03                | 3.90E-03                 | 6.93E-02                 | 6.95E-02                 | 3.67E+01                 | 3.22E-03                 | -3.48E-02                | 3.60E-02                 | 3.72E+01 | 3.10E-04  | -1.17E-03 | -5.14E-05 | 1.21E-03  |            |
| 3.63E+01                 | -3.62E-03                | 5.96E-03                 | 7.74E-02                 | 7.77E-02                 | 3.67E+01                 | -1.14E-03                | -2.23E-03                | 3.89E-02                 | 3.72E+01 | -1.37E-03 | 7.51E-04  | -1.02E-03 | 1.86E-03  |            |
| 3.63E+01                 | -4.38E-03                | 5.20E-03                 | 7.97E-02                 | 8.02E-02                 | 3.68E+01                 | -6.69E-03                | 3.89E-03                 | -3.61E-02                | 3.69E-02 | 3.72E+01  | 1.95E-04  | -1.44E-04 | 2.51E-04  |            |
| 3.63E+01                 | -3.81E-03                | -3.50E-03                | 7.49E-02                 | 7.53E-02                 | 3.68E+01                 | -2.43E-03                | -2.68E-03                | -3.72E-02                | 3.69E-02 | 3.72E+01  | 2.89E-02  | 3.09E-02  | 3.30E-02  |            |
| 3.63E+01                 | -8.78E-03                | -8.25E-04                | 6.13E-02                 | 6.20E-02                 | 3.68E+01                 | -7.73E-04                | 2.18E-04                 | -3.86E-02                | 3.89E-02 | 3.72E+01  | -1.78E-03 | -2.02E-04 | 5.50E-04  | 1.88E-03   |
| 3.64E+01                 | -1.03E-03                | 4.51E-03                 | 4.17E-02                 | 4.20E-02                 | 3.68E+01                 | -3.13E-03                | -3.47E-02                | 3.48E-02                 | 3.48E-02 | 3.72E+01  | -2.17E-03 | -1.28E-03 | -2.33E-04 | 2.53E-03   |
| 3.64E+01                 | -7.32E-05                | 4.20E-03                 | 2.09E-02                 | 2.10E-02                 | 3.68E+01                 | 2.39E-03                 | 1.79E-03                 | -2.72E-02                | 2.73E-02 | 3.72E+01  | -1.96E-05 | -2.28E-04 | 1.02E-04  | 2.50E-04   |
| 3.64E+01                 | -6.65E-03                | 1.24E-03                 | -1.14E-03                | 5.89E-03                 | 3.68E+01                 | 2.86E-03                 | 8.17E-03                 | -2.07E-02                | 2.28E-02 | 3.72E+01  | 8.47E-06  | 1.73E-03  | -1.69E-04 | 1.74E-03   |
| 3.64E+01                 | -1.74E-03                | 3.55E-03                 | -1.08E-02                | 1.15E-02                 | 3.68E+01                 | -2.70E-03                | -1.35E-03                | -4.86E-03                | 5.72E-03 | 3.72E+01  | 1.29E-04  | 1.46E-04  | 4.48E-05  | 1.99E-04   |
| 3.64E+01                 | 5.48E-03                 | 7.73E-03                 | -1.92E-02                | 2.14E-02                 | 3.68E+01                 | -2.24E-03                | -8.75E-04                | 3.64E-03                 | 4.36E-03 | 3.73E+01  | -1.43E-03 | 9.24E-04  | 1.28E-03  | 2.13E-03   |
| 3.64E+01                 | 9.34E-03                 | 2.44E-03                 | -1.71E-02                | 1.97E-02                 | 3.68E+01                 | 2.58E-03                 | -1.85E-03                | 1.82E-03                 | 3.65E-03 | 3.73E+01  | -6.05E-05 | 7.12E-04  | -1.49E-03 | 1.65E-03   |
| 3.64E+01                 | 7.07E-03                 | -2.07E-02                | 2.39E-02                 | 2.39E-02                 | 3.68E+01                 | -4.94E-04                | -3.04E-04                | 2.29E-03                 | 2.34E-03 | 3.73E+01  | -3.96E-04 | 2.96E-03  | 1.95E-03  | 2.80E-03   |
| 3.64E+01                 | 5.17E-03                 | -4.06E-03                | -2.79E-02                | 2.87E-02                 | 3.68E+01                 | 1.80E-03                 | 2.07E-03                 | 2.65E-03                 | 3.73E-03 | 3.73E+01  | 2.81E-04  | -8.30E-04 | -6.10E-04 | 1.07E-03   |
| 3.64E+01                 | -3.42E-03                | -2.51E-03                | -3.88E-02                | 3.91E-02                 | 3.69E+01                 | -7.60E-06                | 1.52E-05                 | -1.85E-03                | 2.40E-03 | 3.73E+01  | -1.64E-03 | -8.63E-04 | 3.40E-05  | 1.88E-03   |
| 3.64E+01                 | -6.99E-03                | -1.08E-03                | -5.84E-02                | 5.72E-02                 | 3.69E+01                 | 3.10E-04                 | 1.77E-03                 | 1.03E-04                 | 1.80E-03 | 3.73E+01  | -1.72E-03 | -1.12E-04 | -7.27E-04 | 1.87E-03   |
| 3.65E+01                 | -6.72E-03                | 2.62E-03                 | -6.54E-02                | 6.61E-02                 | 3.69E+01                 | -5.36E-04                | 1.64E-03                 | -4.84E-04                | 1.79E-03 | 3.73E+01  | 8.14E-07  | 1.73E-03  | -2.91E-03 | 3.05E-03   |
| 3.65E+01                 | -1.14E-02                | 1.87E-02                 | -7.09E-02                | 7.42E-02                 | 3.69E+01                 | 1.32E-03                 | -1.32E-03                | -1.95E-03                | 1.95E-03 | 3.73E+01  | -4.79E-04 | -8.28E-04 | -1.05E-03 | 7.13E-04   |
| 3.65E+01                 | -7.42E-04                | 9.81E-03                 | -7.18E-02                | 7.25E-02                 | 3.69E+01                 | 1.70E-03                 | -1.99E-04                | 1.82E-03                 | 1.92E-03 | 3.73E+01  | 4.85E-03  | 1.92E-03  | 6.63E-03  | 5.79E-03</ |

|                          |                          |                          |                          |                          |                          |                          |                          |                          |          |          |          |           |           |          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------|----------|----------|-----------|-----------|----------|
| air bearing data page 91 | air bearing data page 91 | air bearing data page 91 | air bearing data page 92 | air bearing data page 92 | air bearing data page 92 | air bearing data page 93 | air bearing data page 93 | air bearing data page 93 |          |          |          |           |           |          |
| 3.89E+01                 | -1.62E-02                | 4.88E-03                 | 3.73E-01                 | 3.74E-01                 | 3.93E-01                 | 4.67E-03                 | -1.88E-04                | -5.28E-02                | 5.30E-02 | 3.98E-01 | 8.63E-03 | -1.78E-03 | -1.64E-01 | 1.65E-01 |
| 3.89E+01                 | -1.77E-02                | 3.97E-03                 | 3.62E-01                 | 3.62E-01                 | 3.93E-01                 | 3.62E-03                 | 5.94E-04                 | -5.67E-02                | 5.68E-02 | 3.98E-01 | 8.74E-03 | -1.51E-03 | -1.68E-01 | 1.67E-01 |
| 3.89E+01                 | -1.91E-02                | 6.55E-03                 | 3.47E-01                 | 3.47E-01                 | 3.94E-01                 | 1.92E-03                 | 4.36E-04                 | -6.15E-02                | 6.16E-02 | 3.98E-01 | 9.83E-03 | -2.15E-03 | -1.68E-01 | 1.68E-01 |
| 3.89E+01                 | -2.05E-02                | 3.37E-01                 | 3.39E-01                 | 3.39E-01                 | 3.94E-01                 | 1.93E-03                 | -1.39E-03                | -6.36E-02                | 6.39E-02 | 3.98E-01 | 1.14E-02 | -1.27E-03 | -1.71E-01 | 1.71E-01 |
| 3.89E+01                 | -1.82E-02                | 5.22E-03                 | 3.24E-01                 | 3.25E-01                 | 3.94E-01                 | 4.01E-03                 | -1.87E-04                | -6.87E-02                | 6.89E-02 | 3.98E-01 | 1.08E-02 | -3.92E-03 | -1.72E-01 | 1.72E-01 |
| 3.89E+01                 | -1.64E-02                | 2.80E-03                 | 3.11E-01                 | 3.11E-01                 | 3.94E-01                 | 4.73E-03                 | -1.27E-03                | -7.22E-02                | 7.24E-02 | 3.98E-01 | 1.03E-02 | -2.71E-03 | -1.73E-01 | 1.73E-01 |
| 3.90E+01                 | -1.89E-02                | 2.77E-03                 | 2.98E-01                 | 2.99E-01                 | 3.94E-01                 | 3.62E-03                 | 1.78E-04                 | -7.79E-02                | 7.80E-02 | 3.98E-01 | 1.01E-02 | -1.41E-03 | -1.73E-01 | 1.73E-01 |
| 3.90E+01                 | -1.45E-02                | 8.74E-03                 | 2.88E-01                 | 2.89E-01                 | 3.94E-01                 | 5.27E-03                 | -4.24E-03                | -8.11E-02                | 8.14E-02 | 3.98E-01 | 1.03E-02 | -2.70E-03 | -1.72E-01 | 1.72E-01 |
| 3.90E+01                 | -1.35E-02                | 2.05E-03                 | 2.82E-01                 | 2.82E-01                 | 3.94E-01                 | 5.52E-03                 | -1.42E-03                | -8.69E-02                | 8.70E-02 | 3.98E-01 | 9.98E-03 | -4.86E-03 | -1.72E-01 | 1.72E-01 |
| 3.90E+01                 | -1.45E-02                | 2.68E-03                 | 2.69E-01                 | 2.69E-01                 | 3.94E-01                 | 7.70E-03                 | 3.54E-03                 | -8.63E-02                | 8.67E-02 | 3.98E-01 | 9.00E-03 | -8.52E-03 | -1.74E-01 | 1.75E-01 |
| 3.90E+01                 | -7.94E-03                | 5.44E-03                 | 2.60E-01                 | 2.60E-01                 | 3.94E-01                 | 4.16E-03                 | -2.27E-03                | -9.19E-02                | 9.21E-02 | 3.99E-01 | 1.03E-02 | -1.62E-03 | -1.77E-01 | 1.77E-01 |
| 3.90E+01                 | -1.54E-02                | 4.46E-03                 | 2.54E-01                 | 2.54E-01                 | 3.94E-01                 | 6.97E-03                 | -1.36E-03                | -9.67E-02                | 9.69E-02 | 3.99E-01 | 9.32E-03 | -3.53E-03 | -1.76E-01 | 1.76E-01 |
| 3.90E+01                 | -1.39E-02                | 3.01E-03                 | 2.42E-01                 | 2.41E-01                 | 3.95E-01                 | 3.88E-03                 | +1.30E-03                | -9.75E-02                | 9.78E-02 | 3.99E-01 | 1.04E-02 | -3.39E-03 | -1.79E-01 | 1.79E-01 |
| 3.90E+01                 | -1.15E-02                | 2.48E-03                 | 2.30E-01                 | 2.30E-01                 | 3.95E-01                 | 6.33E-03                 | -1.72E-03                | -1.00E-01                | 1.00E-01 | 3.99E-01 | 1.07E-02 | -1.80E-03 | -1.77E-01 | 1.78E-01 |
| 3.90E+01                 | -1.16E-02                | 2.59E-03                 | 2.15E-01                 | 2.15E-01                 | 3.95E-01                 | 3.81E-03                 | -2.69E-03                | -1.06E-01                | 1.07E-01 | 3.99E-01 | 9.93E-03 | -2.07E-03 | -1.80E-01 | 1.80E-01 |
| 3.90E+01                 | -6.29E-03                | 4.13E-03                 | 2.05E-01                 | 2.05E-01                 | 3.95E-01                 | 5.42E-03                 | -3.66E-03                | -1.08E-01                | 1.08E-01 | 3.99E-01 | 1.20E-02 | -3.22E-03 | -1.81E-01 | 1.81E-01 |
| 3.91E+01                 | -1.17E-02                | 1.69E-03                 | 1.93E-01                 | 1.93E-01                 | 3.95E-01                 | 5.53E-03                 | -2.03E-03                | -1.11E-01                | 1.12E-01 | 3.99E-01 | 8.75E-03 | -2.26E-03 | -1.80E-01 | 1.80E-01 |
| 3.91E+01                 | -7.75E-03                | 1.80E-01                 | 1.80E-01                 | 1.80E-01                 | 3.95E-01                 | 6.83E-03                 | -8.22E-03                | -1.16E-01                | 1.16E-01 | 3.99E-01 | 1.03E-02 | -2.52E-03 | -1.83E-01 | 1.83E-01 |
| 3.91E+01                 | -8.33E-03                | 3.18E-03                 | 1.69E-01                 | 1.70E-01                 | 3.95E-01                 | 5.91E-03                 | -3.24E-03                | -1.19E-01                | 1.19E-01 | 3.99E-01 | 9.98E-03 | -1.93E-03 | -1.80E-01 | 1.81E-01 |
| 3.91E+01                 | -4.91E-03                | 1.74E-03                 | 1.59E-01                 | 1.60E-01                 | 3.95E-01                 | 6.75E-03                 | 2.55E-04                 | -1.17E-01                | 1.17E-01 | 4.00E-01 | 7.83E-03 | -4.54E-03 | -1.80E-01 | 1.80E-01 |
| 3.91E+01                 | -8.85E-03                | 1.48E-03                 | 1.44E-01                 | 1.44E-01                 | 3.95E-01                 | 6.08E-03                 | -1.42E-03                | -1.20E-01                | 1.21E-01 | 4.00E-01 | 1.23E-02 | -1.45E-03 | -1.81E-01 | 1.82E-01 |
| 3.91E+01                 | -6.51E-03                | 6.08E-04                 | 1.30E-01                 | 1.30E-01                 | 3.95E-01                 | 6.92E-03                 | 9.34E-04                 | -1.23E-01                | 1.23E-01 | 4.00E-01 | 9.72E-03 | -8.12E-03 | -1.82E-01 | 1.82E-01 |
| 3.91E+01                 | -6.64E-03                | 2.50E-03                 | 1.18E-01                 | 1.18E-01                 | 3.96E-01                 | 6.49E-03                 | 3.41E-04                 | -1.29E-01                | 1.29E-01 | 4.00E-01 | 7.83E-03 | -2.38E-03 | -1.81E-01 | 1.81E-01 |
| 3.91E+01                 | -5.47E-03                | 1.42E-03                 | 1.06E-01                 | 1.07E-01                 | 3.96E-01                 | 7.98E-03                 | 1.34E-03                 | -1.33E-01                | 1.33E-01 | 4.00E-01 | 8.75E-03 | -1.86E-03 | -1.80E-01 | 1.80E-01 |
| 3.91E+01                 | -5.08E-03                | 1.91E-03                 | 9.26E-02                 | 9.27E-02                 | 3.96E-01                 | 6.75E-03                 | -2.66E-03                | -1.32E-01                | 1.32E-01 | 4.00E-01 | 9.90E-03 | -2.30E-04 | -1.81E-01 | 1.81E-01 |
| 3.91E+01                 | -4.92E-03                | 8.35E-02                 | 8.35E-02                 | 8.35E-02                 | 3.96E-01                 | 6.34E-03                 | -2.65E-03                | -1.35E-01                | 1.35E-01 | 4.00E-01 | 8.01E-03 | -1.52E-03 | -1.84E-01 | 1.84E-01 |
| 3.92E+01                 | -4.23E-03                | 1.77E-03                 | 7.15E-02                 | 7.16E-02                 | 3.96E-01                 | 6.99E-03                 | -8.03E-04                | -1.34E-01                | 1.35E-01 | 4.00E-01 | 7.08E-03 | -2.35E-03 | -1.81E-01 | 1.81E-01 |
| 3.92E+01                 | -1.05E-03                | 1.05E-03                 | 6.96E-02                 | 6.97E-02                 | 3.96E-01                 | 3.91E-03                 | -3.91E-03                | -1.37E-01                | 1.37E-01 | 4.00E-01 | 1.23E-02 | -3.45E-03 | -1.83E-01 | 1.83E-01 |
| 3.92E+01                 | -2.19E-03                | 4.75E-02                 | 4.75E-02                 | 4.75E-02                 | 3.96E-01                 | 8.70E-03                 | -8.41E-03                | -1.43E-01                | 1.43E-01 | 4.00E-01 | 1.02E-02 | -4.71E-03 | -1.81E-01 | 1.81E-01 |
| 3.92E+01                 | -1.17E-04                | 1.81E-03                 | 3.52E-02                 | 3.53E-02                 | 3.96E-01                 | 8.99E-03                 | -8.69E-04                | -1.46E-01                | 1.46E-01 | 4.01E-01 | 7.96E-03 | 6.15E-04  | -1.83E-01 | 1.84E-01 |
| 3.92E+01                 | -4.27E-03                | 2.33E-02                 | 2.37E-02                 | 2.37E-02                 | 3.96E-01                 | 8.84E-03                 | -2.10E-03                | -1.47E-01                | 1.47E-01 | 4.01E-01 | 9.92E-03 | -3.21E-03 | -1.81E-01 | 1.81E-01 |
| 3.92E+01                 | -1.62E-03                | -2.15E-03                | 1.11E-02                 | 1.14E-02                 | 3.96E-01                 | 6.10E-03                 | -1.95E-03                | -1.49E-01                | 1.49E-01 | 4.01E-01 | 1.03E-02 | -3.65E-03 | -1.80E-01 | 1.80E-01 |
| 3.92E+01                 | 2.28E-04                 | -2.38E-03                | 2.30E-04                 | 2.40E-03                 | 3.97E-01                 | 7.96E-03                 | -2.64E-03                | -1.49E-01                | 1.49E-01 | 4.01E-01 | 8.11E-03 | -4.15E-03 | -1.80E-01 | 1.80E-01 |
| 3.92E+01                 | 4.18E-04                 | 2.80E-03                 | -7.68E-03                | 8.19E-03                 | 3.97E-01                 | 8.10E-03                 | -2.77E-03                | -1.52E-01                | 1.52E-01 | 4.01E-01 | 9.00E-03 | -3.28E-03 | -1.82E-01 | 1.82E-01 |
| 3.92E+01                 | 1.50E-03                 | 2.42E-04                 | -1.24E-02                | 1.25E-02                 | 3.97E-01                 | 8.94E-03                 | -1.31E-03                | -1.54E-01                | 1.55E-01 | 4.01E-01 | 8.02E-03 | -3.69E-03 | -1.79E-01 | 1.79E-01 |
| 3.93E+01                 | 2.95E-03                 | -1.53E-03                | -4.95E-02                | 1.97E-02                 | 3.97E-01                 | 6.70E-03                 | -8.23E-04                | -1.57E-01                | 1.57E-01 | 4.01E-01 | 8.01E-03 | -3.45E-03 | -1.79E-01 | 1.79E-01 |
| 3.93E+01                 | 1.67E-03                 | -1.26E-03                | -2.28E-02                | 2.29E-02                 | 3.97E-01                 | 6.55E-03                 | -2.25E-03                | -1.57E-01                | 1.57E-01 | 4.01E-01 | 9.97E-03 | -6.89E-03 | -1.79E-01 | 1.79E-01 |
| 3.93E+01                 | 2.08E-03                 | 5.73E-04                 | -2.36E-02                | 2.37E-02                 | 3.97E-01                 | 7.51E-03                 | -1.92E-03                | -1.60E-01                | 1.60E-01 | 4.01E-01 | 8.34E-03 | -1.36E-03 | -1.78E-01 | 1.78E-01 |
| 3.93E+01                 | 5.96E-04                 | -3.23E-04                | -3.06E-02                | 3.06E-02                 | 3.97E-01                 | 9.48E-03                 | 1.33E-03                 | -1.58E-01                | 1.59E-01 | 4.01E-01 | 1.13E-02 | -4.87E-03 | -1.79E-01 | 1.79E-01 |
| 3.93E+01                 | -2.12E-04                | -9.78E-04                | -3.52E-02                | 3.52E-02                 | 3.97E-01                 | 7.86E-03                 | -1.20E-03                | -1.61E-01                | 1.61E-01 | 4.02E-01 | 8.62E-03 | -1.56E-04 | -1.79E-01 | 1.79E-01 |
| 3.93E+01                 | 3.35E-03                 | -1.60E-03                | -4.05E-02                | 4.07E-02                 | 3.97E-01                 | 9.98E-03                 | -4.39E-03                | -1.63E-01                | 1.64E-01 | 4.02E-01 | 9.09E-03 | -2.65E-03 | -1.76E-01 | 1.76E-01 |
| 3.93E+01                 | 3.29E-03                 | -3.53E-04                | -6.64E-02                | 4.65E-02                 | 3.97E-01                 | 8.18E-03                 | -2.36E-03                | -1.64E-01                | 1.64E-01 | 4.02E-01 | 9.16E-03 | -2.54E-03 | -1.76E-01 | 1.76E-01 |
| 3.93E+01                 | 6.13E-04                 | -1.37E-03                | -5.17E-02                | 5.17E-02                 | 3.98E-01                 | 9.38E-03                 | -1.41E-04                | -1.64E-01                | 1.65E-01 | 4.02E-01 | 9.39E-03 | -1.79E-04 | -1.76E-01 | 1.76E-01 |

|                          |                          |                          |                          |                          |                          |                          |                          |                          |          |          |           |           |           |          |
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| 4.02E+01                 | 9.70E-03                 | -3.21E-03                | -1.78E-01                | 1.78E-01                 | 4.06E+01                 | 4.24E-03                 | -3.18E-03                | -1.13E-01                | 1.13E-01 | 4.11E+01 | -1.90E-03 | 9.22E-04  | -1.05E-02 | 1.07E-02 |
| 4.02E+01                 | 9.50E-03                 | -3.21E-03                | -1.79E-01                | 1.79E-01                 | 4.06E+01                 | 3.38E-03                 | -1.91E-03                | -1.13E-01                | 1.10E-01 | 4.11E+01 | -1.22E-03 | -4.31E-04 | -8.75E-03 | 8.66E-03 |
| 4.02E+01                 | 9.44E-03                 | -7.94E-04                | -1.74E-01                | 1.74E-01                 | 4.06E+01                 | 3.34E-03                 | -7.99E-04                | -1.11E-01                | 1.11E-01 | 4.11E+01 | 3.78E-04  | 2.75E-03  | -5.68E-03 | 6.32E-03 |
| 4.02E+01                 | 1.07E-02                 | -4.33E-03                | -1.67E-01                | 1.67E-01                 | 4.07E+01                 | 4.03E-03                 | -1.37E-03                | -1.11E-01                | 1.11E-01 | 4.11E+01 | -4.91E-04 | -6.12E-04 | -4.53E-03 | 5.19E-03 |
| 4.02E+01                 | 9.23E-03                 | -1.35E-03                | -1.74E-01                | 1.74E-01                 | 4.07E+01                 | 3.14E-03                 | -1.89E-03                | -1.03E-01                | 1.03E-01 | 4.11E+01 | -1.52E-03 | 1.83E-03  | 8.82E-04  | 2.53E-03 |
| 4.02E+01                 | 1.01E-02                 | -3.08E-03                | -1.72E-01                | 1.72E-01                 | 4.07E+01                 | 2.83E-03                 | 2.22E-04                 | -1.02E-01                | 1.02E-01 | 4.11E+01 | -2.22E-04 | -1.01E-03 | -1.21E-03 | 1.60E-03 |
| 4.03E+01                 | 6.57E-03                 | -8.82E-04                | -1.72E-01                | 1.72E-01                 | 4.07E+01                 | 2.94E-03                 | -2.59E-03                | -9.73E-02                | 9.74E-02 | 4.11E+01 | -2.05E-03 | -1.29E-03 | 6.38E-04  | 2.51E-03 |
| 4.03E+01                 | 8.69E-03                 | -8.51E-04                | -1.72E-01                | 1.72E-01                 | 4.07E+01                 | 2.69E-03                 | -3.40E-03                | -9.63E-02                | 9.64E-02 | 4.11E+01 | -5.38E-05 | 8.62E-04  | -1.69E-03 | 1.77E-03 |
| 4.03E+01                 | 6.79E-03                 | -2.18E-04                | -1.72E-01                | 1.72E-01                 | 4.07E+01                 | 4.80E-03                 | -3.42E-04                | -9.25E-02                | 9.28E-02 | 4.11E+01 | -6.07E-04 | 1.30E-03  | -9.88E-04 | 1.87E-03 |
| 4.03E+01                 | 7.84E-03                 | -2.54E-03                | -1.69E-01                | 1.69E-01                 | 4.07E+01                 | 3.49E-03                 | -1.96E-04                | -9.40E-02                | 9.41E-02 | 4.12E+01 | 2.97E-04  | -1.40E-03 | -1.06E-03 | 1.78E-03 |
| 4.03E+01                 | 7.78E-03                 | -3.29E-03                | -1.70E-01                | 1.70E-01                 | 4.07E+01                 | 1.75E-03                 | -8.65E-04                | -8.62E-02                | 8.83E-02 | 4.12E+01 | -2.22E-03 | -1.75E-03 | 1.39E-03  | 3.15E-03 |
| 4.03E+01                 | 8.71E-03                 | -2.41E-03                | -1.65E-01                | 1.65E-01                 | 4.07E+01                 | 4.09E-03                 | 3.51E-04                 | -8.69E-02                | 8.92E-02 | 4.12E+01 | -1.21E-03 | -6.93E-04 | -1.38E-04 | 1.54E-03 |
| 4.03E+01                 | 9.15E-03                 | -1.98E-03                | -1.64E-01                | 1.65E-01                 | 4.07E+01                 | 8.79E-04                 | -1.15E-03                | -8.22E-02                | 8.22E-02 | 4.12E+01 | -3.22E-03 | -2.94E-04 | -2.08E-03 | 3.13E-03 |
| 4.03E+01                 | 7.82E-03                 | 1.15E-04                 | -1.63E-01                | 1.63E-01                 | 4.08E+01                 | 2.85E-03                 | -8.46E-05                | -8.33E-02                | 8.33E-02 | 4.12E+01 | -2.90E-03 | -3.46E-04 | -1.46E-03 | 3.26E-03 |
| 4.03E+01                 | 7.16E-03                 | -2.41E-03                | -1.62E-01                | 1.62E-01                 | 4.08E+01                 | 3.81E-03                 | 2.30E-04                 | -8.10E-02                | 8.11E-02 | 4.12E+01 | -1.93E-03 | -1.35E-03 | -1.12E-03 | 2.33E-03 |
| 4.03E+01                 | 7.19E-03                 | 7.61E-05                 | -1.62E-01                | 1.62E-01                 | 4.08E+01                 | 3.99E-03                 | 3.32E-03                 | -7.65E-02                | 7.66E-02 | 4.12E+01 | 1.81E-04  | 2.06E-03  | 2.15E-03  | 2.99E-03 |
| 4.04E+01                 | 6.96E-03                 | -3.62E-04                | -1.61E-01                | 1.62E-01                 | 4.08E+01                 | 2.47E-03                 | 1.57E-04                 | -7.32E-02                | 7.32E-02 | 4.12E+01 | -2.01E-03 | 1.68E-03  | 2.28E-04  | 2.63E-03 |
| 4.04E+01                 | 6.26E-03                 | -9.79E-04                | -1.59E-01                | 1.60E-01                 | 4.08E+01                 | 9.58E-04                 | -2.63E-03                | -7.09E-02                | 7.09E-02 | 4.12E+01 | -2.52E-03 |           |           |          |

|                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |          |           |           |           |          |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|----------|-----------|-----------|-----------|----------|
| air bearing data page 100 |          |           |           |           |          |
| 4.28E+01                  | -4.02E-03                 | 1.84E-03                  | 1.21E-02                  | 1.29E-02                  | 4.32E+01                  | -5.55E-04                 | 2.20E-03                  | 1.07E-02                  | 1.09E-02                  | 4.37E+01 | -1.02E-04 | 3.22E-03  | -3.22E-03 | 4.58E-03 |
| 4.28E+01                  | -6.00E-04                 | 1.11E-03                  | 1.05E-02                  | 1.06E-02                  | 4.32E+01                  | -3.60E-03                 | 1.24E-03                  | 9.92E-03                  | 1.06E-02                  | 4.37E+01 | -2.86E-03 | 1.86E-03  | -2.13E-04 | 3.42E-03 |
| 4.28E+01                  | 1.07E-03                  | -2.29E-04                 | 1.91E-02                  | 1.31E-02                  | 4.32E+01                  | -2.72E-03                 | 1.84E-03                  | 1.01E-02                  | 1.06E-02                  | 4.37E+01 | -3.77E-03 | 8.87E-04  | 1.81E-03  | 4.29E-03 |
| 4.28E+01                  | -3.84E-03                 | 3.24E-03                  | 1.15E-02                  | 1.20E-02                  | 4.33E+01                  | -2.91E-03                 | -1.46E-03                 | 8.37E-03                  | 8.75E-03                  | 4.37E+01 | -3.20E-03 | 1.04E-05  | -4.49E-03 | 2.89E-03 |
| 4.28E+01                  | -6.93E-04                 | 3.11E-03                  | 1.16E-02                  | 1.20E-02                  | 4.33E+01                  | -2.52E-03                 | -2.81E-04                 | 9.84E-03                  | 1.02E-02                  | 4.37E+01 | -3.23E-04 | -2.17E-03 | -1.80E-03 | 2.84E-03 |
| 4.28E+01                  | -3.49E-03                 | 4.14E-03                  | 1.33E-02                  | 1.43E-02                  | 4.33E+01                  | -2.31E-03                 | -2.70E-04                 | 9.83E-03                  | 9.91E-03                  | 4.37E+01 | -1.59E-03 | 6.53E-04  | -5.84E-04 | 2.17E-03 |
| 4.28E+01                  | -1.82E-03                 | -7.86E-04                 | 1.50E-02                  | 1.51E-02                  | 4.33E+01                  | -1.03E-03                 | 1.88E-03                  | 9.84E-03                  | 9.88E-03                  | 4.37E+01 | -8.99E-06 | 2.30E-03  | 1.00E-03  | 2.51E-03 |
| 4.28E+01                  | -1.13E-03                 | -3.74E-03                 | 1.68E-02                  | 1.72E-02                  | 4.33E+01                  | 1.00E-03                  | 1.66E-04                  | 6.41E-03                  | 6.49E-03                  | 4.37E+01 | -2.98E-03 | 4.01E-03  | -4.23E-03 | 6.38E-03 |
| 4.29E+01                  | -5.16E-03                 | -2.93E-04                 | 1.08E-02                  | 1.20E-02                  | 4.33E+01                  | -3.40E-03                 | -3.50E-04                 | 9.39E-03                  | 1.00E-02                  | 4.37E+01 | -4.68E-03 | -4.28E-03 | -1.71E-03 | 6.58E-03 |
| 4.29E+01                  | -3.84E-03                 | 2.36E-03                  | 1.41E-02                  | 1.48E-02                  | 4.33E+01                  | 2.14E-03                  | -3.97E-03                 | 1.04E-02                  | 1.22E-02                  | 4.37E+01 | -3.04E-03 | -2.01E-04 | -4.32E-03 | 5.29E-03 |
| 4.29E+01                  | -1.68E-03                 | 3.24E-03                  | 1.49E-02                  | 1.53E-02                  | 4.33E+01                  | -6.09E-03                 | 4.41E-03                  | 4.08E-03                  | 8.59E-03                  | 4.38E+01 | -8.47E-04 | 1.42E-03  | 1.19E-03  | 2.04E-03 |
| 4.29E+01                  | -3.91E-03                 | 1.37E-03                  | 1.67E-02                  | 1.53E-02                  | 4.33E+01                  | -2.34E-03                 | 1.28E-03                  | 6.94E-03                  | 7.63E-03                  | 4.38E+01 | -3.97E-03 | 1.39E-03  | 2.99E-03  | 4.57E-03 |
| 4.29E+01                  | -1.17E-03                 | -4.11E-03                 | 1.37E-02                  | 1.44E-02                  | 4.33E+01                  | -1.62E-03                 | 3.37E-03                  | 5.42E-03                  | 6.95E-03                  | 4.38E+01 | -1.85E-03 | -1.35E-03 | 2.21E-03  | 3.25E-03 |
| 4.29E+01                  | -6.44E-04                 | -1.77E-03                 | 1.59E-02                  | 1.61E-02                  | 4.34E+01                  | -1.75E-03                 | 2.15E-03                  | 6.69E-03                  | 7.24E-03                  | 4.38E+01 | -1.23E-03 | 8.89E-04  | -3.04E-03 | 3.39E-03 |
| 4.29E+01                  | -7.75E-05                 | 2.28E-03                  | 1.28E-02                  | 1.28E-02                  | 4.34E+01                  | -2.21E-03                 | 3.86E-03                  | 4.85E-03                  | 6.32E-03                  | 4.38E+01 | 9.42E-04  | 1.90E-03  | -1.14E-03 | 2.41E-03 |
| 4.29E+01                  | -2.93E-03                 | -1.01E-03                 | 1.35E-02                  | 1.39E-02                  | 4.34E+01                  | 1.28E-03                  | -1.19E-03                 | 6.05E-03                  | 6.31E-03                  | 4.38E+01 | -1.14E-03 | 3.01E-03  | -1.32E-03 | 3.48E-03 |
| 4.29E+01                  | -4.78E-04                 | 7.87E-04                  | 1.49E-02                  | 1.58E-02                  | 4.34E+01                  | -4.35E-03                 | 2.27E-03                  | 4.12E-03                  | 6.41E-03                  | 4.38E+01 | -2.40E-03 | 2.01E-03  | 1.47E-03  | 3.48E-03 |
| 4.30E+01                  | -2.06E-03                 | 1.53E-02                  | 1.53E-02                  | 1.56E-02                  | 4.34E+01                  | -3.42E-03                 | 1.10E-03                  | 4.52E-03                  | 5.77E-03                  | 4.38E+01 | -1.69E-03 | -2.89E-04 | 1.44E-04  | 1.72E-03 |
| 4.30E+01                  | -1.27E-03                 | -3.04E-04                 | 1.41E-02                  | 1.42E-02                  | 4.34E+01                  | 1.27E-03                  | 3.68E-04                  | 4.14E-03                  | 4.34E-03                  | 4.38E+01 | -7.80E-04 | -3.42E-04 | -1.63E-04 | 8.71E-04 |
| 4.30E+01                  | -3.91E-03                 | -2.93E-04                 | 1.67E-02                  | 1.53E-02                  | 4.34E+01                  | -2.54E-03                 | 7.96E-04                  | 6.85E-03                  | 7.07E-03                  | 4.38E+01 | -4.59E-04 | -4.98E-04 | -4.78E-04 | 1.57E-03 |
| 4.30E+01                  | -3.52E-03                 | -1.20E-03                 | 1.29E-02                  | 1.35E-02                  | 4.34E+01                  | -1.30E-03                 | 1.87E-03                  | 3.56E-03                  | 4.14E-03                  | 4.38E+01 | -2.94E-03 | 4.33E-04  | -3.78E-05 | 2.98E-03 |
| 4.30E+01                  | -2.10E-03                 | -2.51E-04                 | 1.51E-02                  | 1.53E-02                  | 4.34E+01                  | -4.78E-03                 | 6.35E-03                  | 1.81E-03                  | 1.18E-02                  | 4.39E+01 | -2.73E-03 | 1.69E-03  | -2.92E-03 | 3.28E-03 |
| 4.30E+01                  | -2.28E-03                 | -2.01E-03                 | 1.33E-02                  | 1.37E-02                  | 4.34E+01                  | -6.73E-04                 | -4.94E-03                 | 1.85E-03                  | 5.32E-03                  | 4.39E+01 | -2.26E-03 | 3.73E-04  | -1.08E-04 | 2.30E-03 |
| 4.30E+01                  | -1.12E-03                 | 1.18E-03                  | 1.36E-02                  | 1.37E-02                  | 4.35E+01                  | -2.41E-03                 | -4.27E-03                 | 5.39E-03                  | 7.29E-03                  | 4.39E+01 | 5.83E-05  | 2.14E-03  | -8.40E-04 | 2.30E-03 |
| 4.30E+01                  | -3.09E-03                 | 8.20E-04                  | 1.25E-02                  | 1.29E-02                  | 4.35E+01                  | 1.78E-03                  | 2.82E-03                  | 3.82E-03                  | 5.07E-03                  | 4.39E+01 | -3.64E-03 | 6.89E-03  | -1.51E-03 | 7.94E-03 |
| 4.30E+01                  | -3.23E-03                 | -1.77E-03                 | 1.62E-02                  | 1.66E-02                  | 4.35E+01                  | -2.22E-04                 | 5.87E-04                  | 4.72E-03                  | 4.76E-03                  | 4.39E+01 | -2.64E-04 | 1.54E-03  | 1.13E-03  | 1.93E-03 |
| 4.31E+01                  | -3.09E-03                 | -1.91E-02                 | 1.22E-02                  | 1.27E-02                  | 4.35E+01                  | -1.50E-03                 | -7.81E-05                 | 1.09E-03                  | 2.19E-03                  | 4.39E+01 | 1.98E-04  | -6.49E-03 | 3.30E-03  | 6.41E-03 |
| 4.31E+01                  | -4.09E-03                 | 4.09E-04                  | 1.40E-02                  | 1.41E-02                  | 4.35E+01                  | -4.35E-03                 | -4.10E-04                 | 4.31E-03                  | 2.89E-03                  | 4.39E+01 | -1.39E-03 | -1.49E-03 | -4.28E-04 | 1.31E-03 |
| 4.31E+01                  | -1.85E-03                 | 1.85E-03                  | 1.51E-02                  | 1.59E-02                  | 4.35E+01                  | -2.18E-03                 | 2.43E-03                  | 2.58E-03                  | 4.18E-03                  | 4.39E+01 | -1.73E-03 | 1.08E-03  | -1.09E-03 | 2.85E-03 |
| 4.31E+01                  | -2.18E-03                 | 1.38E-03                  | 1.30E-02                  | 1.32E-02                  | 4.35E+01                  | -7.62E-04                 | -1.46E-03                 | 2.32E-03                  | 2.85E-03                  | 4.39E+01 | 1.03E-03  | -1.62E-05 | -3.88E-04 | 1.05E-03 |
| 4.31E+01                  | -1.04E-03                 | -1.28E-03                 | 1.12E-02                  | 1.13E-02                  | 4.35E+01                  | -1.38E-03                 | 5.21E-04                  | 9.04E-04                  | 1.73E-03                  | 4.40E+01 | -2.73E-03 | 7.86E-04  | 1.22E-03  | 3.09E-03 |
| 4.31E+01                  | -3.43E-03                 | 6.11E-03                  | 1.63E-02                  | 1.78E-02                  | 4.35E+01                  | -3.39E-03                 | 1.28E-04                  | 3.64E-03                  | 4.98E-03                  | 4.40E+01 | -2.71E-03 | 1.91E-03  | -9.02E-03 | 3.47E-03 |
| 4.31E+01                  | -1.57E-03                 | 3.55E-03                  | 1.19E-02                  | 1.25E-02                  | 4.35E+01                  | -5.24E-04                 | -1.08E-04                 | 3.93E-03                  | 3.97E-03                  | 4.40E+01 | -1.18E-03 | 4.68E-04  | 1.12E-04  | 1.68E-03 |
| 4.31E+01                  | -1.93E-04                 | -1.37E-04                 | 1.31E-02                  | 1.32E-02                  | 4.36E+01                  | -3.59E-03                 | 3.46E-04                  | 3.38E-03                  | 4.93E-03                  | 4.40E+01 | -1.60E-03 | -8.47E-05 | -1.12E-03 | 1.95E-03 |
| 4.31E+01                  | -2.94E-04                 | -4.23E-04                 | 1.48E-02                  | 1.49E-02                  | 4.36E+01                  | -8.41E-04                 | 3.86E-03                  | 9.03E-04                  | 4.07E-03                  | 4.40E+01 | -2.35E-03 | 1.59E-03  | 1.16E-03  | 3.06E-03 |
| 4.31E+01                  | -4.67E-03                 | 2.22E-04                  | 1.51E-02                  | 1.51E-02                  | 4.36E+01                  | -2.95E-03                 | 1.80E-03                  | 4.90E-03                  | 4.90E-03                  | 4.40E+01 | -4.52E-03 | 8.69E-04  | -1.11E-05 | 1.71E-03 |
| 4.32E+01                  | -1.15E-03                 | 1.55E-03                  | 1.25E-02                  | 1.27E-02                  | 4.36E+01                  | -1.64E-03                 | 1.10E-03                  | 7.89E-04                  | 2.18E-03                  | 4.40E+01 | -1.73E-03 | 2.04E-03  | -1.89E-04 | 2.72E-03 |
| 4.32E+01                  | -3.90E-03                 | 1.24E-03                  | 1.22E-02                  | 1.28E-02                  | 4.36E+01                  | -3.39E-03                 | 8.16E-04                  | -1.16E-03                 | 3.67E-03                  | 4.40E+01 | -1.41E-03 | 9.95E-04  | -2.95E-04 | 1.89E-03 |
| 4.32E+01                  | -2.16E-03                 | -1.58E-03                 | 1.23E-02                  | 1.25E-02                  | 4.36E+01                  | -4.60E-03                 | -1.78E-03                 | -1.35E-03                 | 5.11E-03                  | 4.40E+01 | -2.48E-03 | 1.60E-03  | -8.07E-04 | 3.06E-03 |
| 4.32E+01                  | -1.54E-03                 | -2.88E-03                 | 9.21E-03                  | 9.77E-03                  | 4.36E+01                  | -1.65E-03                 | -2.20E-03                 | -2.02E-04                 | 1.75E-03                  | 4.40E+01 | -6.34E-04 | 5.78E-04  | -1.16E-03 | 1.60E-03 |
| 4.32E+01                  | -1.93E-03                 | 5.20E-04                  | 1.08E-02                  | 1.10E-02                  | 4.36E+01                  | -2.00E-04                 | -1.37E-03                 | 1.48E-03                  | 2.03E-03                  | 4.41E+01 | -7.05E-04 | 9.26E-04  | 2.41E-04  | 1.19E-03 |
| 4.32E+01                  | -3.35E-03                 | -7.31E-04                 | 1.04E-02                  | 1.09E-02                  | 4.36E+01                  | -1.49E-03                 | -3.91E-04                 | 7.34E-04                  | 1.71E-03                  | 4.41E+01 | -1.88E-03 | 1.25E-03  | -2.56E-03 | 3.56E-03 |
| 4.32E+01                  | -1.19E-03                 | 1.89E-03                  | 1.01E-02                  | 1.03E-02                  | 4.36E+01                  | -1.18E-03                 | 1.22E-02                  | -2.38E-03                 | 2.92E-03                  | 4.41E+01 | -3.04E-03 | -2.79E-03 | 1.54E-04  | 4.13E-03 |

|                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |          |           |           |           |          |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|----------|-----------|-----------|-----------|----------|
| air bearing data page 103 | air bearing data page 103 | air bearing data page 103 | air bearing data page 104 | air bearing data page 104 | air bearing data page 104 | air bearing data page 105 |          |           |           |           |          |
| 4.41E+01                  | -2.42E-03                 | 3.65E-04                  | 9.68E-04                  | 2.63E-03                  | 4.45E+01                  | -2.11E-03                 | 4.48E-06                  | 2.34E-03                  | 3.29E-03                  | 4.50E+01 | 4.97E-03  | -2.65E-03 | -1.23E-01 | 1.23E-01 |
| 4.41E+01                  | -2.83E-03                 | 1.52E-03                  | 1.26E-03                  | 3.45E-03                  | 4.45E+01                  | 1.49E-03                  | 1.96E-03                  | 3.34E-03                  | 3.29E-03                  | 4.50E+01 | -2.92E-03 | -9.02E-03 | -1.21E-01 | 1.15E-01 |
| 4.41E+01                  | 1.77E-03                  | -2.22E-03                 | 5.82E-03                  | 6.47E-03                  | 4.45E+01                  | -2.17E-03                 | -7.55E-04                 | 5.85E-04                  | 2.37E-03                  | 4.50E+01 | 5.78E-03  | -1.61E-03 | -1.15E-01 | 1.15E-01 |
| 4.41E+01                  | -3.81E-03                 | 3.42E-03                  | 3.42E-03                  | 4.41E-03                  | 4.45E+01                  | -3.42E-03                 | -2.50E-03                 | -2.50E-03                 | 2.30E-03                  | 4.50E+01 | 6.05E-03  | 8.05E-03  | -1.13E-01 | 1.15E-01 |
| 4.41E+01                  | -6.40E-06                 | 4.28E-03                  | -1.16E-03                 | 4.44E-03                  | 4.45E+01                  | -1.70E-03                 | 2.13E-03                  | 1.95E-03                  | 3.35E-03                  | 4.50E+01 | 6.04E-03  | -1.58E-03 | -1.09E-01 | 1.10E-01 |
| 4.41E+01                  | -3.88E-03                 | 1.20E-03                  | -1.02E-03                 | 4.18E-03                  | 4.45E+01                  | -1.82E-04                 | 1.74E-03                  | 5.84E-03                  | 6.10E-03                  | 4.50E+01 | 6.69E-03  | 6.10E-03  | -1.11E-01 | 1.11E-01 |
| 4.41E+01                  | -2.99E-03                 | 2.66E-05                  | 1.41E-03                  | 3.31E-03                  | 4.46E+01                  | -7.81E-04                 | -1.51E-03                 | 5.20E-03                  | 5.47E-03                  | 4.50E+01 | 1.88E-03  | -2.03E-03 | -1.05E-01 | 1.05E-01 |
| 4.42E+01                  | -2.06E-03                 | -1.27E-03                 | 2.22E-04                  | 2.43E-03                  | 4.46E+01                  | -3.24E-03                 | -6.22E-04                 | 9.00E-03                  | 9.59E-03                  | 4.50E+01 | 3.28E-03  | -3.02E-03 | -1.04E-01 | 1.04E-01 |
| 4.42E+01                  | -2.05E-03                 | -3.24E-03                 | 1.55E-03                  | 4.13E-03                  | 4.46E+01                  | -3.42E-03                 | 1.18E-03                  | 1.28E-02                  | 1.33E-02                  | 4.50E+01 | 4.84E-03  | -1.88E-03 | -1.02E-01 | 1.02E-01 |
| 4.42E+01                  | -1.96E-04                 | 2.98E-03                  | -1.02E-03                 | 3.16E-03                  | 4.46E+01                  | -1.05E-03                 | -2.70E-04                 | 1.44E-02                  | 1.45E-02                  | 4.50E+01 | 3.94E-03  | -4.16E-03 | -9.58E-02 | 9.60E-02 |
| 4.42E+01                  | -2.34E-03                 | 1.22E-03                  | 1.59E-03                  | 3.07E-03                  | 4.46E+01                  | -7.46E-04                 | -2.65E-04                 | 1.75E-02                  | 1.75E-02                  | 4.51E+01 | 5.40E-03  | -3.52E-03 | -8.04E-02 | 9.56E-02 |
| 4.42E+01                  | -3.73E-03                 | 2.14E-03                  | 4.97E-03                  | 4.70E-03                  | 4.46E+01                  | -1.32E-03                 | 1.20E-03                  | 2.33E-02                  | 2.49E-02                  | 4.51E+01 | 1.32E-03  | 1.69E-04  | -8.71E-02 | 8.71E-02 |
| 4.42E+01                  | -1.38E-03                 | 7.41E-05                  | -2.01E-04                 | 1.40E-03                  | 4.46E+01                  | -3.21E-03                 | 3.18E-03                  | 2.69E-02                  | 2.69E-02                  | 4.51E+01 | 4.67E-03  | -8.12E-04 | -8.33E-02 | 8.64E-02 |
| 4.42E+01                  | -1.17E-03                 | 6.11E-04                  | -1.17E-03                 | 1.78E-03                  | 4.46E+01                  | -4.49E-03                 | 2.61E-03                  | 2.92E-02                  | 2.97E-02                  | 4.51E+01 | 3.69E-03  | -4.05E-03 | -8.11E-02 | 8.13E-02 |
| 4.42E+01                  | -1.44E-03                 | -1.63E-03                 | 1.02E-03                  | 2.40E-03                  | 4.47E+01                  | -5.74E-03                 | 1.16E-03                  | 2.97E-02                  | 3.03E-02                  | 4.51E+01 | 2.24E-03  | -8.85E-04 | -8.11E-02 | 8.11E-02 |
| 4.42E+01                  | -1.05E-03                 | 6.35E-04                  | -1.03E-03                 | 2.27E-03                  | 4.47E+01                  | -1.30E-03                 | 7.13E-04                  | 2.48E-02                  | 2.48E-02                  | 4.51E+01 | 4.01E-04  | -1.58E-03 | -7.81E-02 | 7.81E-02 |
| 4.42E+01                  | -1.63E-03                 | 9.14E-04                  | 1.49E-03                  | 2.39E-03                  | 4.47E+01                  | -4.35E-03                 | 3.07E-04                  | 2.41E-02                  | 2.45E-02                  | 4.51E+01 | 2.59E-03  | -3.79E-03 | -7.44E-02 | 7.48E-02 |
| 4.43E+01                  | 7.85E-05                  | 6.31E-04                  | 8.00E-05                  | 6.41E-04                  | 4.47E+01                  | -4.30E-03                 | 1.62E-02                  | 1.62E-0                   |                           |          |           |           |           |          |

|                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |           |          |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|-----------|----------|
| air bearing data page 109 | air bearing data page 110 | air bearing data page 111 | air bearing data page 111 | air bearing data page 111 |           |          |
| 4.67E+01                  | -1.49E+03                 | -4.76E-04                 | -1.28E-03                 | 2.08E-03                  | 4.71E+01                  | -4.73E-02                 | 1.58E-02                  | 8.13E-01                  | 8.14E-01                  | 4.75E+01                  | -7.18E+03                 | -4.08E-04                 | 1.29E-01  | 1.29E-01 |
| 4.67E+01                  | 6.18E-04                  | 1.78E-04                  | -1.48E-03                 | 1.89E-03                  | 4.71E+01                  | -4.54E-02                 | 1.09E-02                  | 7.90E-01                  | 7.91E-01                  | 4.76E+01                  | -4.96E+03                 | 3.34E-03                  | 1.16E-01  | 1.16E-01 |
| 4.67E+01                  | 1.15E-04                  | -1.32E-03                 | -1.35E-03                 | 1.89E-03                  | 4.71E+01                  | -4.12E-02                 | 1.38E-02                  | 7.74E-01                  | 7.76E-01                  | 4.76E+01                  | -6.97E+03                 | 2.00E-03                  | 1.03E-01  | 1.03E-01 |
| 4.67E+01                  | 1.07E+03                  | 1.20E+03                  | -4.95E-04                 | 2.53E-03                  | 4.71E+01                  | -4.03E-02                 | 1.69E-02                  | 7.95E-01                  | 7.97E-01                  | 4.76E+01                  | -4.71E+03                 | -1.10E-03                 | 8.94E-02  | 8.94E-02 |
| 4.67E+01                  | 1.06E+03                  | 3.02E+03                  | 6.94E-04                  | 3.27E-03                  | 4.72E+01                  | -4.00E-02                 | 1.01E-02                  | 7.20E-01                  | 7.40E-01                  | 4.76E+01                  | 7.00E-05                  | -2.28E-04                 | 8.38E-02  | 8.38E-02 |
| 4.67E+01                  | -4.88E-04                 | 7.95E-04                  | 2.34E-03                  | 2.51E-03                  | 4.72E+01                  | -4.12E-02                 | 1.05E-02                  | 7.21E-01                  | 7.23E-01                  | 4.76E+01                  | -6.12E+03                 | -3.36E-03                 | 6.81E-02  | 6.84E-02 |
| 4.67E+01                  | -1.39E+03                 | -1.27E-03                 | 7.26E-04                  | 2.02E-03                  | 4.72E+01                  | -3.90E-02                 | 1.68E-02                  | 7.06E-01                  | 7.07E-01                  | 4.76E+01                  | -3.37E+03                 | 3.11E-03                  | 5.88E-02  | 5.70E-02 |
| 4.67E+01                  | -1.99E+03                 | -1.05E-03                 | -1.63E-03                 | 2.90E-03                  | 4.72E+01                  | -3.51E-02                 | 8.24E-03                  | 6.89E-01                  | 6.90E-01                  | 4.76E+01                  | -2.16E+03                 | -4.11E-03                 | 4.67E-02  | 4.69E-02 |
| 4.68E+01                  | 3.64E+03                  | 1.83E-03                  | -1.47E-03                 | 4.33E-03                  | 4.72E+01                  | -3.62E-02                 | 7.73E-03                  | 6.73E-01                  | 6.74E-01                  | 4.76E+01                  | -6.61E-04                 | 1.62E-04                  | 3.24E-02  | 3.34E-02 |
| 4.68E+01                  | -1.66E-03                 | -7.12E-04                 | 1.65E-03                  | 2.93E-03                  | 4.72E+01                  | -3.60E-02                 | 1.06E-02                  | 6.66E-01                  | 6.67E-01                  | 4.76E+01                  | -1.88E-03                 | 6.60E-04                  | 2.74E-02  | 2.74E-02 |
| 4.68E+01                  | -2.69E-03                 | 5.78E-04                  | -3.62E-04                 | 2.77E-03                  | 4.72E+01                  | -3.45E-02                 | 1.18E-02                  | 6.39E-01                  | 6.40E-01                  | 4.76E+01                  | -8.40E-04                 | 8.19E-04                  | 2.12E-02  | 2.13E-02 |
| 4.68E+01                  | -3.97E-04                 | -1.33E-03                 | -1.15E-03                 | 1.79E-03                  | 4.72E+01                  | -3.39E-02                 | 1.25E-02                  | 6.22E-01                  | 6.23E-01                  | 4.77E+01                  | -1.33E-04                 | 1.13E-02                  | 1.23E-02  | 1.23E-02 |
| 4.68E+01                  | -3.30E-04                 | -1.55E-04                 | 2.90E-04                  | 4.65E-04                  | 4.72E+01                  | -3.32E-02                 | 1.05E-02                  | 6.06E-01                  | 6.07E-01                  | 4.77E+01                  | -7.41E-04                 | 2.50E-03                  | 6.06E-03  | 6.06E-03 |
| 4.68E+01                  | -1.79E-04                 | -1.00E-03                 | -3.16E-04                 | 1.15E-03                  | 4.72E+01                  | -2.87E-02                 | 6.06E-03                  | 5.88E-01                  | 5.89E-01                  | 4.77E+01                  | 2.13E-04                  | -7.69E-06                 | 7.89E-04  | 7.89E-04 |
| 4.68E+01                  | -1.31E+03                 | -3.14E-03                 | 2.21E-03                  | 4.05E-03                  | 4.73E+01                  | -3.02E-02                 | 9.52E-03                  | 5.72E-01                  | 5.73E-01                  | 4.77E+01                  | -1.22E+03                 | -4.07E-03                 | -1.43E-03 | 5.40E-03 |
| 4.68E+01                  | -2.67E+03                 | 8.98E-04                  | -2.32E-03                 | 3.80E-03                  | 4.73E+01                  | -2.94E-02                 | 8.63E-03                  | 5.59E-01                  | 5.60E-01                  | 4.77E+01                  | -1.88E-03                 | 2.48E-04                  | 3.80E-04  | 1.93E-03 |
| 4.68E+01                  | 1.30E+03                  | 1.94E-03                  | 1.35E-04                  | 2.34E-03                  | 4.73E+01                  | -2.67E-02                 | 7.33E-03                  | 5.41E-01                  | 5.41E-01                  | 4.77E+01                  | 1.17E+03                  | 7.27E-04                  | -1.32E-04 | 1.39E-03 |
| 4.69E+01                  | -2.13E+03                 | -2.94E-04                 | 3.13E-03                  | 3.80E-03                  | 4.73E+01                  | -2.68E-02                 | 8.98E-03                  | 5.27E-01                  | 5.27E-01                  | 4.77E+01                  | -1.50E+03                 | 4.91E-03                  | -4.27E-04 | 4.28E-03 |
| 4.69E+01                  | -6.46E-04                 | -6.87E-04                 | 3.79E-03                  | 3.91E-03                  | 4.73E+01                  | -2.55E-02                 | 9.28E-03                  | 5.10E-01                  | 5.11E-01                  | 4.77E+01                  | -1.14E+03                 | -1.50E-03                 | -6.78E-04 | 1.94E-03 |
| 4.69E+01                  | -1.09E+03                 | 1.12E-02                  | 1.12E-02                  | 1.73E-03                  | 4.73E+01                  | -2.50E-02                 | 8.71E-03                  | 4.95E-01                  | 4.96E-01                  | 4.77E+01                  | -2.77E+03                 | -4.96E-04                 | -4.96E-04 | 2.27E-03 |
| 4.69E+01                  | -3.33E-03                 | -1.38E-03                 | 2.41E-02                  | 2.44E-02                  | 4.73E+01                  | -2.81E-02                 | 7.56E-03                  | 4.81E-01                  | 4.82E-01                  | 4.77E+01                  | -2.94E-04                 | -1.19E-04                 | -5.81E-04 | 9.70E-04 |
| 4.69E+01                  | -3.28E-03                 | -2.55E-03                 | 4.32E-02                  | 4.34E-02                  | 4.73E+01                  | -2.53E-02                 | 6.72E-03                  | 4.67E-01                  | 4.68E-01                  | 4.77E+01                  | 1.56E-03                  | -1.04E-03                 | -1.04E-03 | 1.53E-03 |
| 4.69E+01                  | -5.61E-03                 | 7.16E-04                  | 6.49E-02                  | 6.49E-02                  | 4.73E+01                  | -2.34E-02                 | 6.71E-03                  | 4.52E-01                  | 4.53E-01                  | 4.78E+01                  | 1.10E+03                  | 8.83E-04                  | 6.08E-06  | 1.41E-03 |
| 4.69E+01                  | -6.39E-03                 | 1.77E-05                  | 9.39E-02                  | 9.41E-02                  | 4.73E+01                  | -2.49E-02                 | 5.32E-03                  | 4.37E-01                  | 4.37E-01                  | 4.78E+01                  | -1.93E+03                 | -1.02E-03                 | -1.80E-03 | 2.57E-03 |
| 4.69E+01                  | -1.05E-02                 | 1.94E-03                  | 1.27E-01                  | 1.27E-01                  | 4.74E+01                  | -2.28E-02                 | 7.29E-03                  | 4.23E-01                  | 4.24E-01                  | 4.78E+01                  | -2.10E+03                 | 1.60E-03                  | -1.37E-03 | 2.98E-03 |
| 4.69E+01                  | -8.47E-03                 | 2.63E-03                  | 1.65E-01                  | 1.65E-01                  | 4.74E+01                  | -2.10E-02                 | 6.87E-03                  | 4.09E-01                  | 4.10E-01                  | 4.78E+01                  | -1.00E-04                 | -1.93E-03                 | 4.82E-04  | 1.99E-03 |
| 4.69E+01                  | -1.04E-02                 | 5.02E-03                  | 2.09E-01                  | 2.10E-01                  | 4.74E+01                  | -2.13E-02                 | 5.69E-03                  | 3.94E-01                  | 3.95E-01                  | 4.78E+01                  | 1.92E+03                  | -7.89E-04                 | 7.89E-04  | 2.27E-03 |
| 4.70E+01                  | -4.46E-02                 | -8.46E-02                 | -4.70E-02                 | -4.70E-02                 | 4.74E+01                  | -2.07E-02                 | 8.75E-03                  | 3.74E-01                  | 3.75E-01                  | 4.78E+01                  | 2.23E+03                  | -4.28E-03                 | -4.28E-03 | 4.89E-03 |
| 4.70E+01                  | -1.62E-02                 | 5.11E-03                  | 2.94E-01                  | 2.94E-01                  | 4.74E+01                  | -1.87E-02                 | 7.71E-03                  | 3.61E-01                  | 3.62E-01                  | 4.78E+01                  | 2.43E+03                  | 1.18E-04                  | -2.37E-03 | 2.43E-03 |
| 4.70E+01                  | -1.90E-02                 | 2.66E-03                  | 3.41E-01                  | 3.42E-01                  | 4.74E+01                  | -1.69E-02                 | 7.67E-03                  | 3.44E-01                  | 3.44E-01                  | 4.78E+01                  | 2.46E-04                  | -3.42E-03                 | -3.24E-04 | 3.44E-03 |
| 4.70E+01                  | -1.98E-02                 | 6.73E-04                  | 3.89E-01                  | 3.87E-01                  | 4.74E+01                  | -1.65E-02                 | 3.29E-01                  | 3.29E-01                  | 3.29E-01                  | 4.78E+01                  | 9.27E-04                  | 1.35E-03                  | 7.77E-04  | 1.60E-03 |
| 4.70E+01                  | -2.49E-02                 | 5.58E-03                  | 4.34E-01                  | 4.34E-01                  | 4.74E+01                  | -1.74E-02                 | 9.53E-03                  | 3.12E-01                  | 3.13E-01                  | 4.78E+01                  | -2.12E-04                 | 1.87E-03                  | -6.01E-04 | 1.87E-03 |
| 4.70E+01                  | -2.56E-02                 | 7.90E-03                  | 4.81E-01                  | 4.82E-01                  | 4.74E+01                  | -1.22E-02                 | 2.93E-01                  | 2.94E-01                  | 2.94E-01                  | 4.78E+01                  | 3.62E-04                  | 6.17E-04                  | -3.75E-04 | 1.09E-03 |
| 4.70E+01                  | -2.85E-02                 | 9.93E-03                  | 5.44E-01                  | 5.44E-01                  | 4.74E+01                  | -1.46E-02                 | 2.71E-03                  | 2.73E-01                  | 2.74E-01                  | 4.78E+01                  | -1.79E-04                 | 8.30E-04                  | 1.79E-03  | 1.55E-03 |
| 4.70E+01                  | -3.48E-02                 | 7.84E-03                  | 6.06E-01                  | 6.07E-01                  | 4.75E+01                  | -1.52E-02                 | 3.86E-03                  | 2.59E-01                  | 2.60E-01                  | 4.79E+01                  | 3.07E+03                  | -1.92E-03                 | 2.63E-03  | 4.46E-03 |
| 4.70E+01                  | -3.97E-02                 | 6.15E-03                  | 6.79E-01                  | 6.80E-01                  | 4.75E+01                  | -1.51E-02                 | 8.31E-03                  | 2.49E-01                  | 2.49E-01                  | 4.79E+01                  | -2.79E+03                 | -1.69E-03                 | -1.69E-03 | 3.96E-03 |
| 4.70E+01                  | -3.79E-02                 | 1.34E-02                  | 7.43E-01                  | 7.44E-01                  | 4.75E+01                  | -1.50E-02                 | 4.97E-03                  | 2.30E-01                  | 2.30E-01                  | 4.79E+01                  | -6.14E-04                 | 2.25E-03                  | 1.03E-03  | 2.55E-03 |
| 4.71E+01                  | -4.04E-02                 | 1.53E-02                  | 7.95E-01                  | 7.97E-01                  | 4.75E+01                  | -1.34E-02                 | 5.83E-03                  | 2.13E-01                  | 2.14E-01                  | 4.79E+01                  | -3.52E+03                 | -1.20E-04                 | -3.93E-04 | 3.54E-03 |
| 4.71E+01                  | -4.32E-02                 | 1.72E-02                  | 8.34E-01                  | 8.35E-01                  | 4.75E+01                  | -1.49E-02                 | 4.02E-03                  | 1.99E-01                  | 2.00E-01                  | 4.79E+01                  | 3.20E-04                  | -6.24E-04                 | 6.46E-05  | 7.04E-04 |
| 4.71E+01                  | -4.19E-02                 | 1.98E-02                  | 8.55E-01                  | 8.56E-01                  | 4.75E+01                  | -1.47E-02                 | 3.38E-03                  | 1.85E-01                  | 1.86E-01                  | 4.79E+01                  | -1.28E-04                 | 1.01E-03                  | 1.01E-03  | 2.27E-03 |
| 4.71E+01                  | -4.57E-02                 | 1.52E-02                  | 8.57E-01                  | 8.59E-01                  | 4.75E+01                  | -1.00E-02                 | 6.38E-03                  | 1.68E-01                  | 1.69E-01                  | 4.79E+01                  | 9.47E-04                  | 3.61E-04                  | 1.51E-03  | 1.82E-03 |
| 4.71E+01                  | -4.46E-02                 | 1.61E-02                  | 8.44E-01                  | 8.46E-01                  | 4.75E+01                  | -1.05E-02                 | 1.16E-03                  | 1.57E-01                  | 1.57E-01                  | 4.80E+01                  | 1.29E+03                  | -2.19E-03                 | -1.38E-03 | 2.89E-03 |
| 4.71E+01                  | -4.52E-02                 | 6.65E-03                  | 8.29E-01                  | 8.31E-01                  | 4.75E+01                  | -8.22E-03                 | 2.67E-03                  | 1.43E-01                  | 1.44E-01                  | 4.80E+01                  | -6.23E-03                 | 1.32E-03                  | -4.94E-03 | 9.69E-03 |

|                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |           |          |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|-----------|----------|
| air bearing data page 112 | air bearing data page 112 | air bearing data page 112 | air bearing data page 113 | air bearing data page 113 | air bearing data page 113 | air bearing data page 114 |           |          |
| 4.80E+01                  | -2.88E+03                 | -7.06E-03                 | 1.78E-05                  | 7.62E-03                  | 4.84E+01                  | -1.64E+03                 | 8.49E-04                  | 1.57E-03                  | 2.42E-03                  | 4.88E+01                  | 3.15E+03                  | 3.70E-03                  | -6.14E-04 | 4.89E-03 |
| 4.80E+01                  | 2.87E-04                  | 1.92E-03                  | 1.92E-03                  | 1.92E-03                  | 4.84E+01                  | 1.21E+03                  | 4.42E-04                  | 1.15E-03                  | 1.29E-03                  | 4.89E+01                  | -1.32E+03                 | -9.20E-03                 | 5.77E-04  | 3.54E-03 |
| 4.80E+01                  | -1.23E+03                 | -1.15E-03                 | -8.46E-04                 | 1.89E-03                  | 4.84E+01                  | -1.88E+03                 | 2.22E-03                  | 1.32E-03                  | 3.19E-03                  | 4.89E+01                  | -3.22E+03                 | 1.29E-03                  | -1.26E-04 | 3.54E-03 |
| 4.80E+01                  | -3.03E+03                 | -2.85E-03                 | 1.94E-03                  | 4.94E-03                  | 4.84E+01                  | -1.07E+03                 | -1.74E-03                 | -3.40E-03                 | 3.86E-03                  | 4.89E+01                  | -2.97E+03                 | -1.96E-03                 | -1.96E-03 | 4.89E-03 |
| 4.80E+01                  | -4.04E-04                 | 2.21E-03                  | -1.07E-03                 | 2.49E-03                  | 4.84E+01                  | 6.49E-04                  | 1.14E-03                  | 4.87E-04                  | 1.40E-03                  | 4.89E+01                  | -5.73E-05                 | 6.91E-03                  | -4.79E-03 | 8.41E-03 |
| 4.80E+01                  | -7.89E-04                 | 5.33E-04                  | -7.89E-04                 | 1.22E-03                  | 4.85E+01                  | -1.40E-03                 | -7.97E-04                 | 1.35E-03                  | 2.10E-03                  | 4.89E+01                  | 9.70E+03                  | -6.55E-03                 | 1.27E-02  | 1.27E-02 |
| 4.80E+01                  | 7.60E-04                  | -6.09E-04                 | -6.80E-05                 | 9.76E-04                  | 4.85E+01                  | 7.20E-04                  | 4.93E-04                  | 2.70E-03                  | 2.84E-03                  | 4.89E+01                  | -6.70E-04                 | -1.80E-02                 | 1.33E-02  | 2.24E-02 |
| 4.80E+01                  | 8.25E-04                  | -3.01E-04                 | 3.40E-05                  | 1.05E-03                  | 4.85E+01                  | -1.41E-03                 | 2.54E-04                  | 2.36E-03                  | 2.79E-03                  | 4.89E+01                  | -1.13E-02                 | 2.46E-03                  | 6.90E-03  | 4.34E-02 |
| 4.81E+01                  | 1.31E+03                  | 3.00E-03                  | 2.66E-03                  | 4.15E-03                  | 4.85E+01                  | -3.04E-04                 | 1.20E-03                  | -1.08E-03                 | 1.64E-03                  | 4.89E+01                  | -2.31E-02                 | -4.78E-02                 | -1.95E-02 | 5.68E-02 |
| 4.81E+01                  | 9.02E-04                  | 2.20E-04                  | -1.65E-03                 | 1.90E-03                  | 4.85E+01                  | -7.12E-04                 | -2.65E-03                 | -2.30E-03                 | 3.58E-03                  | 4.89E+01                  | -2.46E-02                 | -6.23E-02                 | -1.26E-02 | 8.59E-02 |
| 4.81E+01                  | -6.93E-04                 | 2.10E-04                  | -1.46E-03                 | 1.79E-03                  | 4.85E+01                  | -1.68E-04                 | -2.26E-03                 | 3.77E-03                  | 4.40E-03                  | 4.89E+01                  | -1.75E-02                 | -6.46E-02                 | -7.17E-03 | 6.72E-02 |
| 4.81E+01                  | -4.97E-05                 | 4.30E-03                  | 6.43E-04                  | 3.12E-03                  | 4.85E+01                  | 1.89E-04                  | -8.97E-04                 | 1.05E-03                  | 1.29E-03                  | 4.89E+01                  | -1.49E-02                 | -3.69E-02                 | -4.35E-02 | 9.04E-02 |
| 4.81E+01                  | -6.46E-04                 | -3.34E-04                 | 1.00E-03                  | 1.42E-03                  | 4.85E+01                  | -7.07E-04                 | -1.02E-03                 | 1.04E-03                  | 1.52E-03                  | 4.90E+01                  | -2.91E-02                 | -4.11E-02                 | -1.21E-02 | 5.19E-02 |
| 4.81E+01                  | -2.53E-05                 | -9.76E-04                 | -0.77E-04                 | 1.38E-03                  | 4.85E+01                  | 1.49E-03                  | 8.46E-04                  | 1.46E-03                  | 2.28E-03                  | 4.90E+01                  | -1.97E-02                 | -6.91E-02                 | -1.30E-03 | 9.12E-02 |
| 4.81E+01                  | -2.20E-03                 | 2.78E-03                  | -6.75E-06                 | 3.54E-03                  | 4.85E+01                  | -6.41E-04                 | 3.91E-04                  | 1.89E-03                  | 2.00E-03                  | 4.90E+01                  | -3.01E-02                 | -1.09E-01                 | 4.37E-03  | 1.13E-01 |
| 4.81E+01                  | 4.38E-04                  | 1.78E-03                  | -1.20E-03                 | 2.19E-03                  | 4.86E+01                  | -8.18E-04                 | 1.01E-04                  | 9.50E-04                  | 1.28E-03                  | 4.90E+01                  | -3.03E-02                 | -1.24E-01                 | 4.44E-03  | 1.27E-01 |
| 4.81E+01                  | -2.04E-03                 | -1.25E-04                 | 2.83E-04                  | 2.08E-03                  | 4.86E+01                  | -1.04E-03                 | -2.02E-03                 | 3.82E-03                  | 4.45E-03                  | 4.90E+01                  | -3.06E-02                 | -1.05E-01                 | -1.77E-02 | 1.10E-01 |
| 4.81E+01                  | -2.35E-04                 | -8.25E-0                  |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |           |          |

|                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |          |           |           |           |          |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|----------|-----------|-----------|-----------|----------|
| air bearing data page 118 | air bearing data page 119 | air bearing data page 119 | air bearing data page 119 | air bearing data page 120 | air bearing data page 120 | air bearing data page 120 |          |           |           |           |          |
| 5.06E+01                  | -3.20E-03                 | -7.75E-04                 | -3.92E-03                 | 5.11E+03                  | 2.81E-02                  | -8.56E-03                 | -6.71E-01                 | 6.72E-01                  | 5.14E-01                  | 1.68E-02 | -1.80E-03 | -2.99E-01 | 3.00E-01  |          |
| 5.06E+01                  | 5.59E-04                  | 2.53E-04                  | -1.77E-03                 | 1.87E+03                  | 5.10E+01                  | 3.27E-02                  | -8.13E-03                 | -6.56E-01                 | 6.57E-01                  | 1.28E-02 | -7.96E-03 | -2.93E-01 | 2.93E-01  |          |
| 5.06E+01                  | -2.34E-03                 | 2.39E-04                  | -5.05E-03                 | 5.57E+03                  | 5.10E+01                  | 2.64E-02                  | -7.33E-03                 | -6.39E-01                 | 6.39E-01                  | 5.15E+01 | 1.12E-02  | -1.48E-03 | -2.85E-01 | 2.85E-01 |
| 5.06E+01                  | 2.79E-03                  | -1.07E-03                 | -3.98E-03                 | 4.98E+03                  | 5.10E+01                  | 3.02E-02                  | -5.38E-03                 | -6.24E-01                 | 6.24E-01                  | 5.15E+01 | 1.37E-02  | 1.21E-04  | -2.81E-01 | 2.81E-01 |
| 5.06E+01                  | -3.12E-03                 | -4.13E-04                 | -8.73E-03                 | 9.28E+03                  | 5.10E+01                  | 2.74E-02                  | -1.02E-02                 | -6.11E-01                 | 6.12E-01                  | 5.15E+01 | 1.19E-02  | -1.22E-03 | -2.72E-01 | 2.72E-01 |
| 5.06E+01                  | -2.04E-03                 | -1.33E-03                 | -2.25E-02                 | 1.32E-02                  | 5.11E+01                  | 2.50E-02                  | -8.46E-03                 | -5.91E-01                 | 5.92E-01                  | 5.15E+01 | 9.17E-03  | -8.17E-04 | -2.66E-01 | 2.67E-01 |
| 5.06E+01                  | -1.16E-04                 | -1.79E-03                 | -1.97E-02                 | 1.98E-02                  | 5.11E+01                  | 2.40E-02                  | -7.94E-03                 | -5.80E-01                 | 5.80E-01                  | 5.15E+01 | 1.18E-02  | -1.44E-03 | -2.60E-01 | 2.60E-01 |
| 5.06E+01                  | -1.38E-03                 | 7.40E-04                  | -2.76E-02                 | 2.76E-02                  | 5.11E+01                  | 2.59E-02                  | -4.86E-03                 | -5.63E-01                 | 5.64E-01                  | 5.15E+01 | 1.13E-02  | -6.44E-04 | -2.52E-01 | 2.53E-01 |
| 5.07E+01                  | 1.27E-03                  | -1.54E-03                 | -3.94E-02                 | 3.95E-02                  | 5.11E+01                  | 2.62E-02                  | -6.81E-03                 | -5.49E-01                 | 5.49E-01                  | 5.15E+01 | 1.10E-02  | -2.68E-03 | -2.44E-01 | 2.44E-01 |
| 5.07E+01                  | 1.01E-04                  | -1.06E-03                 | -5.48E-02                 | 5.48E-02                  | 5.11E+01                  | 2.27E-02                  | -7.18E-03                 | -5.29E-01                 | 5.30E-01                  | 5.15E+01 | 1.04E-02  | -1.37E-03 | -2.37E-01 | 2.37E-01 |
| 5.07E+01                  | 3.33E-03                  | -3.06E-03                 | -7.27E-02                 | 7.28E-02                  | 5.11E+01                  | 2.31E-02                  | -6.32E-03                 | -5.13E-01                 | 5.14E-01                  | 5.15E+01 | 1.27E-02  | -3.57E-03 | -2.30E-01 | 2.30E-01 |
| 5.07E+01                  | 3.09E-04                  | 1.27E-03                  | -4.20E-01                 | 1.02E-01                  | 5.11E+01                  | 2.29E-02                  | -3.29E-02                 | -4.01E-01                 | 4.02E-01                  | 5.15E+01 | 1.05E-02  | -3.19E-03 | -2.19E-01 | 2.19E-01 |
| 5.07E+01                  | 5.89E-03                  | -2.46E-03                 | -1.30E-01                 | 1.30E-01                  | 5.11E+01                  | 2.31E-02                  | 1.59E-03                  | -4.85E-01                 | 4.85E-01                  | 5.15E+01 | 9.77E-03  | -1.03E-03 | -2.16E-01 | 2.17E-01 |
| 5.07E+01                  | 7.19E-03                  | 4.90E-03                  | -1.86E-01                 | 1.86E-01                  | 5.11E+01                  | 2.56E-02                  | -1.32E-03                 | -4.74E-01                 | 4.75E-01                  | 5.16E+01 | 8.98E-03  | -1.84E-03 | -2.06E-01 | 2.06E-01 |
| 5.07E+01                  | 9.83E-03                  | 1.25E-03                  | -2.06E-01                 | 2.06E-01                  | 5.11E+01                  | 2.19E-02                  | -1.72E-03                 | -4.62E-01                 | 4.63E-01                  | 5.16E+01 | 7.58E-03  | -1.51E-03 | -1.86E-01 | 1.86E-01 |
| 5.07E+01                  | 9.25E-03                  | 2.31E-04                  | -2.45E-01                 | 2.46E-01                  | 5.12E+01                  | 2.10E-02                  | -3.00E-03                 | -4.58E-01                 | 4.58E-01                  | 5.16E+01 | 6.13E-03  | -8.01E-03 | -1.87E-01 | 1.87E-01 |
| 5.07E+01                  | 1.08E-02                  | -4.25E-03                 | -2.94E-01                 | 2.94E-01                  | 5.12E+01                  | 2.04E-02                  | -2.56E-03                 | -4.48E-01                 | 4.48E-01                  | 5.16E+01 | 9.12E-03  | -1.62E-03 | -1.82E-01 | 1.82E-01 |
| 5.07E+01                  | 1.33E-02                  | -5.63E-03                 | -3.46E-01                 | 3.46E-01                  | 5.12E+01                  | 2.23E-02                  | -1.99E-03                 | -4.41E-01                 | 4.41E-01                  | 5.16E+01 | 9.93E-03  | -4.2E-03  | -1.75E-01 | 1.75E-01 |
| 5.08E+01                  | 1.67E-02                  | -8.65E-03                 | -3.99E-01                 | 3.99E-01                  | 5.12E+01                  | 2.05E-02                  | -4.47E-03                 | -4.36E-01                 | 4.37E-01                  | 5.16E+01 | 5.29E-03  | -1.98E-03 | -1.68E-01 | 1.67E-01 |
| 5.08E+01                  | 2.05E-02                  | -4.63E-01                 | -4.63E-01                 | 4.63E-01                  | 5.12E+01                  | 1.92E-02                  | -3.09E-02                 | -4.25E-01                 | 4.26E-01                  | 5.16E+01 | 8.03E-03  | -1.33E-03 | -1.59E-01 | 1.59E-01 |
| 5.08E+01                  | 2.05E-02                  | -1.10E-02                 | -5.10E-01                 | 5.10E-01                  | 5.12E+01                  | 1.93E-02                  | -5.22E-03                 | -4.26E-01                 | 4.27E-01                  | 5.16E+01 | 8.27E-03  | -2.04E-03 | -1.48E-01 | 1.48E-01 |
| 5.08E+01                  | 2.58E-02                  | -1.30E-02                 | -5.85E-01                 | 5.85E-01                  | 5.12E+01                  | 1.98E-02                  | -8.32E-03                 | -4.16E-01                 | 4.17E-01                  | 5.16E+01 | 7.32E-03  | -1.42E-01 | -1.42E-01 | 1.42E-01 |
| 5.08E+01                  | 3.12E-02                  | -1.10E-02                 | -6.16E-01                 | 6.17E-01                  | 5.12E+01                  | 1.97E-02                  | -4.54E-03                 | -4.11E-01                 | 4.12E-01                  | 5.17E+01 | 6.94E-03  | 1.20E-03  | -1.32E-01 | 1.32E-01 |
| 5.08E+01                  | 3.19E-02                  | -6.64E-03                 | -6.64E-01                 | 6.65E-01                  | 5.12E+01                  | 1.69E-02                  | -1.31E-03                 | -4.06E-01                 | 4.07E-01                  | 5.17E+01 | 6.09E-03  | -6.41E-03 | -1.24E-01 | 1.24E-01 |
| 5.08E+01                  | 3.21E-02                  | -1.04E-02                 | -7.06E-01                 | 7.07E-01                  | 5.12E+01                  | 1.76E-02                  | -3.42E-03                 | -4.03E-01                 | 4.03E-01                  | 5.17E+01 | 6.10E-03  | -3.93E-03 | -1.19E-01 | 1.19E-01 |
| 5.08E+01                  | 3.50E-02                  | -1.07E-02                 | -7.41E-01                 | 7.42E-01                  | 5.13E+01                  | 1.81E-02                  | -5.17E-03                 | -3.98E-01                 | 3.98E-01                  | 5.17E+01 | 3.67E-03  | -3.05E-03 | -1.10E-01 | 1.10E-01 |
| 5.08E+01                  | 3.56E-02                  | -1.01E-02                 | -7.72E-01                 | 7.73E-01                  | 5.13E+01                  | 2.00E-02                  | -2.73E-03                 | -3.89E-01                 | 3.90E-01                  | 5.17E+01 | 4.41E-03  | 3.23E-04  | -1.02E-01 | 1.02E-01 |
| 5.08E+01                  | -8.44E-03                 | -1.10E-02                 | -7.99E-01                 | 7.99E-01                  | 5.13E+01                  | 1.78E-02                  | -1.94E-03                 | -3.87E-01                 | 3.88E-01                  | 5.17E+01 | 5.17E-03  | 1.34E-03  | -9.61E-02 | 9.61E-02 |
| 5.09E+01                  | 3.81E-02                  | -8.50E-03                 | -7.96E-01                 | 7.97E-01                  | 5.13E+01                  | 1.78E-02                  | -3.87E-03                 | -3.83E-01                 | 3.83E-01                  | 5.17E+01 | 3.74E-03  | -1.08E-03 | -8.74E-02 | 8.74E-02 |
| 5.09E+01                  | 3.64E-02                  | -7.93E-03                 | -8.00E-01                 | 8.01E-01                  | 5.13E+01                  | 1.69E-02                  | -6.16E-03                 | -3.73E-01                 | 3.74E-01                  | 5.17E+01 | 3.47E-03  | 2.58E-03  | -7.95E-02 | 7.95E-02 |
| 5.09E+01                  | 3.81E-02                  | -8.20E-03                 | -7.98E-01                 | 7.99E-01                  | 5.13E+01                  | 1.71E-02                  | -5.94E-03                 | -3.67E-01                 | 3.67E-01                  | 5.17E+01 | 2.37E-03  | -1.81E-03 | -7.03E-02 | 7.04E-02 |
| 5.09E+01                  | 3.91E-02                  | -6.74E-03                 | -7.88E-01                 | 7.89E-01                  | 5.13E+01                  | 1.74E-02                  | -1.85E-03                 | -3.63E-01                 | 3.64E-01                  | 5.17E+01 | -1.68E-03 | 2.53E-03  | -6.66E-02 | 6.66E-02 |
| 5.09E+01                  | 3.59E-02                  | -8.57E-03                 | -7.81E-01                 | 7.82E-01                  | 5.13E+01                  | 1.46E-02                  | -3.52E-03                 | -3.57E-01                 | 3.57E-01                  | 5.18E+01 | -2.13E-03 | 9.42E-04  | -5.87E-02 | 5.88E-02 |
| 5.09E+01                  | 3.49E-02                  | -9.59E-03                 | -7.75E-01                 | 7.75E-01                  | 5.13E+01                  | 1.66E-02                  | -1.44E-03                 | -3.51E-01                 | 3.51E-01                  | 5.18E+01 | 3.36E-03  | -3.30E-03 | -4.97E-02 | 5.01E-02 |
| 5.09E+01                  | 3.07E-02                  | -1.02E-02                 | -7.64E-01                 | 7.64E-01                  | 5.13E+01                  | 1.44E-02                  | -3.40E-03                 | -3.48E-01                 | 3.48E-01                  | 5.18E+01 | 8.36E-04  | -3.71E-03 | -3.98E-02 | 4.00E-02 |
| 5.09E+01                  | 3.35E-02                  | -8.35E-03                 | -7.59E-01                 | 7.59E-01                  | 5.14E+01                  | 1.74E-02                  | -1.21E-02                 | -3.36E-01                 | 3.37E-01                  | 5.18E+01 | 2.30E-03  | -1.33E-03 | -3.95E-02 | 3.95E-02 |
| 5.09E+01                  | 3.22E-02                  | -8.14E-03                 | -7.50E-01                 | 7.51E-01                  | 5.14E+01                  | 1.70E-02                  | -3.02E-03                 | -3.39E-01                 | 3.39E-01                  | 5.18E+01 | 1.37E-04  | 2.58E-03  | -2.21E-02 | 2.22E-02 |
| 5.09E+01                  | 3.24E-02                  | -6.76E-03                 | -7.40E-01                 | 7.40E-01                  | 5.14E+01                  | 1.43E-02                  | -3.10E-03                 | -3.32E-01                 | 3.33E-01                  | 5.18E+01 | 1.21E-03  | 3.35E-04  | -1.74E-02 | 1.75E-02 |
| 5.10E+01                  | 3.29E-02                  | -8.58E-03                 | -7.29E-01                 | 7.30E-01                  | 5.14E+01                  | 1.42E-02                  | 7.90E-05                  | -3.26E-01                 | 3.26E-01                  | 5.18E+01 | -1.88E-03 | -4.06E-04 | -1.05E-02 | 1.07E-02 |
| 5.10E+01                  | 3.27E-02                  | -8.95E-03                 | -7.19E-01                 | 7.20E-01                  | 5.14E+01                  | 1.60E-02                  | -1.78E-03                 | -3.20E-01                 | 3.20E-01                  | 5.18E+01 | 1.90E-03  | -6.96E-03 | -3.60E-03 | 3.60E-03 |
| 5.10E+01                  | 3.23E-02                  | -1.14E-02                 | -7.10E-01                 | 7.11E-01                  | 5.14E+01                  | 1.08E-02                  | -2.34E-03                 | -3.14E-01                 | 3.14E-01                  | 5.18E+01 | 2.78E-03  | 3.62E-04  | -1.67E-04 | 2.80E-03 |
| 5.10E+01                  | 3.18E-02                  | -9.22E-03                 | -6.97E-01                 | 6.98E-01                  | 5.14E+01                  | 1.08E-02                  | -1.96E-03                 | -3.11E-01                 | 3.11E-01                  | 5.18E+01 | -6.72E-04 | 7.29E-03  | 2.41E-04  | 7.32E-03 |
| 5.10E+01                  | 3.12E-02                  | -1.22E-02                 | -6.86E-01                 | 6.87E-01                  | 5.14E+01                  | 1.57E-02                  | -2.82E-03                 | -3.05E-01                 | 3.05E-01                  | 5.19E+01 | -4.30E-04 | 9.30E-04  | -2.23E-03 | 2.46E-03 |

|                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |            |           |           |          |          |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|------------|-----------|-----------|----------|----------|
| air bearing data page 121 | air bearing data page 121 | air bearing data page 121 | air bearing data page 122 | air bearing data page 122 | air bearing data page 122 | air bearing data page 123 |            |           |           |          |          |
| 5.19E+01                  | 2.44E-03                  | 2.44E-04                  | -2.45E-04                 | 2.44E+03                  | 5.23E+01                  | -2.03E-04                 | -1.30E-04                 | 5.51E-04                  | 6.02E-04                  | 5.27E+01   | -4.83E-03 | -3.97E-04 | 4.77E-02 | 4.79E-02 |
| 5.19E+01                  | -2.52E-03                 | 2.44E-04                  | -1.97E-03                 | 3.20E+03                  | 5.23E+01                  | 7.89E-04                  | 1.92E-03                  | -6.31E-04                 | 2.17E-03                  | 5.27E+01   | -1.65E-03 | 6.88E-02  | 6.38E-02 | 6.39E-02 |
| 5.19E+01                  | 8.72E-04                  | -4.09E-04                 | 4.68E-04                  | 1.07E+03                  | 5.23E+01                  | 1.35E-03                  | 2.08E-03                  | 1.17E-03                  | 2.74E-03                  | 5.28E+01   | -2.49E-03 | 1.08E-03  | 8.47E-02 | 8.57E-02 |
| 5.19E+01                  | -4.98E-04                 | -4.98E-04                 | -1.17E-03                 | 1.17E-03                  | 5.23E+01                  | -4.91E-03                 | -3.39E-03                 | -1.92E-03                 | 1.92E-03                  | 5.28E+01   | -3.65E-03 | 1.33E-03  | 1.02E-01 | 1.02E-01 |
| 5.19E+01                  | 1.16E-04                  | -2.90E-04                 | 2.29E-03                  | 2.31E+03                  | 5.23E+01                  | 1.29E-03                  | 1.64E-03                  | -2.72E-04                 | 2.11E+03                  | 5.28E+01   | -8.79E-03 | -2.24E-03 | 1.18E-01 | 1.19E-01 |
| 5.19E+01                  | -3.93E-04                 | -1.14E-03                 | 9.84E-05                  | 1.21E+03                  | 5.23E+01                  | 3.71E-04                  | 7.05E-05                  | -2.34E-04                 | 4.44E-04                  | 5.28E+01   | -6.53E-03 | -8.32E-04 | 1.37E-01 | 1.38E-01 |
| 5.19E+01                  | -2.95E-03                 | 2.80E-04                  | 1.99E-03                  | 3.01E+03                  | 5.24E+01                  | -1.26E-03                 | -6.45E-04                 | -1.77E-03                 | 2.26E-03                  | 5.28E+01   | -5.32E-03 | -2.83E-02 | 1.62E-01 | 1.63E-01 |
| 5.19E+01                  | -6.10E-04                 | -1.38E-03                 | 3.59E-04                  | 1.59E-03                  | 5.24E+01                  | -2.50E-04                 | 8.31E-04                  | -2.10E-03                 | 2.27E-03                  | 5.28E+01   | -2.25E-02 | 8.92E-03  | 1.69E-01 | 1.69E-01 |
| 5.19E+01                  | -3.8E-04                  | 2.70E-03                  | 1.04E-03                  | 2.91E+03                  | 5.24E+01                  | -6.83E-04                 | 1.15E-03                  | -1.23E-03                 | 1.93E-03                  | 5.28E+01   | -8.72E-03 | -1.01E-02 | 2.46E-01 | 2.46E-01 |
| 5.20E+01                  | 2.55E-03                  | -1.15E-04                 | -2.14E-03                 | 3.33E+03                  | 5.24E+01                  | 7.33E-04                  | -6.62E-04                 | -2.11E-03                 | 2.33E-03                  | 5.28E+01   | -8.14E-03 | 1.72E-02  | 2.79E-01 | 2.80E-01 |
| 5.20E+01                  | 9.09E-04                  | -1.75E-03                 | -1.81E-04                 | 1.89E-03                  | 5.24E+01                  | 1.86E-03                  | -6.55E-05                 | 1.02E-03                  | 2.12E-03                  | 5.28E+01   | -1.94E-02 | -2.71E-03 | 3.35E-01 | 3.35E-01 |
| 5.20E+01                  | -4.95E-04                 | 8.74E-04                  | 2.04E-03                  | 2.19E+03                  | 5.24E+01                  | 1.87E-03                  | -2.86E-04                 | 2.29E-03                  | 3.01E+03                  | 5.28E+01   | -1.59E-02 | -4.27E-03 | 3.85E-01 | 3.85E-01 |
| 5.20E+01                  | -1.20E-03                 | 1.80E-03                  | 1.21E-03                  | 2.48E+03                  | 5.24E+01                  | -6.88E-04                 | 2.68E-04                  | 1.01E-04                  | 5.49E-04                  | 5.28E+01   | -1.79E-02 | 3.01E-04  | 4.41E-01 | 4.41E-01 |
| 5.20E+01                  | 1.52E-03                  | 1.31E-03                  | -1.83E-03                 | 2.59E-03                  | 5.24E+01                  | -6.69E-04                 | -1.06E-03                 | -9.45E-04                 | 1.72E-03                  | 5.29E+01   | -2.46E-02 | 1.69E-03  | 5.07E-01 | 5.07E-01 |
| 5.20E+01                  | -4.50E-04                 | -1.49E-03                 | 9.56E-04                  | 1.83E-03                  | 5.24E+01                  | 7.42E-04                  | -7.21E-05                 | -3.02E-04                 | 8.04E-04                  | 5.29E+01   | -2.69E-02 | 9.97E-03  | 6.72E-01 | 6.72E-01 |
| 5.20E+01                  | -1.14E-03                 | 1.29E-03                  | 4.59E-04                  | 1.78E+03                  | 5.24E+01                  | 3.89E-04                  | -2.65E-03                 | -6.75E-04                 | 2.77E-03                  | 5.29E+01   | -3.15E-02 | 1.11E-02  | 6.34E-01 | 6.35E-01 |
| 5.20E+01                  | 1.92E-03                  | -4.15E-03                 | -4.13E-04                 | 4.59E-03                  | 5.25E+01                  | -8.77E-03                 | -8.82E-03                 | 9.87E-03                  | 9.87E-03                  | 5.29E+01   | -3.05E-02 | 6.15E-03  | 7.04E-01 | 7.05E-01 |
| 5.20E+01                  | -2.17E-03                 | -4.44E-03                 | -8.44E-03                 | 8.51E-03                  | 5.25E+01                  | -3.22E-03                 | 1.68E-03                  | -3.22E-03                 | 5.57E-03                  | 5.29E+01</ |           |           |          |          |

|                           |                           |                           |                           |                           |                           |                           |                           |           |          |          |          |           |           |          |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|-----------|----------|----------|----------|-----------|-----------|----------|
| air bearing data page 127 | air bearing data page 127 | air bearing data page 128 | air bearing data page 128 | air bearing data page 128 | air bearing data page 129 | air bearing data page 129 | air bearing data page 129 |           |          |          |          |           |           |          |
| 5.45E+01                  | -3.28E-04                 | -4.10E-04                 | 1.69E-05                  | 5.24E-04                  | 5.46E+01                  | 2.89E-02                  | -6.39E-03                 | -5.63E-01 | 5.64E-01 | 5.53E+01 | 1.70E-02 | -4.67E-03 | -3.96E-01 | 3.97E-01 |
| 5.45E+01                  | -2.46E-03                 | 2.74E-03                  | -3.04E-04                 | 2.74E-03                  | 5.46E+01                  | 2.80E-02                  | -1.58E-03                 | -5.71E-01 | 5.71E-01 | 5.53E+01 | 1.94E-02 | -4.17E-03 | -3.85E-01 | 3.86E-01 |
| 5.45E+01                  | -2.19E-03                 | 2.12E-03                  | 1.70E-04                  | 3.05E-03                  | 5.46E+01                  | 3.11E-02                  | -3.52E-03                 | -5.74E-01 | 5.79E-01 | 5.53E+01 | 1.87E-02 | -4.22E-03 | -3.78E-01 | 3.77E-01 |
| 5.45E+01                  | -4.07E-04                 | -1.98E-03                 | 2.01E-05                  | 1.79E-03                  | 5.46E+01                  | 2.98E-02                  | -8.83E-03                 | -5.74E-01 | 5.79E-01 | 5.54E+01 | 1.76E-02 | -4.53E-03 | -3.72E-01 | 3.72E-01 |
| 5.45E+01                  | 1.21E-03                  | -8.70E-04                 | 1.54E-03                  | 2.19E-03                  | 5.46E+01                  | 2.87E-02                  | -7.95E-03                 | -5.74E-01 | 5.74E-01 | 5.54E+01 | 1.47E-02 | -5.44E-03 | -3.59E-01 | 3.59E-01 |
| 5.45E+01                  | 1.71E-04                  | -4.75E-04                 | -5.10E-04                 | 7.18E-04                  | 5.46E+01                  | 2.87E-02                  | -6.76E-03                 | -5.73E-01 | 5.74E-01 | 5.54E+01 | 1.54E-02 | -5.26E-03 | -3.54E-01 | 3.54E-01 |
| 5.45E+01                  | -7.18E-04                 | -8.53E-05                 | 8.85E-04                  | 1.14E-03                  | 5.50E+01                  | 2.85E-02                  | -5.77E-03                 | -5.69E-01 | 5.70E-01 | 5.54E+01 | 1.65E-02 | -4.26E-03 | -3.44E-01 | 3.46E-01 |
| 5.45E+01                  | -1.40E-03                 | -1.29E-03                 | 2.37E-03                  | 3.04E-03                  | 5.50E+01                  | 2.58E-02                  | -8.16E-03                 | -5.70E-01 | 5.70E-01 | 5.54E+01 | 1.84E-02 | -4.74E-03 | -3.24E-01 | 3.34E-01 |
| 5.45E+01                  | -2.24E-04                 | 4.83E-04                  | 1.27E-03                  | 1.38E-03                  | 5.50E+01                  | 2.72E-02                  | -4.55E-03                 | -5.71E-01 | 5.72E-01 | 5.54E+01 | 1.35E-02 | -4.29E-03 | -3.27E-01 | 3.27E-01 |
| 5.46E+01                  | -6.57E-04                 | -2.27E-03                 | -2.62E-04                 | 2.98E-03                  | 5.50E+01                  | 2.92E-02                  | -7.86E-03                 | -5.71E-01 | 5.72E-01 | 5.54E+01 | 1.22E-02 | -4.79E-03 | -3.19E-01 | 3.19E-01 |
| 5.46E+01                  | 5.17E-04                  | -1.18E-03                 | 1.72E-04                  | 1.30E-03                  | 5.50E+01                  | 2.96E-02                  | -7.10E-03                 | -5.70E-01 | 5.71E-01 | 5.54E+01 | 1.50E-02 | -4.94E-03 | -3.09E-01 | 3.09E-01 |
| 5.46E+01                  | 2.29E-03                  | 5.14E-04                  | -7.85E-04                 | 2.44E-03                  | 5.50E+01                  | 2.61E-02                  | -3.98E-03                 | -5.70E-01 | 5.70E-01 | 5.54E+01 | 1.35E-02 | -4.35E-03 | -3.05E-01 | 3.05E-01 |
| 5.46E+01                  | -3.00E-04                 | 1.73E-03                  | 3.84E-04                  | 1.80E-03                  | 5.50E+01                  | 2.98E-02                  | -5.86E-03                 | -5.68E-01 | 5.69E-01 | 5.54E+01 | 1.15E-02 | -4.95E-03 | -2.94E-01 | 2.94E-01 |
| 5.46E+01                  | 9.63E-04                  | 7.40E-04                  | -6.84E-04                 | 1.39E-03                  | 5.50E+01                  | 2.70E-02                  | -5.70E-03                 | -5.65E-01 | 5.65E-01 | 5.55E+01 | 1.31E-02 | -5.59E-03 | -2.88E-01 | 2.88E-01 |
| 5.46E+01                  | -1.49E-03                 | -1.64E-03                 | 5.41E-04                  | 2.28E-03                  | 5.50E+01                  | 2.88E-02                  | -8.93E-03                 | -5.68E-01 | 5.69E-01 | 5.55E+01 | 1.13E-02 | -4.35E-03 | -2.80E-01 | 2.81E-01 |
| 5.46E+01                  | -1.14E-03                 | 6.04E-04                  | -1.18E-03                 | 1.75E-03                  | 5.50E+01                  | 2.71E-02                  | -7.05E-03                 | -5.69E-01 | 5.69E-01 | 5.55E+01 | 1.35E-02 | -4.78E-03 | -2.72E-01 | 2.72E-01 |
| 5.46E+01                  | -1.93E-03                 | 1.62E-03                  | -6.86E-05                 | 2.52E-03                  | 5.51E+01                  | 2.68E-02                  | -7.78E-03                 | -5.61E-01 | 5.62E-01 | 5.55E+01 | 1.07E-02 | -4.67E-03 | -2.67E-01 | 2.67E-01 |
| 5.46E+01                  | 1.11E-03                  | 8.31E-04                  | -1.73E-04                 | 1.40E-03                  | 5.51E+01                  | 2.67E-02                  | -5.15E-03                 | -5.60E-01 | 5.61E-01 | 5.55E+01 | 1.11E-02 | -4.98E-03 | -2.56E-01 | 2.57E-01 |
| 5.46E+01                  | 3.88E-04                  | -8.91E-04                 | -2.29E-03                 | 2.49E-03                  | 5.51E+01                  | 2.61E-02                  | -4.49E-03                 | -5.60E-01 | 5.60E-01 | 5.55E+01 | 1.25E-02 | -4.89E-03 | -2.53E-01 | 2.54E-01 |
| 5.47E+01                  | 1.19E-03                  | 2.29E-03                  | -4.87E-04                 | 6.39E-04                  | 5.51E+01                  | 2.76E-02                  | -7.16E-03                 | -5.59E-01 | 5.59E-01 | 5.55E+01 | 9.85E-03 | -4.34E-03 | -2.49E-01 | 2.49E-01 |
| 5.47E+01                  | 2.29E-04                  | 2.32E-04                  | -1.23E-03                 | 1.27E-03                  | 5.51E+01                  | 2.88E-02                  | -8.40E-03                 | -5.55E-01 | 5.56E-01 | 5.55E+01 | 1.07E-02 | -4.80E-03 | -2.42E-01 | 2.42E-01 |
| 5.47E+01                  | 7.27E-04                  | 4.67E-04                  | -6.05E-03                 | 6.11E-03                  | 5.51E+01                  | 2.51E-02                  | -8.98E-03                 | -5.53E-01 | 5.54E-01 | 5.55E+01 | 8.25E-03 | -2.05E-03 | -2.55E-01 | 2.55E-01 |
| 5.47E+01                  | 9.39E-05                  | -1.99E-03                 | -1.04E-02                 | 1.06E-02                  | 5.51E+01                  | 2.76E-02                  | -6.47E-03                 | -5.48E-01 | 5.48E-01 | 5.55E+01 | 9.06E-03 | -3.28E-03 | -2.33E-01 | 2.33E-01 |
| 5.47E+01                  | 2.04E-03                  | -1.89E-03                 | -1.85E-02                 | 1.87E-02                  | 5.51E+01                  | 2.67E-02                  | -6.51E-03                 | -5.46E-01 | 5.47E-01 | 5.56E+01 | 9.23E-03 | -4.78E-03 | -2.29E-01 | 2.29E-01 |
| 5.47E+01                  | 3.24E-03                  | -5.37E-03                 | -2.62E-02                 | 2.69E-02                  | 5.51E+01                  | 2.70E-02                  | -6.54E-03                 | -5.43E-01 | 5.43E-01 | 5.56E+01 | 8.81E-03 | -4.99E-03 | -2.21E-01 | 2.21E-01 |
| 5.47E+01                  | 3.42E-03                  | -4.98E-03                 | -2.42E-02                 | 2.49E-02                  | 5.51E+01                  | 2.50E-02                  | -6.00E-03                 | -5.39E-01 | 5.40E-01 | 5.56E+01 | 1.13E-02 | -4.42E-03 | -2.18E-01 | 2.18E-01 |
| 5.47E+01                  | 3.69E-03                  | -5.31E-03                 | -6.22E-02                 | 6.29E-02                  | 5.52E+01                  | 2.65E-02                  | -6.14E-03                 | -5.32E-01 | 5.32E-01 | 5.56E+01 | 8.29E-03 | -4.10E-03 | -2.16E-01 | 2.16E-01 |
| 5.47E+01                  | 5.94E-03                  | -1.91E-03                 | -4.92E-02                 | 4.93E-02                  | 5.52E+01                  | 2.52E-02                  | -6.17E-03                 | -5.29E-01 | 5.29E-01 | 5.56E+01 | 9.56E-03 | -4.34E-03 | -2.09E-01 | 2.09E-01 |
| 5.47E+01                  | 3.85E-03                  | -3.44E-03                 | -1.12E-01                 | 1.13E-01                  | 5.52E+01                  | 2.62E-02                  | -8.22E-03                 | -5.22E-01 | 5.22E-01 | 5.56E+01 | 8.30E-03 | -4.20E-03 | -2.06E-01 | 2.06E-01 |
| 5.48E+01                  | 7.43E-03                  | -4.20E-04                 | -1.39E-01                 | 1.39E-01                  | 5.52E+01                  | 2.50E-02                  | -6.31E-03                 | -5.13E-01 | 5.14E-01 | 5.56E+01 | 7.70E-03 | -3.93E-03 | -2.00E-01 | 2.00E-01 |
| 5.48E+01                  | 9.18E-03                  | -3.13E-03                 | -1.69E-01                 | 1.69E-01                  | 5.52E+01                  | 2.46E-02                  | -6.43E-03                 | -5.09E-01 | 5.09E-01 | 5.56E+01 | 8.96E-03 | -4.35E-03 | -2.01E-01 | 2.02E-01 |
| 5.48E+01                  | 8.48E-03                  | -3.15E-03                 | -1.65E-01                 | 1.65E-01                  | 5.52E+01                  | 2.34E-02                  | -5.79E-03                 | -5.02E-01 | 5.02E-01 | 5.56E+01 | 8.76E-03 | -4.37E-03 | -1.98E-01 | 1.98E-01 |
| 5.48E+01                  | 1.09E-02                  | -3.23E-03                 | -2.26E-01                 | 2.28E-01                  | 5.52E+01                  | 2.42E-02                  | -4.94E-03                 | -4.94E-01 | 4.94E-01 | 5.56E+01 | 1.01E-02 | -4.80E-03 | -1.90E-01 | 1.90E-01 |
| 5.48E+01                  | 1.35E-02                  | -3.40E-03                 | -2.61E-01                 | 2.62E-01                  | 5.52E+01                  | 2.50E-02                  | -4.59E-03                 | -4.86E-01 | 4.86E-01 | 5.57E+01 | 7.75E-03 | -4.17E-03 | -1.88E-01 | 1.88E-01 |
| 5.48E+01                  | 1.59E-02                  | -4.10E-03                 | -3.04E-01                 | 3.04E-01                  | 5.52E+01                  | 2.02E-02                  | -4.14E-03                 | -4.77E-01 | 4.77E-01 | 5.57E+01 | 9.58E-03 | -3.05E-03 | -1.86E-01 | 1.87E-01 |
| 5.48E+01                  | 1.39E-02                  | -2.67E-03                 | -3.37E-01                 | 3.37E-01                  | 5.52E+01                  | 2.17E-02                  | -4.14E-03                 | -4.69E-01 | 4.69E-01 | 5.57E+01 | 8.54E-03 | -3.54E-03 | -1.81E-01 | 1.82E-01 |
| 5.48E+01                  | 1.62E-02                  | -6.33E-03                 | -3.78E-01                 | 3.78E-01                  | 5.53E+01                  | 2.21E-02                  | -4.40E-03                 | -4.61E-01 | 4.61E-01 | 5.57E+01 | 5.70E-04 | -3.20E-03 | -1.83E-01 | 1.83E-01 |
| 5.48E+01                  | 1.79E-02                  | -4.70E-04                 | -4.16E-01                 | 4.17E-01                  | 5.53E+01                  | 2.00E-02                  | -4.36E-03                 | -4.54E-01 | 4.54E-01 | 5.57E+01 | 5.11E-03 | -3.91E-03 | -1.75E-01 | 1.75E-01 |
| 5.48E+01                  | 2.00E-02                  | -1.65E-03                 | -4.49E-01                 | 4.49E-01                  | 5.53E+01                  | 2.31E-02                  | -5.88E-03                 | -4.44E-01 | 4.44E-01 | 5.57E+01 | 1.06E-02 | -4.50E-03 | -1.75E-01 | 1.76E-01 |
| 5.49E+01                  | 2.40E-02                  | -6.43E-04                 | -4.83E-01                 | 4.84E-01                  | 5.53E+01                  | 1.88E-02                  | -6.64E-03                 | -4.32E-01 | 4.33E-01 | 5.57E+01 | 8.16E-03 | -3.22E-03 | -1.72E-01 | 1.72E-01 |
| 5.49E+01                  | 2.11E-02                  | -2.39E-03                 | -5.09E-01                 | 5.09E-01                  | 5.53E+01                  | 1.96E-02                  | -1.29E-02                 | -4.23E-01 | 4.23E-01 | 5.57E+01 | 8.24E-03 | -3.33E-03 | -1.65E-01 | 1.65E-01 |
| 5.49E+01                  | 2.33E-02                  | -3.03E-03                 | -5.28E-01                 | 5.29E-01                  | 5.53E+01                  | 2.20E-02                  | -3.76E-03                 | -4.14E-01 | 4.15E-01 | 5.57E+01 | 6.57E-03 | -3.06E-03 | -1.60E-01 | 1.60E-01 |
| 5.49E+01                  | 2.92E-02                  | -4.13E-03                 | -5.51E-01                 | 5.52E-01                  | 5.53E+01                  | 2.00E-02                  | -2.79E-03                 | -4.06E-01 | 4.07E-01 | 5.57E+01 | 5.85E-03 | -3.99E-03 | -1.58E-01 | 1.58E-01 |

|                           |                           |                           |                           |                           |                           |                           |                           |                           |          |          |           |           |          |          |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|----------|----------|-----------|-----------|----------|----------|
| air bearing data page 130 | air bearing data page 130 | air bearing data page 130 | air bearing data page 131 | air bearing data page 131 | air bearing data page 131 | air bearing data page 132 | air bearing data page 132 | air bearing data page 132 |          |          |           |           |          |          |
| 5.58E+01                  | 8.05E-03                  | -2.11E-04                 | -1.56E-01                 | 1.57E-01                  | 5.62E+01                  | 7.68E-04                  | 4.66E-04                  | -1.49E-02                 | 1.50E-02 | 5.66E+01 | -1.41E-02 | 5.08E-03  | 3.20E-01 | 3.30E-01 |
| 5.58E+01                  | 7.59E-03                  | -4.04E-03                 | -1.50E-01                 | 1.50E-01                  | 5.62E+01                  | 3.4E-03                   | -4.06E-04                 | -1.23E-02                 | 1.29E-02 | 5.66E+01 | -1.56E-02 | 6.40E-04  | 4.08E-01 | 4.07E-01 |
| 5.58E+01                  | 6.58E-03                  | -3.78E-03                 | -1.50E-01                 | 1.50E-01                  | 5.62E+01                  | -3.09E-03                 | -5.01E-04                 | -9.39E-03                 | 9.89E-03 | 5.66E+01 | -2.46E-02 | 7.85E-03  | 4.78E-01 | 4.78E-01 |
| 5.58E+01                  | 6.58E-03                  | -2.27E-03                 | -1.42E-01                 | 1.42E-01                  | 5.62E+01                  | 5.61E-04                  | -1.36E-03                 | -4.63E-03                 | 5.24E-03 | 5.66E+01 | -2.57E-03 | -4.37E-03 | 5.59E-01 | 5.59E-01 |
| 5.58E+01                  | 4.22E-03                  | 4.20E-03                  | -1.43E-01                 | 1.43E-01                  | 5.62E+01                  | -2.58E-03                 | 9.02E-04                  | -4.07E-03                 | 4.99E-03 | 5.67E+01 | -2.86E-02 | 9.64E-03  | 5.85E-01 | 5.85E-01 |
| 5.58E+01                  | 6.00E-03                  | -1.57E-03                 | -1.42E-01                 | 1.42E-01                  | 5.62E+01                  | 1.64E-03                  | 9.20E-04                  | -1.66E-03                 | 2.51E-03 | 5.67E+01 | -2.67E-02 | 6.24E-03  | 6.24E-01 | 6.25E-01 |
| 5.58E+01                  | 4.92E-03                  | -2.25E-03                 | -1.35E-01                 | 1.35E-01                  | 5.62E+01                  | 8.17E-04                  | 1.56E-03                  | 6.92E-04                  | 1.89E-03 | 5.67E+01 | -2.95E-02 | 7.79E-03  | 6.49E-01 | 6.50E-01 |
| 5.58E+01                  | 5.15E-03                  | -4.36E-03                 | -1.32E-01                 | 1.32E-01                  | 5.63E+01                  | -5.51E-04                 | 1.16E-03                  | 1.13E-03                  | 1.72E-03 | 5.67E+01 | -3.06E-02 | 3.72E-03  | 6.69E-01 | 6.69E-01 |
| 5.58E+01                  | 6.35E-03                  | -3.27E-03                 | -1.28E-01                 | 1.28E-01                  | 5.63E+01                  | 6.76E-04                  | 1.18E-03                  | 2.42E-03                  | 2.77E-03 | 5.67E+01 | -3.29E-02 | 1.00E-02  | 6.76E-01 | 6.77E-01 |
| 5.58E+01                  | 4.90E-03                  | -3.10E-03                 | -1.24E-01                 | 1.24E-01                  | 5.63E+01                  | -4.46E-04                 | 2.00E-03                  | 4.31E-03                  | 4.77E-03 | 5.67E+01 | -3.03E-02 | 6.94E-03  | 6.80E-01 | 6.81E-01 |
| 5.59E+01                  | 4.39E-03                  | -1.84E-03                 | -1.23E-01                 | 1.23E-01                  | 5.63E+01                  | 9.97E-04                  | 2.69E-04                  | 1.43E-03                  | 1.79E-03 | 5.67E+01 | -3.08E-02 | 1.11E-02  | 6.81E-01 | 6.82E-01 |
| 5.59E+01                  | 5.07E-03                  | -4.21E-03                 | 1.29E-01                  | 1.29E-01                  | 5.63E+01                  | 3.91E-04                  | 1.91E-03                  | 3.22E-03                  | 3.79E-03 | 5.67E+01 | -3.39E-02 | 4.22E-02  | 6.91E-01 | 6.92E-01 |
| 5.59E+01                  | 5.62E-03                  | -5.62E-03                 | -1.17E-01                 | 1.17E-01                  | 5.63E+01                  | -6.64E-04                 | 5.10E-04                  | 4.46E-03                  | 4.52E-03 | 5.67E+01 | -3.23E-02 | 1.07E-02  | 6.86E-01 | 6.87E-01 |
| 5.59E+01                  | 3.04E-03                  | -1.47E-03                 | -1.11E-01                 | 1.11E-01                  | 5.63E+01                  | -1.18E-03                 | 7.96E-04                  | 7.09E-03                  | 7.24E-03 | 5.68E+01 | -3.20E-02 | 9.58E-03  | 6.88E-01 | 6.89E-01 |
| 5.59E+01                  | 5.13E-03                  | -3.42E-03                 | -1.12E-01                 | 1.12E-01                  | 5.63E+01                  | -4.19E-04                 | -7.53E-04                 | 3.95E-03                  | 4.04E-03 | 5.68E+01 | -3.54E-02 | 1.22E-02  | 6.91E-01 | 6.92E-01 |
| 5.59E+01                  | 4.34E-03                  | -1.87E-03                 | -1.07E-01                 | 1.07E-01                  | 5.63E+01                  | -6.12E-04                 | 1.58E-03                  | 6.49E-03                  | 6.71E-03 | 5.68E+01 | -3.32E-02 | 7.41E-03  | 6.69E-01 | 6.70E-01 |
| 5.59E+01                  | 4.96E-03                  | -7.97E-04                 | -1.05E-01                 | 1.05E-01                  | 5.64E+01                  | -3.34E-04                 | 9.39E-04                  | 6.75E-03                  | 6.83E-03 | 5.68E+01 | -3.37E-02 | 8.59E-03  | 6.79E-01 | 6.79E-01 |
| 5.59E+01                  | 8.79E-04                  | -6.41E-03                 | -9.91E-02                 | 9.93E-02                  | 5.64E+01                  | -8.66E-04                 | 2.55E-03                  | 7.01E-03                  | 7.51E-03 | 5.68E+01 | -2.97E-02 |           |          |          |

|                           |                           |                           |                           |                           |                           |                           |                           |                           |          |          |           |           |           |          |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|----------|----------|-----------|-----------|-----------|----------|
| air bearing data page 136 | air bearing data page 136 | air bearing data page 137 | air bearing data page 138 | air bearing data page 138 | air bearing data page 138 |          |          |           |           |           |          |
| 5.84E+01                  | 2.30E+02                  | -4.63E-03                 | -4.74E-01                 | 4.74E-01                  | 5.88E+01                  | 7.12E-03                  | 2.42E-04                  | -1.16E-01                 | 1.16E-01 | 5.92E+01 | -1.30E-03 | 3.92E-03  | 3.39E-04  | 4.15E-03 |
| 5.84E+01                  | 1.94E+02                  | -5.07E-03                 | -4.55E-01                 | 4.55E-01                  | 5.88E+01                  | 4.59E-03                  | -1.26E-03                 | -1.15E-01                 | 1.15E-01 | 5.92E+01 | 9.89E-04  | 6.68E-04  | -1.59E-03 | 1.99E-03 |
| 5.84E+01                  | 2.11E+02                  | -4.46E-03                 | -4.39E-01                 | 4.39E-01                  | 5.88E+01                  | 4.07E-03                  | -2.08E-03                 | -1.11E-01                 | 1.11E-01 | 5.92E+01 | -1.13E-03 | -1.68E-06 | -4.43E-04 | 1.27E-03 |
| 5.84E+01                  | 1.89E+02                  | -4.74E-03                 | -4.24E-01                 | 4.24E-01                  | 5.88E+01                  | 4.96E-03                  | -7.03E-04                 | -1.09E-01                 | 1.09E-01 | 5.92E+01 | -1.35E-03 | -4.15E-05 | 1.81E-03  | 2.91E-03 |
| 5.84E+01                  | 1.89E+02                  | -4.34E-03                 | -4.02E-01                 | 4.10E-01                  | 5.88E+01                  | 4.21E-03                  | -8.82E-04                 | -1.06E-01                 | 1.06E-01 | 5.93E+01 | 1.21E-03  | 1.42E-03  | 2.33E-03  | 2.98E-03 |
| 5.84E+01                  | 2.04E+02                  | -5.77E-03                 | -3.97E-01                 | 3.97E-01                  | 5.88E+01                  | 4.58E-03                  | 1.20E-04                  | -1.04E-01                 | 1.04E-01 | 5.93E+01 | -2.06E-04 | -3.70E-04 | 5.82E-04  | 3.84E-03 |
| 5.84E+01                  | 1.67E+02                  | -1.07E-03                 | -3.78E-01                 | 3.79E-01                  | 5.88E+01                  | 3.63E-03                  | -3.21E-03                 | -1.02E-01                 | 1.02E-01 | 5.93E+01 | 4.16E-04  | -2.05E-03 | -3.44E-03 | 4.03E-03 |
| 5.84E+01                  | 1.83E+02                  | -4.67E-03                 | -3.71E-01                 | 3.72E-01                  | 5.88E+01                  | 5.44E-03                  | -2.36E-03                 | -0.98E-02                 | 1.00E-01 | 5.93E+01 | 1.00E-03  | 1.94E-03  | -6.84E-04 | 2.29E-03 |
| 5.84E+01                  | 1.67E+02                  | -2.87E-03                 | -3.58E-01                 | 3.58E-01                  | 5.88E+01                  | 4.58E-03                  | 1.45E-05                  | -0.97E-02                 | 0.99E-02 | 5.93E+01 | -1.80E-03 | 1.65E-03  | 6.23E-04  | 2.31E-03 |
| 5.84E+01                  | 1.62E+02                  | -5.93E-03                 | -3.47E-01                 | 3.48E-01                  | 5.88E+01                  | 3.46E-03                  | -1.11E-03                 | -0.93E-02                 | 0.93E-02 | 5.93E+01 | -1.81E-04 | 7.72E-04  | 1.50E-03  | 1.70E-03 |
| 5.85E+01                  | 1.63E+02                  | -4.78E-03                 | -3.37E-01                 | 3.38E-01                  | 5.88E+01                  | 4.01E-03                  | -1.93E-03                 | -0.91E-02                 | 9.11E-02 | 5.93E+01 | -6.02E-04 | -2.77E-03 | 3.10E-04  | 2.83E-03 |
| 5.85E+01                  | 1.71E+02                  | -1.16E-03                 | -3.26E-01                 | 3.26E-01                  | 5.88E+01                  | 3.37E-03                  | 1.38E-04                  | -0.89E-02                 | 8.92E-02 | 5.93E+01 | 1.01E-03  | -2.25E-04 | -1.94E-03 | 2.20E-03 |
| 5.85E+01                  | 1.29E+02                  | -1.58E-03                 | -3.15E-01                 | 3.15E-01                  | 5.88E+01                  | 2.70E-03                  | -7.04E-04                 | -8.41E-02                 | 8.42E-02 | 5.93E+01 | -4.84E-03 | 2.02E-03  | 1.00E-03  | 2.93E-03 |
| 5.85E+01                  | 1.06E+02                  | -3.04E-03                 | -3.05E-01                 | 3.05E-01                  | 5.88E+01                  | 3.08E-03                  | 2.52E-04                  | -8.46E-02                 | 8.47E-02 | 5.93E+01 | -6.25E-04 | 4.04E-03  | -0.59E-04 | 4.18E-03 |
| 5.85E+01                  | 1.33E+02                  | -3.89E-03                 | -2.97E-01                 | 2.98E-01                  | 5.88E+01                  | 5.67E-03                  | -1.24E-04                 | -8.19E-02                 | 8.21E-02 | 5.94E+01 | -4.11E-04 | 1.94E-03  | -1.38E-04 | 1.99E-03 |
| 5.85E+01                  | 1.28E+02                  | -1.99E-03                 | -2.88E-01                 | 2.89E-01                  | 5.88E+01                  | 4.78E-03                  | -4.04E-04                 | -7.48E-02                 | 7.50E-02 | 5.94E+01 | 4.20E-04  | -3.71E-04 | -3.81E-04 | 9.17E-04 |
| 5.85E+01                  | 1.16E+02                  | -2.12E-03                 | -2.80E-01                 | 2.80E-01                  | 5.88E+01                  | 3.11E-03                  | 3.92E-04                  | -7.59E-02                 | 7.59E-02 | 5.94E+01 | 1.15E-03  | 3.50E-04  | -1.83E-03 | 2.19E-03 |
| 5.85E+01                  | 1.10E+02                  | -2.63E-03                 | -2.71E-01                 | 2.71E-01                  | 5.90E+01                  | 3.81E-03                  | 4.79E-04                  | -6.83E-02                 | 6.84E-02 | 5.94E+01 | 5.26E-04  | 4.21E-04  | 6.21E-04  | 6.78E-04 |
| 5.85E+01                  | 1.29E+02                  | -1.40E-03                 | -2.63E-01                 | 2.63E-01                  | 5.90E+01                  | 3.94E-03                  | -1.03E-03                 | -6.52E-02                 | 6.53E-02 | 5.94E+01 | -1.73E-03 | 1.41E-03  | 3.09E-05  | 2.25E-03 |
| 5.85E+01                  | 1.05E+02                  | -3.05E-03                 | -2.55E-01                 | 2.55E-01                  | 5.90E+01                  | 3.71E-03                  | -1.12E-03                 | -6.32E-02                 | 6.34E-02 | 5.94E+01 | -1.32E-03 | 1.34E-04  | -3.34E-04 | 4.95E-03 |
| 5.85E+01                  | 5.92E-03                  | -3.25E-03                 | -2.44E-01                 | 2.44E-01                  | 5.90E+01                  | 2.74E-03                  | -1.23E-03                 | -5.96E-02                 | 5.97E-02 | 5.94E+01 | -1.25E-04 | -1.02E-03 | -1.52E-03 | 1.83E-03 |
| 5.85E+01                  | 8.81E-03                  | -1.30E-03                 | -2.35E-01                 | 2.35E-01                  | 5.90E+01                  | 6.08E-03                  | 3.35E-03                  | -5.85E-02                 | 5.88E-02 | 5.94E+01 | 2.17E-03  | 3.3E-03   | -2.19E-05 | 2.46E-03 |
| 5.86E+01                  | 1.92E+02                  | -4.21E-03                 | -2.27E-01                 | 2.28E-01                  | 5.90E+01                  | 1.95E-04                  | 1.77E-03                  | -5.33E-02                 | 5.33E-02 | 5.94E+01 | -1.06E-04 | -1.96E-03 | -1.46E-03 | 2.45E-03 |
| 5.86E+01                  | 5.79E-03                  | -6.71E-04                 | -2.20E-01                 | 2.20E-01                  | 5.90E+01                  | 2.33E-03                  | 2.35E-03                  | -4.50E-02                 | 4.51E-02 | 5.94E+01 | 1.06E-03  | 2.50E-03  | -1.70E-03 | 6.04E-03 |
| 5.86E+01                  | 1.01E+02                  | 2.54E-03                  | -2.13E-01                 | 2.13E-01                  | 5.90E+01                  | 3.17E-03                  | -2.06E-03                 | -4.23E-02                 | 4.25E-02 | 5.95E+01 | -2.88E-03 | -3.59E-03 | -3.98E-03 | 6.07E-03 |
| 5.86E+01                  | 1.15E+02                  | -1.14E-03                 | -2.03E-01                 | 2.03E-01                  | 5.90E+01                  | 4.65E-03                  | -1.99E-03                 | -3.88E-02                 | 3.91E-02 | 5.95E+01 | -1.24E-03 | 3.18E-03  | -5.98E-04 | 3.46E-03 |
| 5.86E+01                  | 1.02E+02                  | -8.14E-03                 | -1.99E-01                 | 2.00E-01                  | 5.90E+01                  | 4.84E-03                  | -1.28E-03                 | -3.28E-02                 | 3.32E-02 | 5.95E+01 | -2.78E-04 | 2.25E-03  | -2.03E-03 | 3.04E-03 |
| 5.86E+01                  | 5.85E-03                  | -3.57E-03                 | -1.95E-01                 | 1.95E-01                  | 5.91E+01                  | 5.91E-03                  | 6.75E-03                  | -3.93E-02                 | 3.95E-02 | 5.95E+01 | -3.95E-03 | -3.05E-02 | -2.96E-03 | 4.39E-03 |
| 5.86E+01                  | 9.88E-03                  | -5.84E-03                 | -1.88E-01                 | 1.88E-01                  | 5.91E+01                  | 2.11E-03                  | 8.53E-03                  | -2.83E-02                 | 2.85E-02 | 5.95E+01 | -2.41E-04 | 5.56E-04  | 3.76E-03  | 3.81E-03 |
| 5.86E+01                  | 8.13E-03                  | -3.70E-03                 | -1.82E-01                 | 1.82E-01                  | 5.91E+01                  | -3.40E-04                 | 1.89E-03                  | -1.95E-02                 | 1.96E-02 | 5.95E+01 | 1.90E-03  | 3.27E-03  | -1.89E-03 | 4.14E-03 |
| 5.87E+01                  | 8.39E-03                  | -1.80E-03                 | -1.79E-01                 | 1.80E-01                  | 5.91E+01                  | -1.35E-04                 | 2.62E-03                  | -1.44E-02                 | 1.47E-02 | 5.95E+01 | -1.59E-03 | -4.99E-04 | -6.31E-04 | 1.96E-03 |
| 5.87E+01                  | 5.72E-03                  | -2.36E-03                 | -1.77E-01                 | 1.77E-01                  | 5.91E+01                  | 4.38E-04                  | -1.17E-03                 | -8.21E-03                 | 8.31E-03 | 5.95E+01 | 1.60E-03  | -2.56E-04 | 1.91E-04  | 1.64E-03 |
| 5.87E+01                  | 3.74E-03                  | -3.46E-03                 | -1.71E-01                 | 1.71E-01                  | 5.91E+01                  | 4.07E-04                  | 3.28E-04                  | -2.13E-03                 | 2.19E-03 | 5.95E+01 | 1.20E-03  | 1.11E-03  | 3.36E-03  | 3.74E-03 |
| 5.87E+01                  | 6.04E-03                  | -1.63E-01                 | -1.63E-01                 | 1.63E-01                  | 5.91E+01                  | -2.64E-04                 | 5.97E-04                  | 1.09E-04                  | 6.62E-04 | 5.95E+01 | 7.79E-04  | -3.79E-04 | 2.23E-03  | 2.43E-03 |
| 5.87E+01                  | 8.85E-03                  | -3.79E-03                 | -1.67E-01                 | 1.68E-01                  | 5.91E+01                  | 3.15E-03                  | -4.99E-03                 | 2.54E-03                  | 6.39E-03 | 5.95E+01 | 1.42E-03  | 2.23E-03  | -4.17E-04 | 2.69E-03 |
| 5.87E+01                  | 4.89E-03                  | -3.35E-04                 | -1.53E-01                 | 1.53E-01                  | 5.91E+01                  | -1.39E-03                 | -1.89E-03                 | -1.89E-03                 | 4.92E-03 | 5.95E+01 | -1.35E-03 | 3.94E-04  | -2.54E-04 | 1.32E-03 |
| 5.87E+01                  | 6.57E-03                  | -4.58E-04                 | -1.46E-01                 | 1.46E-01                  | 5.91E+01                  | -2.82E-03                 | 8.75E-04                  | 1.07E-03                  | 2.94E-03 | 5.95E+01 | -3.30E-04 | -1.81E-03 | -3.17E-04 | 2.05E-03 |
| 5.87E+01                  | 6.88E-03                  | -1.93E-03                 | -1.43E-01                 | 1.43E-01                  | 5.92E+01                  | 6.68E-05                  | 2.84E-03                  | 4.82E-04                  | 2.88E-03 | 5.95E+01 | 3.94E-04  | 6.47E-04  | -2.29E-04 | 7.91E-04 |
| 5.87E+01                  | 4.63E-03                  | -3.94E-03                 | -1.42E-01                 | 1.42E-01                  | 5.92E+01                  | 8.27E-04                  | -1.52E-03                 | 7.31E-04                  | 1.88E-03 | 5.95E+01 | -1.47E-04 | 1.42E-04  | 1.65E-04  | 2.63E-04 |
| 5.87E+01                  | 6.04E-03                  | 6.10E-04                  | -1.34E-01                 | 1.34E-01                  | 5.92E+01                  | -0.27E-03                 | 4.24E-04                  | 3.02E-03                  | 3.02E-03 | 5.96E+01 | -0.69E-04 | -1.05E-03 | -7.84E-04 | 1.34E-03 |
| 5.88E+01                  | 5.99E-03                  | -2.22E-03                 | -1.31E-01                 | 1.32E-01                  | 5.92E+01                  | -6.75E-04                 | 1.82E-03                  | -0.68E-04                 | 1.92E-03 | 5.96E+01 | -4.10E-04 | 3.49E-04  | -0.99E-04 | 6.16E-04 |
| 5.88E+01                  | 6.07E-03                  | -1.10E-04                 | -1.26E-01                 | 1.26E-01                  | 5.92E+01                  | 1.49E-03                  | -4.77E-04                 | 9.43E-04                  | 1.83E-03 | 5.96E+01 | 5.00E-04  | 5.36E-04  | -1.13E-03 | 1.35E-03 |
| 5.88E+01                  | 5.83E-03                  | -1.33E-03                 | -1.20E-01                 | 1.21E-01                  | 5.92E+01                  | 5.25E-03                  | 1.41E-03                  | 5.50E-03                  | 7.74E-03 | 5.96E+01 | 9.37E-04  | 2.95E-03  | 2.02E-03  | 3.70E-03 |

|                           |                           |                           |                           |                           |                           |                           |                           |                           |          |          |           |           |           |          |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|----------|----------|-----------|-----------|-----------|----------|
| air bearing data page 139 | air bearing data page 139 | air bearing data page 139 | air bearing data page 140 | air bearing data page 140 | air bearing data page 140 | air bearing data page 141 | air bearing data page 141 | air bearing data page 141 |          |          |           |           |           |          |
| 5.96E+01                  | 1.60E-03                  | 2.56E-03                  | -1.15E-03                 | 3.23E-03                  | 6.01E+01                  | -1.87E-03                 | 2.41E-03                  | -1.53E-03                 | 3.41E-03 | 6.05E+01 | -0.07E+02 | 2.13E-04  | 7.28E-01  | 7.28E-01 |
| 5.97E+01                  | 1.95E-04                  | 1.86E-03                  | 1.84E-03                  | 2.30E-03                  | 6.01E+01                  | -0.99E-03                 | 1.62E-03                  | -1.16E-03                 | 3.04E-03 | 6.05E+01 | -3.16E-02 | 1.12E-02  | 7.03E-01  | 7.03E-01 |
| 5.97E+01                  | 1.15E-03                  | -1.72E-03                 | 8.31E-05                  | 2.07E-03                  | 6.01E+01                  | -2.52E-03                 | 1.02E-04                  | 1.33E-03                  | 2.88E-03 | 6.05E+01 | -3.24E-02 | 9.74E-03  | 6.74E-01  | 6.75E-01 |
| 5.97E+01                  | 2.99E-04                  | 2.94E-03                  | 2.01E-03                  | 2.01E-03                  | 6.01E+01                  | 1.94E-03                  | -1.96E-03                 | -1.05E-03                 | 5.92E-03 | 6.05E+01 | -3.05E-02 | -3.05E-02 | 6.23E-01  | 6.23E-01 |
| 5.97E+01                  | -4.77E-04                 | 1.96E-03                  | -1.56E-03                 | 2.68E-03                  | 6.01E+01                  | -3.32E-03                 | 2.66E-03                  | -1.27E-03                 | 4.44E-03 | 6.06E+01 | -2.88E-02 | 9.90E-03  | 5.85E-01  | 5.85E-01 |
| 5.97E+01                  | 1.80E-03                  | -1.12E-03                 | 1.32E-03                  | 2.49E-03                  | 6.01E+01                  | 2.89E-04                  | 4.09E-03                  | -1.13E-03                 | 4.28E-03 | 6.06E+01 | -2.16E-02 | 4.95E-01  | 4.95E-01  | 4.95E-01 |
| 5.97E+01                  | -2.71E-03                 | -8.49E-03                 | 2.65E-05                  | 8.91E-03                  | 6.01E+01                  | -1.28E-03                 | -1.94E-03                 | 2.57E-03                  | 3.46E-03 | 6.06E+01 | -2.09E-02 | 9.96E-03  | 4.29E-01  | 4.29E-01 |
| 5.97E+01                  | -4.37E-03                 | -4.58E-03                 | 1.63E-03                  | 6.62E-03                  | 6.02E+01                  | 7.27E-05                  | -1.17E-03                 | 8.48E-05                  | 1.17E-03 | 6.06E+01 | -1.97E-02 | 4.44E-03  | 3.59E-01  | 3.59E-01 |
| 5.97E+01                  | 2.69E-03                  | 8.51E-06                  | 7.09E-03                  | 7.58E-03                  | 6.02E+01                  | 9.15E-04                  | 3.05E-03                  | 2.43E-03                  | 4.00E-03 | 6.06E+01 | -1.45E-02 | 3.38E-03  | 2.96E-01  | 2.97E-01 |
| 5.97E+01                  | -5.04E-03                 | 1.68E-02                  | 1.85E-04                  | 1.85E-04                  | 6.02E+01                  | -6.00E-04                 | 2.06E-03                  | 1.73E-03                  | 2.85E-03 | 6.06E+01 | -1.12E-02 | 3.96E-03  | 2.27E-01  | 2.28E-01 |
| 5.97E+01                  | -4.29E-03                 | -2.41E-03                 | 3.39E-02                  | 3.40E-02                  | 6.02E+01                  | -4.65E-04                 | 3.72E-04                  | -1.77E-03                 | 1.92E-03 | 6.06E+01 | -7.93E-03 | 3.78E-03  | 1.61E-01  | 1.61E-01 |
| 5.98E+01                  | -3.31E-03                 | 4.99E-02                  | 5.07E-02                  | 5.07E-02                  | 6.02E+01                  | -1.78E-03                 | -4.23E-04                 | -5.23E-04                 | 3.92E-03 | 6.06E+01 | -4.67E-03 | 1.78E-01  | 9.86E-02  | 9.87E-02 |
| 5.98E+01                  | -5.83E-03                 | -6.00E-03                 | 7.34E-02                  | 7.39E-02                  | 6.02E+01                  | 4.23E-04                  | 1.00E-03                  | 3.07E-04                  | 1.13E-03 | 6.06E+01 | -3.79E-03 | 1.99E-03  | 3.87E-02  | 3.90E-02 |
| 5.98E+01                  | -5.17E-03                 | 1.84E-03                  | 9.25E-02                  | 9.28E-02                  | 6.02E+01                  | 8.18E-04                  | 2.54E-03                  | -3.04E-06                 | 2.67E-03 | 6.06E+01 | 2.65E-03  | 2.09E-03  | -9.90E-03 | 1.05E-02 |
| 5.98E+01                  | -3.68E-03                 | 2.20E-03                  | 1.17E-01                  | 1.17E-01                  | 6.02E+01                  | -2.39E-05                 | 2.23E-03                  | -0.72E-03                 | 3.52E-03 | 6.07E+01 | 5.74E-03  | 6.16E-03  | -1.96E-03 | 8.64E-03 |
| 5.98E+01                  | -6.69E-03                 | 2.95E-03                  | 1.44E-01                  | 1.44E-01                  | 6.02E+01                  | -2.14E-04                 | -6.73E-04                 | -9.42E-04                 | 1.12E-03 | 6.07E+01 | -3.57E-03 | 5.41E-03  | -1.71E-03 | 6.70E-03 |
| 5.98E+01                  | -7.55E-03                 | 1.54E-03                  | 1.71E-01                  | 1.71E-01                  | 6.02E+01                  | -1.42E-03                 | 9.69E-04                  | 2.08E-03                  | 2.08E-03 | 6.07E+01 | -7.69E-04 | 4.64E-03  | -4.02E-03 | 6.19E-03 |
| 5.98E+01                  | -7.99E-03                 | 2.04E-01                  | 2.04E-01                  | 2.04E-01                  | 6.03E+01                  | 6.04E-06                  | -7.05E-05                 | -1.26E-03                 | 1.26E-03 | 6.07E+01 |           |           |           |          |

|                           |                           |                           |                           |                           |                           |                           |                           |                           |          |          |           |           |           |          |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|----------|----------|-----------|-----------|-----------|----------|
| air bearing data page 145 | air bearing data page 145 | air bearing data page 146 | air bearing data page 147 | air bearing data page 147 | air bearing data page 147 |          |          |           |           |           |          |
| 6.22E+01                  | 7.55E-05                  | -4.91E-04                 | -1.43E-04                 | 7.10E-04                  | 6.27E+01                  | -2.71E-03                 | 9.60E-03                  | 8.20E-03                  | 1.30E-02 | 6.31E+01 | 2.09E-02  | -1.65E-02 | 7.57E-02  | 8.02E-02 |
| 6.23E+01                  | 1.28E-03                  | -3.01E-03                 | -1.41E-03                 | 3.56E-03                  | 6.27E+01                  | -9.91E-03                 | 6.82E-02                  | 1.23E-02                  | 7.00E-02 | 6.31E+01 | 2.36E-03  | -1.35E-02 | 1.98E-01  | 1.99E-01 |
| 6.23E+01                  | -1.49E-03                 | 2.29E-03                  | -2.09E-05                 | 2.73E-03                  | 6.27E+01                  | 3.74E-04                  | 5.20E-02                  | -2.76E-03                 | 5.27E-02 | 6.31E+01 | 1.04E-01  | -6.63E-02 | 1.17E-01  | 1.79E-01 |
| 6.23E+01                  | -1.07E-03                 | 1.43E-04                  | 1.89E-04                  | 1.31E-03                  | 6.27E+01                  | 1.02E-02                  | 2.81E-02                  | 2.38E-02                  | 3.71E-02 | 6.31E+01 | -1.89E-02 | 6.88E-02  | 6.89E-03  | 6.40E-02 |
| 6.23E+01                  | -7.75E-03                 | 4.37E-03                  | -1.82E-03                 | 9.08E-03                  | 6.27E+01                  | 1.00E-02                  | 1.88E-02                  | 5.54E-03                  | 2.25E-02 | 6.31E+01 | 1.35E-02  | -3.84E-02 | -4.86E-03 | 3.91E-02 |
| 6.23E+01                  | 2.23E-03                  | -1.30E-03                 | -1.87E-03                 | 3.47E-03                  | 6.27E+01                  | 1.02E-02                  | 6.45E-02                  | -2.81E-03                 | 6.54E-02 | 6.32E+01 | -2.69E-02 | -4.52E-02 | 1.71E-03  | 4.43E-02 |
| 6.23E+01                  | -1.49E-03                 | -4.18E-03                 | 7.39E-04                  | 4.49E-03                  | 6.27E+01                  | 1.45E-02                  | 3.53E-03                  | 4.15E-03                  | 1.55E-02 | 6.32E+01 | -3.77E-02 | -8.86E-02 | -1.63E-02 | 7.16E-02 |
| 6.23E+01                  | 7.79E-04                  | 1.88E-03                  | 6.31E-05                  | 2.03E-03                  | 6.27E+01                  | 1.47E-02                  | -3.29E-03                 | -8.85E-03                 | 1.74E-02 | 6.32E+01 | -3.47E-02 | -1.98E-02 | -3.25E-02 | 5.15E-02 |
| 6.23E+01                  | 1.60E-03                  | -3.08E-03                 | -9.54E-04                 | 3.60E-03                  | 6.28E+01                  | 2.44E-02                  | 5.96E-03                  | -1.09E-02                 | 2.74E-02 | 6.32E+01 | 4.63E-03  | 2.12E-02  | -5.47E-02 | 5.89E-02 |
| 6.23E+01                  | 1.08E-03                  | -4.55E-03                 | -2.40E-03                 | 5.28E-03                  | 6.28E+01                  | 1.70E-02                  | -5.89E-03                 | 3.62E-03                  | 1.83E-02 | 6.32E+01 | 7.02E-03  | -2.47E-02 | -4.79E-02 | 2.61E-02 |
| 6.23E+01                  | 5.80E-04                  | 1.84E-03                  | -1.49E-04                 | 1.75E-03                  | 6.28E+01                  | 4.37E-03                  | 1.01E-02                  | 2.44E-02                  | 2.68E-02 | 6.32E+01 | -1.94E-03 | -4.16E-03 | 2.58E-02  | 2.62E-02 |
| 6.24E+01                  | -6.03E-04                 | -4.72E-05                 | -2.94E-04                 | 1.03E-03                  | 6.28E+01                  | 1.39E-02                  | -4.91E-04                 | 4.74E-02                  | 4.93E-02 | 6.32E+01 | 3.22E-02  | 2.38E-02  | 5.91E-02  | 9.09E-02 |
| 6.24E+01                  | -1.13E-03                 | 5.16E-04                  | -1.32E-03                 | 1.81E-03                  | 6.28E+01                  | 7.04E-03                  | -3.22E-03                 | 3.98E-02                  | 4.05E-02 | 6.32E+01 | 7.98E-03  | 2.05E-02  | 2.95E-02  | 2.95E-02 |
| 6.24E+01                  | 1.61E-03                  | 3.36E-03                  | -2.36E-03                 | 4.45E-03                  | 6.28E+01                  | 6.90E-03                  | 3.69E-03                  | 8.08E-03                  | 1.12E-02 | 6.32E+01 | 1.07E-02  | -2.28E-02 | 2.13E-02  | 3.30E-02 |
| 6.24E+01                  | 7.92E-04                  | -1.00E-03                 | 3.02E-04                  | 1.31E-03                  | 6.28E+01                  | 2.24E-03                  | 2.07E-02                  | -1.29E-02                 | 2.45E-02 | 6.32E+01 | -4.37E-02 | 2.87E-05  | -3.81E-03 | 4.84E-02 |
| 6.24E+01                  | -2.20E-03                 | -3.22E-03                 | -2.15E-03                 | 4.45E-03                  | 6.28E+01                  | 8.34E-03                  | 6.28E-03                  | -1.59E-02                 | 1.91E-02 | 6.33E+01 | -3.59E-02 | 2.65E-02  | -3.81E-03 | 4.44E-02 |
| 6.24E+01                  | -7.88E-03                 | 4.19E-03                  | -3.17E-03                 | 9.47E-03                  | 6.28E+01                  | -1.64E-02                 | -5.20E-02                 | -4.48E-04                 | 5.45E-02 | 6.33E+01 | -6.28E-02 | 1.87E-02  | -2.35E-02 | 6.96E-02 |
| 6.24E+01                  | -6.44E-03                 | -3.40E-03                 | 5.66E-05                  | 7.28E-03                  | 6.28E+01                  | 7.61E-03                  | -2.43E-02                 | -1.94E-02                 | 3.20E-02 | 6.33E+01 | -4.80E-02 | 2.37E-02  | -3.30E-02 | 6.29E-02 |
| 6.24E+01                  | -5.31E-03                 | -6.46E-03                 | -9.19E-04                 | 7.67E-03                  | 6.29E+01                  | 3.29E-02                  | -1.85E-02                 | -2.97E-02                 | 4.80E-02 | 6.33E+01 | -6.67E-02 | 5.75E-02  | -6.96E-02 | 1.03E-01 |
| 6.24E+01                  | 1.39E-03                  | 3.98E-04                  | 3.29E-03                  | 1.31E-03                  | 6.29E+01                  | 4.69E-02                  | -1.25E-02                 | 4.59E-02                  | 5.39E-02 | 6.33E+01 | -4.89E-02 | -3.38E-02 | 5.84E-02  | 1.44E-01 |
| 6.24E+01                  | -4.37E-04                 | 2.13E-03                  | 3.29E-04                  | 2.20E-03                  | 6.29E+01                  | 3.94E-02                  | -3.30E-02                 | -1.85E-02                 | 5.46E-02 | 6.33E+01 | -1.72E-02 | 7.27E-02  | 2.03E-02  | 7.74E-02 |
| 6.25E+01                  | 7.65E-04                  | 8.73E-04                  | -1.67E-03                 | 2.04E-03                  | 6.29E+01                  | 4.24E-03                  | -1.43E-02                 | -5.53E-03                 | 1.58E-02 | 6.33E+01 | -3.95E-02 | -3.96E-02 | 1.83E-02  | 8.28E-02 |
| 6.25E+01                  | 5.83E-05                  | -2.32E-03                 | -1.36E-03                 | 2.69E-03                  | 6.29E+01                  | -1.47E-02                 | 7.47E-03                  | 8.31E-03                  | 1.85E-02 | 6.33E+01 | -3.14E-02 | 1.01E-02  | -3.98E-04 | 1.06E-01 |
| 6.25E+01                  | 4.18E-03                  | -4.91E-03                 | -1.12E-03                 | 6.54E-03                  | 6.29E+01                  | -1.98E-02                 | 6.51E-03                  | 8.67E-03                  | 2.28E-02 | 6.33E+01 | -3.20E-02 | 1.67E-02  | -3.95E-02 | 9.20E-02 |
| 6.25E+01                  | 1.08E-02                  | 8.86E-03                  | -1.24E-03                 | 1.40E-02                  | 6.29E+01                  | -2.87E-02                 | 3.84E-03                  | 8.08E-03                  | 3.01E-02 | 6.33E+01 | -1.18E-02 | 2.11E-02  | -1.44E-02 | 4.90E-02 |
| 6.25E+01                  | 2.93E-03                  | 6.78E-03                  | 4.08E-03                  | 8.44E-03                  | 6.29E+01                  | -2.48E-02                 | -1.44E-02                 | 1.48E-02                  | 3.23E-02 | 6.33E+01 | -2.34E-02 | 3.27E-02  | -4.87E-02 | 6.31E-02 |
| 6.25E+01                  | 1.94E-02                  | 9.96E-02                  | -1.44E-04                 | 2.19E-02                  | 6.29E+01                  | -1.83E-02                 | 2.65E-02                  | -3.77E-03                 | 3.24E-02 | 6.34E+01 | -4.24E-02 | 5.36E-02  | -2.49E-02 | 7.28E-02 |
| 6.25E+01                  | 1.20E-03                  | 2.20E-03                  | -2.89E-03                 | 1.79E-01                  | 6.29E+01                  | 6.29E-02                  | 2.01E-02                  | 4.59E-02                  | 5.39E-02 | 6.34E+01 | -1.32E-01 | -1.25E-02 | 1.81E-02  | 5.84E-02 |
| 6.25E+01                  | 1.28E-02                  | 1.19E-02                  | -8.80E-04                 | 1.74E-02                  | 6.30E+01                  | -4.32E-02                 | 2.95E-02                  | -1.02E-01                 | 1.15E-01 | 6.34E+01 | -6.75E-02 | -4.72E-02 | 4.44E-02  | 8.89E-02 |
| 6.25E+01                  | 1.37E-02                  | 1.73E-02                  | 1.95E-03                  | 2.22E-02                  | 6.30E+01                  | -2.68E-02                 | -4.14E-02                 | -1.42E-01                 | 1.50E-01 | 6.34E+01 | -6.38E-02 | 4.58E-02  | 1.30E-02  | 7.18E-02 |
| 6.25E+01                  | 1.58E-02                  | 5.09E-02                  | 6.68E-03                  | 5.37E-02                  | 6.30E+01                  | -3.25E-02                 | -3.09E-02                 | -1.39E-01                 | 1.46E-01 | 6.34E+01 | -6.60E-02 | 1.42E-02  | 6.23E-02  | 8.28E-02 |
| 6.26E+01                  | 2.08E-02                  | 5.96E-02                  | 1.64E-03                  | 6.32E-02                  | 6.30E+01                  | -2.92E-02                 | -3.67E-02                 | -8.08E-02                 | 9.30E-02 | 6.34E+01 | -4.89E-02 | -1.00E-02 | 1.92E-02  | 5.59E-02 |
| 6.26E+01                  | -6.22E-02                 | -9.17E-02                 | 6.19E-04                  | 1.11E-01                  | 6.30E+01                  | -2.13E-02                 | -2.54E-02                 | 2.20E-02                  | 1.98E-02 | 6.34E+01 | -1.09E-02 | -1.54E-02 | 1.04E-02  | 5.33E-02 |
| 6.26E+01                  | -5.18E-02                 | -2.67E-02                 | 1.66E-01                  | 1.65E-01                  | 6.30E+01                  | -6.62E-02                 | -3.29E-02                 | 1.03E-01                  | 1.03E-01 | 6.34E+01 | -3.27E-02 | 8.40E-04  | -8.92E-03 | 3.39E-02 |
| 6.26E+01                  | 4.14E-03                  | 1.99E-02                  | -4.64E-02                 | 6.69E-02                  | 6.30E+01                  | -8.15E-02                 | -1.01E-01                 | 1.12E-01                  | 1.62E-01 | 6.34E+01 | 8.53E-03  | -6.35E-04 | -6.42E-02 | 6.48E-02 |
| 6.26E+01                  | -3.94E-02                 | -1.05E-01                 | 1.19E-01                  | 1.19E-01                  | 6.30E+01                  | -1.07E-02                 | -8.84E-02                 | 4.59E-02                  | 5.39E-02 | 6.35E+01 | -1.35E-01 | -1.25E-02 | 1.81E-02  | 5.84E-02 |
| 6.26E+01                  | -8.21E-03                 | -5.32E-02                 | 1.20E-02                  | 5.51E-02                  | 6.30E+01                  | -1.14E-02                 | -3.00E-03                 | 2.03E-02                  | 2.34E-02 | 6.35E+01 | -6.84E-02 | -3.37E-02 | 2.47E-02  | 7.47E-02 |
| 6.26E+01                  | 2.44E-02                  | 6.47E-02                  | -8.18E-03                 | 6.97E-02                  | 6.30E+01                  | 1.02E-03                  | -7.44E-03                 | 9.40E-03                  | 1.20E-02 | 6.35E+01 | -5.32E-02 | 3.97E-02  | 6.34E-02  | 9.18E-02 |
| 6.26E+01                  | 2.25E-02                  | 3.73E-02                  | 2.11E-03                  | 4.36E-02                  | 6.31E+01                  | -5.78E-04                 | -9.73E-03                 | -1.01E-02                 | 1.40E-02 | 6.35E+01 | 1.50E-02  | 7.77E-03  | 1.07E-02  | 2.00E-02 |
| 6.26E+01                  | 1.06E-02                  | 1.72E-02                  | -3.54E-03                 | 2.05E-02                  | 6.31E+01                  | -6.59E-03                 | -5.22E-03                 | -1.07E-02                 | 1.53E-02 | 6.35E+01 | 1.20E-02  | 2.86E-03  | -4.81E-03 | 1.32E-02 |
| 6.26E+01                  | 3.60E-02                  | 1.03E-02                  | -5.14E-02                 | 6.38E-02                  | 6.31E+01                  | 1.10E-03                  | -1.70E-02                 | -1.65E-03                 | 1.71E-02 | 6.35E+01 | -2.42E-03 | -3.11E-02 | 1.45E-02  | 3.44E-02 |
| 6.27E+01                  | 9.44E-03                  | 3.98E-02                  | -1.99E-02                 | 4.55E-02                  | 6.31E+01                  | -4.11E-03                 | -3.23E-02                 | 2.87E-03                  | 3.27E-02 | 6.35E+01 | -2.16E-03 | -6.84E-03 | 1.46E-02  | 1.65E-02 |
| 6.27E+01                  | 2.09E-02                  | 8.66E-04                  | 4.62E-04                  | 2.09E-02                  | 6.31E+01                  | 3.17E-03                  | -1.64E-02                 | 1.90E-02                  | 2.53E-02 | 6.35E+01 | 2.96E-03  | 1.71E-02  | 7.89E-03  | 1.90E-02 |

|                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |          |           |           |           |          |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|----------|-----------|-----------|-----------|----------|
| air bearing data page 148 | air bearing data page 148 | air bearing data page 148 | air bearing data page 149 | air bearing data page 150 | air bearing data page 150 | air bearing data page 150 |          |           |           |           |          |
| 6.35E+01                  | 8.37E-03                  | 2.07E-02                  | 2.34E-03                  | 2.25E-02                  | 6.40E+01                  | 1.83E-02                  | 1.10E-02                  | -2.93E-02                 | 3.63E-02                  | 6.44E+01 | 3.18E-02  | -7.48E-02 | -2.39E-02 | 8.48E-02 |
| 6.35E+01                  | 1.21E-02                  | 1.29E-02                  | -1.01E-03                 | 1.77E-02                  | 6.40E+01                  | 4.27E-02                  | -1.23E-02                 | -5.64E-02                 | 7.18E-02                  | 6.44E+01 | 8.02E-03  | 3.09E-01  | 9.23E-01  | 3.23E-01 |
| 6.36E+01                  | 5.17E-02                  | -3.91E-03                 | 4.71E-02                  | 7.01E-02                  | 6.40E+01                  | 5.52E-02                  | -2.41E-02                 | -6.60E-02                 | 8.81E-02                  | 6.44E+01 | 7.95E-03  | 1.22E-01  | 1.25E-01  | 1.75E-01 |
| 6.36E+01                  | 8.01E-02                  | -8.87E-02                 | 2.40E-02                  | 8.20E-02                  | 6.40E+01                  | -8.40E-02                 | 5.23E-02                  | -2.23E-02                 | 6.44E-02                  | 6.44E+01 | 2.97E-02  | -4.38E-01 | -4.23E-02 | 1.46E-02 |
| 6.36E+01                  | 4.12E-01                  | -1.54E-01                 | 3.81E-02                  | 4.41E-01                  | 6.40E+01                  | 8.88E-03                  | -2.26E-02                 | 3.84E-03                  | 2.55E-02                  | 6.44E+01 | -1.43E-02 | 1.87E-02  | -2.59E-02 | 3.51E-02 |
| 6.36E+01                  | -4.52E-02                 | -1.34E-03                 | 2.36E-02                  | 5.10E-02                  | 6.40E+01                  | -6.26E-03                 | -1.81E-02                 | 1.13E-03                  | 2.04E-02                  | 6.45E+01 | 7.23E-02  | -3.94E-02 | -2.47E-02 | 8.56E-02 |
| 6.36E+01                  | 3.64E-02                  | 1.05E-02                  | 4.79E-02                  | 6.11E-02                  | 6.40E+01                  | -1.61E-02                 | 2.59E-03                  | -5.12E-03                 | 1.71E-02                  | 6.45E+01 | 8.66E-02  | -6.81E-02 | 9.44E-03  | 1.09E-01 |
| 6.36E+01                  | -4.39E-02                 | 1.15E-02                  | -1.39E-02                 | 4.71E-02                  | 6.40E+01                  | -2.46E-02                 | 1.61E-02                  | -2.21E-02                 | 3.68E-02                  | 6.45E+01 | 6.56E-02  | 1.16E-01  | -2.74E-03 | 1.33E-01 |
| 6.36E+01                  | -1.65E-02                 | -5.50E-02                 | 6.62E-04                  | 5.74E-02                  | 6.41E+01                  | -2.15E-02                 | 9.66E-03                  | -2.04E-02                 | 3.12E-02                  | 6.45E+01 | 1.49E-02  | -2.74E-02 | 4.20E-02  | 5.31E-02 |
| 6.36E+01                  | 1.71E-02                  | -2.32E-02                 | -1.73E-02                 | 3.36E-02                  | 6.41E+01                  | 5.15E-04                  | 7.02E-03                  | -2.90E-02                 | 2.98E-02                  | 6.45E+01 | -6.51E-03 | 4.06E-03  | -1.09E-02 | 1.34E-02 |
| 6.36E+01                  | 2.28E-02                  | 2.81E-02                  | -9.69E-03                 | 3.75E-02                  | 6.41E+01                  | -5.71E-03                 | 2.37E-03                  | -2.91E-02                 | 2.97E-02                  | 6.45E+01 | -4.60E-02 | -2.28E-02 | 7.50E-02  | 9.09E-02 |
| 6.36E+01                  | 1.22E-02                  | 4.30E-04                  | 1.09E-02                  | 1.39E-02                  | 6.41E+01                  | 4.99E-02                  | 3.70E-03                  | 1.07E-02                  | 2.29E-02                  | 6.45E+01 | -7.35E-02 | 2.16E-02  | 1.19E-01  | 1.40E-01 |
| 6.37E+01                  | 1.46E-02                  | -3.33E-02                 | 5.01E-02                  | 6.19E-02                  | 6.41E+01                  | -4.27E-02                 | 2.12E-02                  | 8.46E-02                  | 9.71E-02                  | 6.45E+01 | -1.23E-01 | 1.70E-02  | 1.02E-01  | 1.61E-01 |
| 6.37E+01                  | -3.93E-03                 | -9.40E-03                 | 2.16E-02                  | 2.38E-02                  | 6.41E+01                  | -4.75E-02                 | 6.80E-03                  | 1.08E-01                  | 1.18E-01                  | 6.45E+01 | -6.19E-02 | 3.38E-03  | 2.10E-02  | 6.68E-02 |
| 6.37E+01                  | 1.06E-02                  | 1.85E-02                  | 1.51E-02                  | 2.62E-02                  | 6.41E+01                  | -1.11E-01                 | 3.12E-02                  | 9.97E-02                  | 1.53E-01                  | 6.45E+01 | -4.79E-03 | -1.25E-02 | 6.59E-02  | 6.73E-02 |
| 6.37E+01                  | 1.49E-02                  | 1.44E-02                  | 1.40E-02                  | 2.50E-02                  | 6.41E+01                  | -1.33E-01                 | 3.46E-02                  | 9.54E-02                  | 1.67E-01                  | 6.46E+01 | -4.84E-02 | -7.80E-02 | 1.33E-01  | 1.61E-01 |
| 6.37E+01                  | 9.54E-03                  | 2.19E-03                  | -8.53E-03                 | 1.30E-02                  | 6.41E+01                  | -6.97E-02                 | 4.11E-02                  | -8.74E-03                 | 7.30E-02                  | 6.46E+01 | -3.30E-03 | -8.40E-02 | 7.82E-02  | 9.51E-02 |
| 6.37E+01                  | 7.36E-03                  | 2.01E-02                  | 2.98E-02                  | 2.15E-02                  | 6.41E+01                  | 2.98E-02                  | 1.53E-02                  | -1.92E-02                 | 3.86E-0                   |          |           |           |           |          |