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Robot Manufacturing Cell Product Requirements

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1 Objective

The objective of the Robotic Manufacturing Cell is to integrate the two robots into a mini assembly line, constructing an object by sorting through varied pieces and using specified barcodes to determine the placement of each. One robot will place the objects, the other will push the pieces together. Finally, a conveyor shall distribute all of the parts.

2 Scope

The scope of this document is to define each requirement of the project. Each requirement shall be explicitly stated to ensure they are met.

3 References

3.1 Cited Documents

"Products." Training Courses Available at DENSO Robotics, densorobotics.com/products/vs-g-series/download-materials. (Manuals for the Denso Robotic Arms)

"Robotic Arm Manufacturing Cell." Cutter Types (Mill) - Mindworks, mindworks.shoutwiki.com/wiki/Robotic_Arm_Manufacturing_Cell. (Previous Robot Manufacturing Cell Group Project)

"Denso RC7M Manuals." Manuals Library, www.manualslib.com/products/Denso-Rc7m-8883395.html. (Operating manuals for the Denso Robotic Arms)

WINCAPS III (Program used to write code and simulate the function of the robot)

Davison, Pat. Safety Standards and Collaborative Robots, www.robotics.org/userAssets/riaUploads/file/6-Pat.pdf. (Safety Standards for Robots)

Murashov, Vladimir, et al. "Working Safely with Robot Workers: Recommendations for the New Workplace." Advances in Pediatrics., U.S. National Library of Medicine, Mar. 2016, www.ncbi.nlm.nih.gov/pmc/articles/PMC4779796/. (Safety Recommendations for Industrial Robotics)

"Language Reference." Arduino - Introduction, www.arduino.cc/reference/en/.

3.2 Acronyms

EPO Engineering Purchase Order
ER Engineering Release
POC Proof of Concept
PTP Point to Point
CP Continuous Point
I/O Input/Output
ISO International Organization for Standardization
TCP/IP Transmission Control Protocol/Internet Protocol
R# Robot Number

CR Carriage Return
CRLF Carriage Return Line Feed

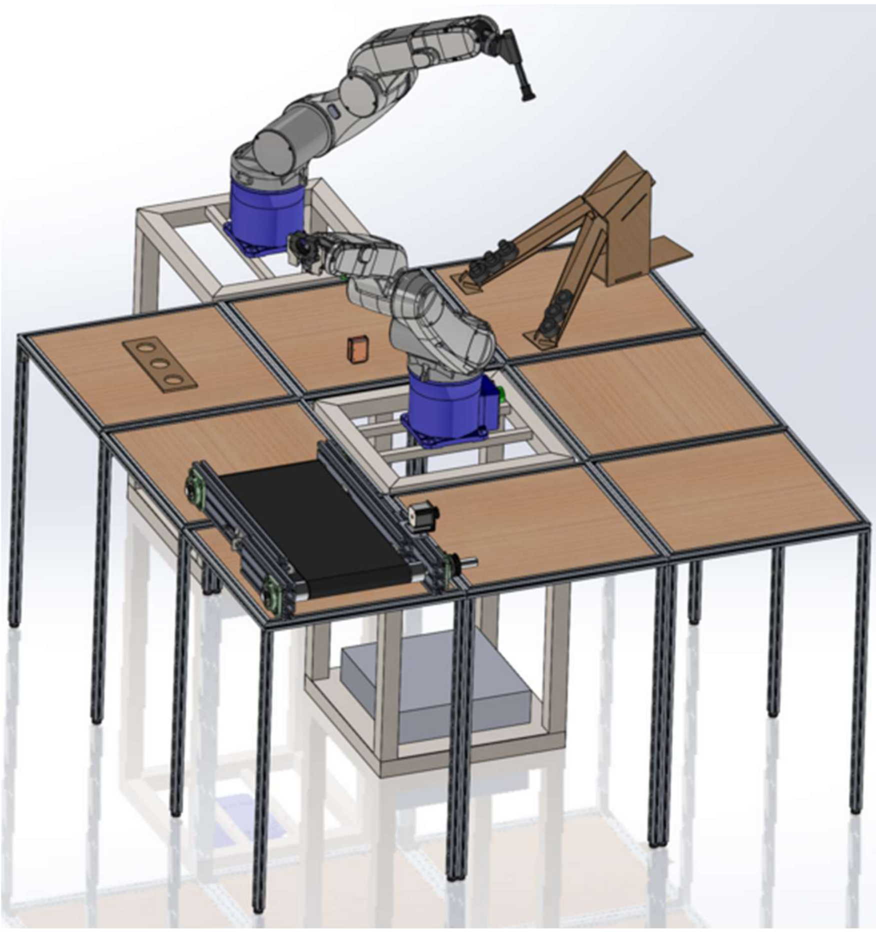
3.3 Variable Types

Type I: Integer
Type F: Floating Point
Type D: Double-precision
Type S: String
Type V: Vector
Type P: Position
Type J: Joint
Type T: Homogeneous
Type IO: I/O

3.4 Commands

PROGRAM XXXX: Declares program name
TAKEARM: Obtains arm control
GIVEARM: Releases arm control
SPEED ###: Sets the internal speed
MOVE: Moves the arm from its current position to a targeted position
END: Ends the robot motion and program
APPROACH: Moves the tool end of the arm to the approach point specified
DEPART: Moves the tool end of the arm to the depart point specified
DRIVEA: Executes an absolute motion of each axis
COM_ENCOM: Opens the port and establishes connection with the external device for the data transmission
COM_DISCOM: Closes the port and disable connection with the external device
FLUSH: Clears the input buffer
INPUT: Gets data from an Ethernet port
WRITE: Outputs data from an Ethernet port to an external device
SET: Set an I/O port to ON
RESET: Set an I/O port to OFF
IF…THEN: Executes statement if condition is true
ELSE: Executes statement if condition is false
SELECT_CASE: Executes statements block associated with the matching condition out of multiple conditions
FOR…NEXT: Repeatedly executes a block of statements in a loop according to the specified condition

3.5 Robot Cell Layout



4 Functional Requirements

4.1 User Interface Requirements

The assembly must be self-functioning, or automated. The only user involvement shall be to start the process. In case of malfunction, emergency stop switches are in place: one on each controller and one on the outside of the cell.

4.2 What it should do

The project must illustrate supervisory control between the two arms. The two robotic arms must be able to communicate with one another via TCP/IP protocols to complete a task – as an integrated assembly line system. One robot should utilize a push finger, while the other will utilize the gripper. A ramp will distribute the parts to the robot, with a scanner recognizing which item is which. This data will be transmitted to one robot arm and a code will be in place for it to acknowledge what to do with that part. The other arm will then push the two parts together, forming an assembly. A final distribution of the parts will then occur via conveyor into a storage for the assembled parts.

5 Mechanical Requirements

5.1 Strength Requirements

The robotic arm has a limitation of 5-7 kg load.

Pressure limitations also take place. The operating air pressure is .1 - .39 MPa. The max air pressure is .49 MPa.

5.2 Spatial Requirements

The assembly line shall fit within the space provided in the manufacturing cell. This area is a 2438.4 mm x 1835 mm rectangle (X vs Y). Due to limitations on the arm with University of Idaho serial number 196-549, the negative X-Axis must not exceed a length of 762 mm. Each arm shall have an initial/rest position to avoid potential collisions.

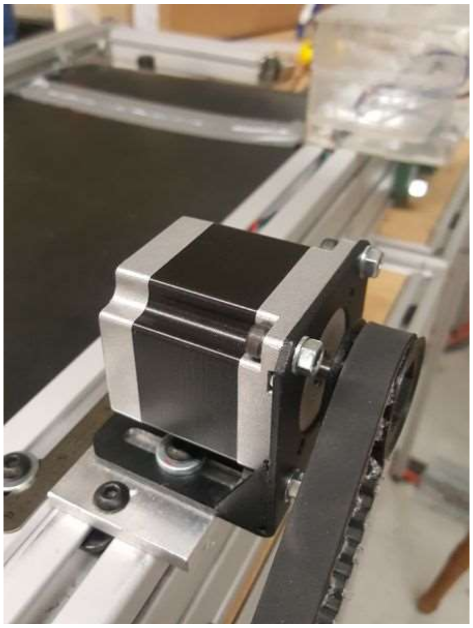
Each part must have its own location in the cell, one side shall be where the robot gathers the part, the other shall be where it distributes the final product. Each storage location shall be specified via the code for the robot.

5.3 Weight/Mass Requirements

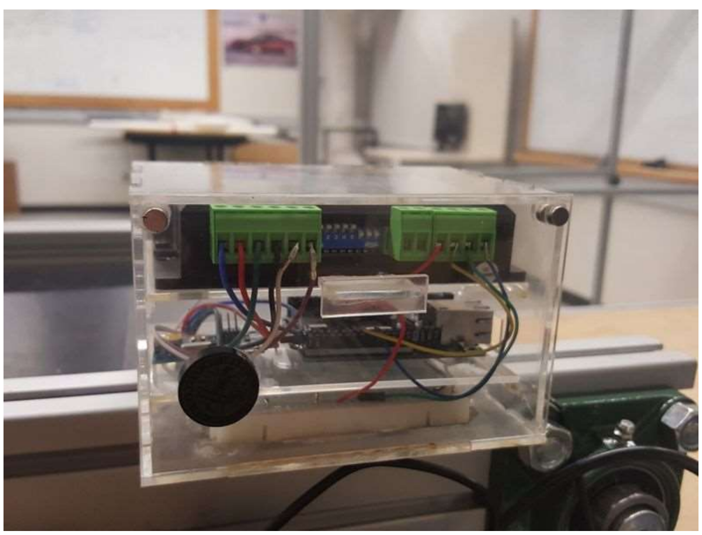
In total, the maximum mass allowed by the end of the robotic arm shall be 5 kg.

5.4 Mounting / Interface Requirements

Any electrical or pneumatic connections will be attached into the back of the robotic arm, seen in the figure at the left. If connecting to the tool slot in the arm, the connections above the black screw ring will be used, seen at the right. Any tool must be able to screw into the figure at the right to be able to attach to the arm, which has a square screw fit and 1.266 inch diagonal.



The stepper motor shall be mounted directly onto the conveyor, on the adjustable part, so as to maintain tension in the belt connected to the bearing.



The controller, Arduino, and wiring for the conveyor shall be placed into an acrylic box to avoid any wiring mishaps from the surrounding environment. This box shall be entirely closed, with a removable door in order to replace wiring if deemed a necessity.

5.5 Appearance Requirements

The final process should be smooth cooperation between the two robotic arms.

Assembly parts used in the process shall be free fit, with a +/- .05” tolerance difference. Fixtures shall have a +/- .05” tolerance for the 2” diameter part.

Each male and female part should be either black, gold, or silver to align with the University of Idaho colors, and the finished assemblies of each should all be the same color.

On the ramp, after removal of one part, the next shall queue into the same place as the previous part in order for Robot 1 to remove them from the ramp to the assembly zone.

5.6 Durability Requirements

The system shall be designed to continuously work, without any human interaction, until the process has ended. Each of the different colored parts should only be required to be assembled once, but for testing purposes, the O-Rings should be able to withstand the force of being put together several times.

5.7 Reliability Requirements

The robots must be programmed to avoid collisions with each other, as well as the surroundings. Due to limitations on the arm with University of Idaho serial number 196-549, the negative X-Axis must not exceed a length of 762 mm in order to not collide with the wall. After each arm completes a task, they will return to a pre-specified origin point to avoid collision with the other. If necessary, multiple emergency stop switches are in place to shut down the program: One on each controller, and one on the outside of the manufacturing cell.

The scanner should be able to read the barcodes of each part, as well as the barcode on the bottom of the end effector of Robot 2. With the female, due to the incapability of getting the exact position of the barcode correct, the barcode must be able to be read no matter the angle of orientation of the female part.

6 Electrical Requirements

6.1 Operational Voltage

The Denso robots will have an AC200-230V power limit. The voltage range of the stepper controller must be between 20-50VDC. For the Arduino, a range of 7-12VDC is required.

6.2 Operational Power Capability

Each axis has a different power limit.

Axis 1 – 750 W
Axis 2 – 400 W
Axis 3 – 200 W
Axis 4 – 100 W
Axis 5 – 80 W
Axis 6 – 50 W

6.3 Energy Storage Capacity

The storage capacity of the equipment shall be the sum of the power of the 6 axes working together. In total, this should be 1.58 kWh.

7 Software Requirements

7.1 Functionality

We will be using WINCAPS III, Solidworks, and Arduino.

7.2 User Interface

The robot will be controlled through WINCAPS III software via the controller. Using the specified controller for each robot, a unique code will program the robot after inputting through the unique IP Address of each robot.

For the Arduino, a laptop is required to monitor the serial output in order to determine whether the Arduino is connected via IP address to the scanner.

8 Environmental Requirements

8.1 Temperature

The robot is expected to be utilized from 0-40 ℃ and to be maintained under 90% RH. The stepper controller must be utilized in a temperature range of -10-45 ℃.

8.2 Environmental Sealing

The manufacturing cell must be surrounded by a wall, to promote the safety of the workers. An emergency stop switch will be located outside of the walls, to kill the program if required.

9 Regulatory Requirements

9.1 UL Requirements

ISO 10218-1:2006 - Standards for Robots, Robot system/cell and application
ISO TS 15066 – Technical Specification Standards on Robots
ANSI/RIA R15.06-2012 – American National Standard for Industrial Robots and Robot Systems
ISO 10218-1:2011 – Standards for Robots, Robot system/cell and application
ISO 10218-2:2011 – Standards for Robots, Robot system/cell and application

9.2 Shipping Requirements

Standard shipping for parts will be used unless absolutely necessary.

10 Cost Requirements

10.1 Prototype Cost

Cost to build a POC prototype shall not exceed $1000.

11 Schedule Requirements

The following are the major Project Milestones:

-	Approval of Requirements	June 25, 2018
-	Concept Design Review	July 26, 2018
-	EPO of long lead parts	Aug. 2, 2018
-	Detailed Design Review	Aug. 2, 2018
-	ER of drawing package	Oct. 2, 2018
-	Complete Prototype build	Nov. 30, 2018
-	Final Report / Drawings	Nov. 30, 2018