BTP2: Robotic Arm

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Objective

- Designing of Robotic Arm
- Manufacturing
- Testing of Robotic Skin being developed at IIT Jammu
- Automating the arm to perform various tasks - pick and place, sorting, scanning: Companies like NoMagic focusing on these tasks

Motivation

Robots are getting popular in a wide range of application ranging from manufacturing to medical surgery.

- Capable to handle tasks that might be repetitive or boring to human beings.
- Has more accuracy and stability in material handling.
- Capable to perform tasks that would be highly dangerous or complex for humans to conduct using conventional means.
- The arm will also work as a tool for training and educational purposes for students of IIT Jammu. Students will be able to easily modify the arm to perform tasks like material handling, welding, quality inspection, test their algorithms, and learn electronics.

Uses in industries

The robotic arm is used for multiple industrial applications, from welding, material handling, and thermal spraying, to painting and drilling.

These may include servicing nuclear power stations, welding and repairing pipelines on the ocean floor, remote servicing of utility power lines, or cleaning up radioactive and other hazardous wastes.

Major concepts used

Forward kinematics

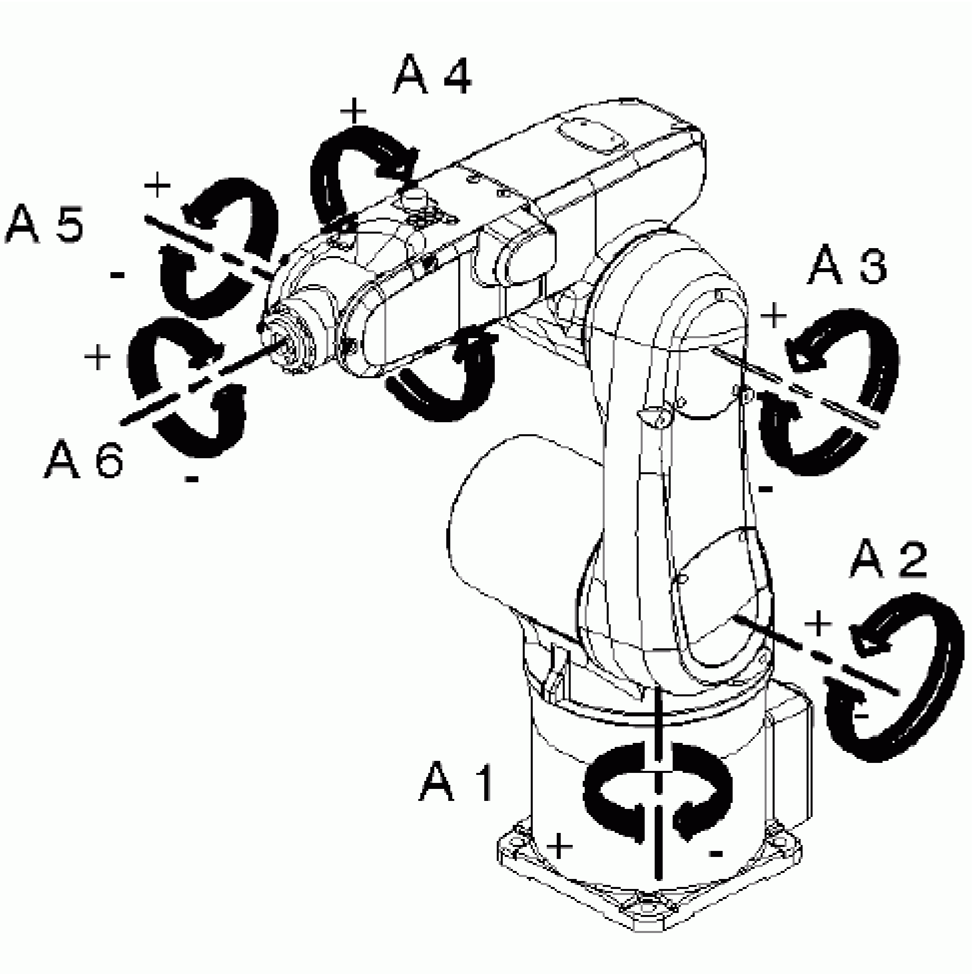
Inverse kinematics

Control theory

Computer vision

6 Degree of Freedom

- **Axis 1-** This axis, located at the robot base, allows the robot to rotate from left to right.
- **Axis 2-** This axis allows the lower arm of the robot to extend forward and backward.
- **Axis 3-** The axis extends the robot's vertical reach. It allows the upper arm to raise and lower.
- **Axis 4-** It rotates the upper arm in a circular motion moving parts between horizontal to vertical orientations.
- **Axis 5-** This axis allows the wrist of the robot arm to tilt up and down.
- **Axis 6-** This is the wrist of the robot arm. It is responsible for a twisting motion, allowing it to rotate freely in a circular motion.



Robotic Skin

- Flexibility and stretchability are the key criterions of the electronic skin.
- **Polydimethylsiloxane** (PDMS) is used as a skin material due to its mechanical robustness.

Design our robotic arm under some skin implementation constraints as it will be testing on our robotic arm under the guidance of Prof. Vijay Pal.

- Use to interconnect Joints.
- PDMS properties will be checked and based on the properties tested further method will be decided.
- Force sensor, can be infused in the skin for detecting desired force to pick different materials.
- Limitation is that skin will be planar. For complex shapes, moulds will have to be used which are hard to manufacture in this short interval of time.

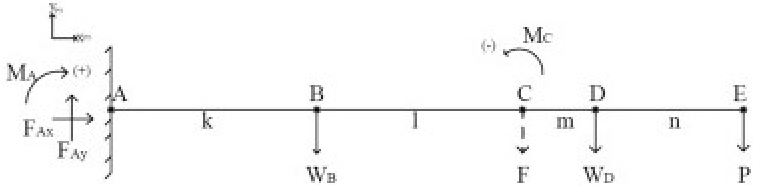
Manufacturing of the Arm

- Material chosen: Aluminium
- Reach: 60 cm
- Payload: 2 kg (90% amazon products are below 2 kg weight)
- Robot weight: Under 12 kgs

Kuka robot is the inspiration

Structural Design

1. Deciding of payload
2. Decided reach based on industry standards
3. Calculate the lengths of each link based on reach
4. Calculate torque at each joint



5. Design accordingly and check the stress at each joint. Induced stress should be below allowed stress by FOS 4 (say).
6. Choose electronics according to the torques calculated

Components needed

Structural components - These are the links that will make up the arm

Hardware components - These includes the bearings, belts, pulleys,screws, etc

Stepper Motors and Drivers - the motors, drivers and power supplies

Electrical components

Functions that can be performed

1. Forward kinematics: Move to a position with given angle parameters
2. Inverse kinematics: Find angles for the given end effector position. This will be used majorly for all below functions.
3. Position saving: Gazebo can give us angles that we can save and reuse. Will not have to perform the maths again and again.
4. Sorting: Will be able to sort say defected products from undefeated products
5. Pick and place: Pick the item from the shelf, bring it in front of the camera to scan it, and then put it on the conveyor belt
6. Stack/ move /align/ adjustment of bottles/ boxes/ bagged materials, etc
7. Other tasks involving touch (thus force) like cleaning window using force-position control law hybrid

Specifications of the Arm

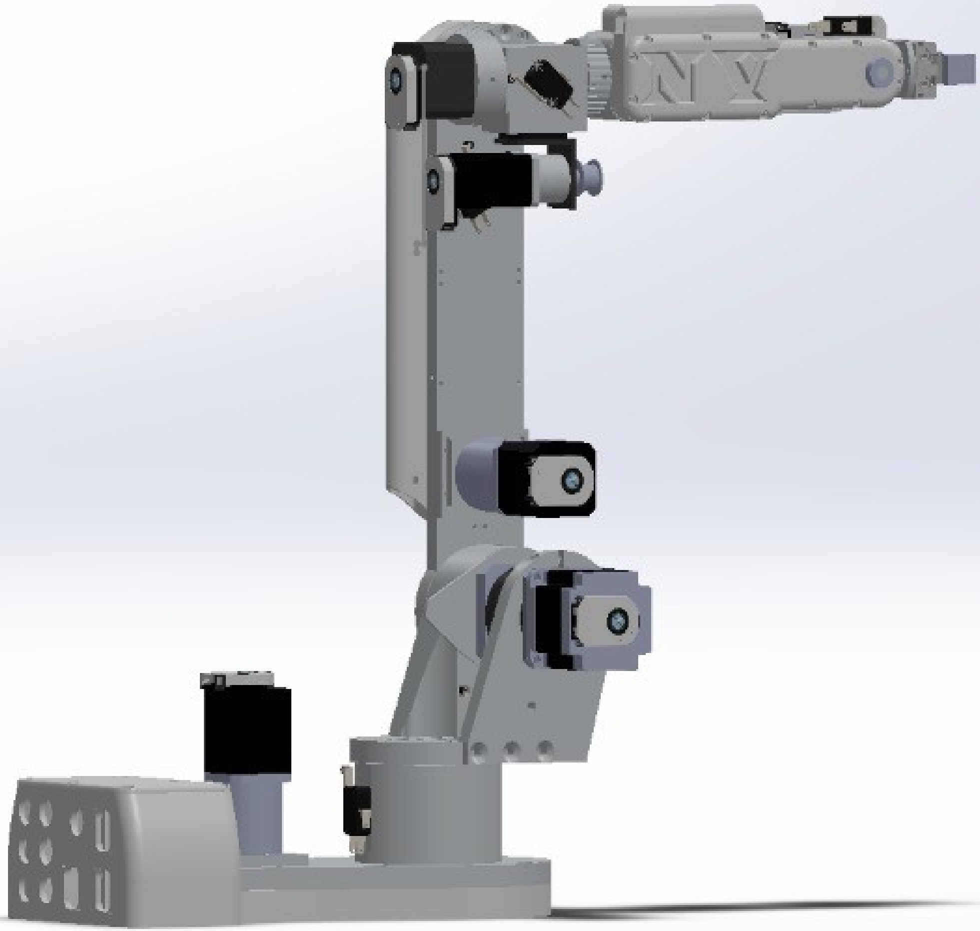
Reach – 24.75 inches (62.9cm)

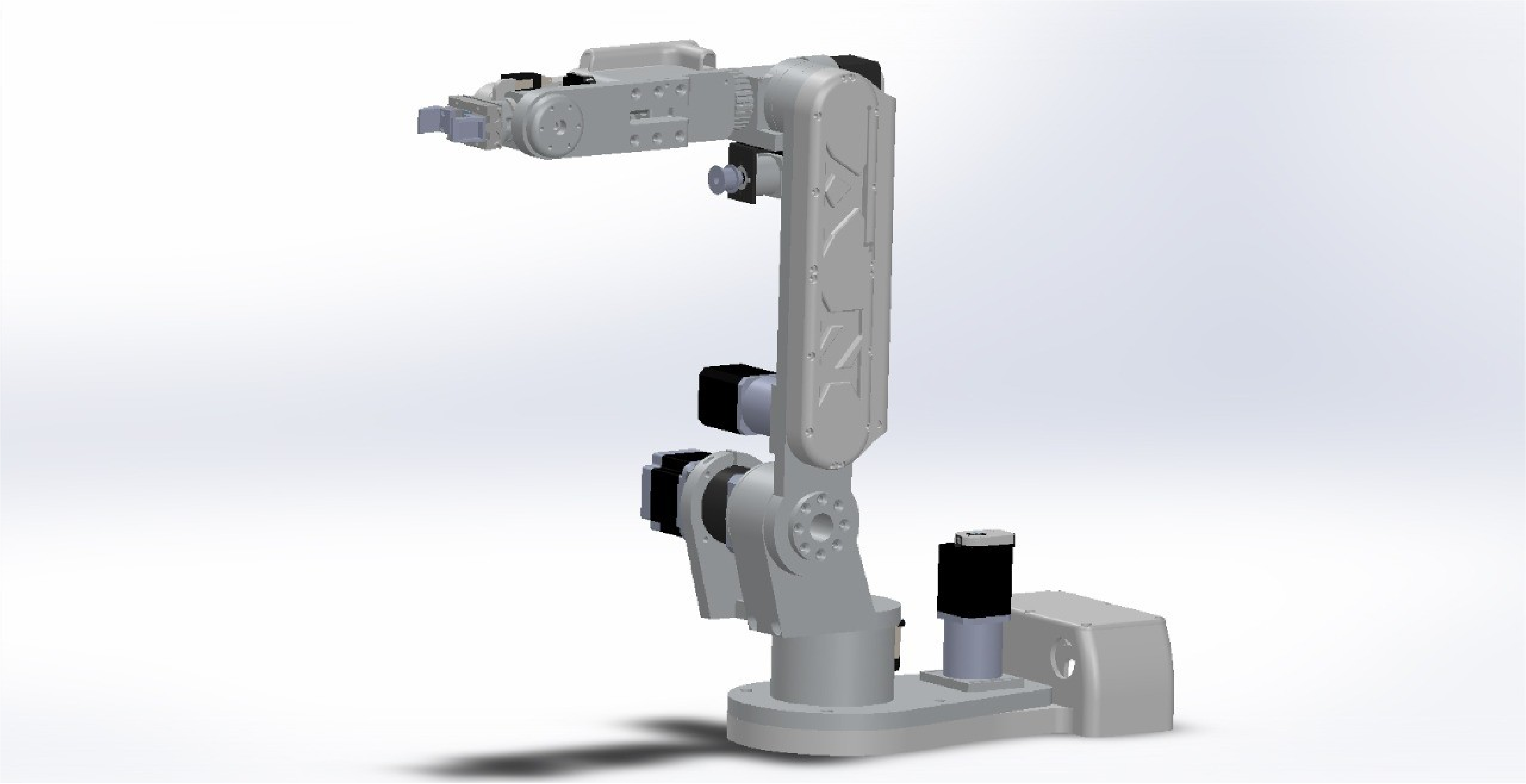
Payload – 4.15 lbs (1.9kg)

Robot weight (aluminum) – 27lbs (12.25kg)

Enclosure weight – 12.5lbs (5.6kg)

Max Power Consumption – 8.25amp (198 watts)



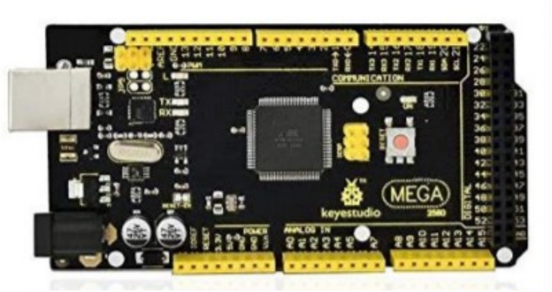


Hardware

Main Hardware Components used in this project are

- Motors and Drivers
- Controllers

Controllers: The Arduino Mega 2560 and Teensy 3.5 are the controllers used for this project due to their low cost and both can accept 5vdc inputs and outputs.

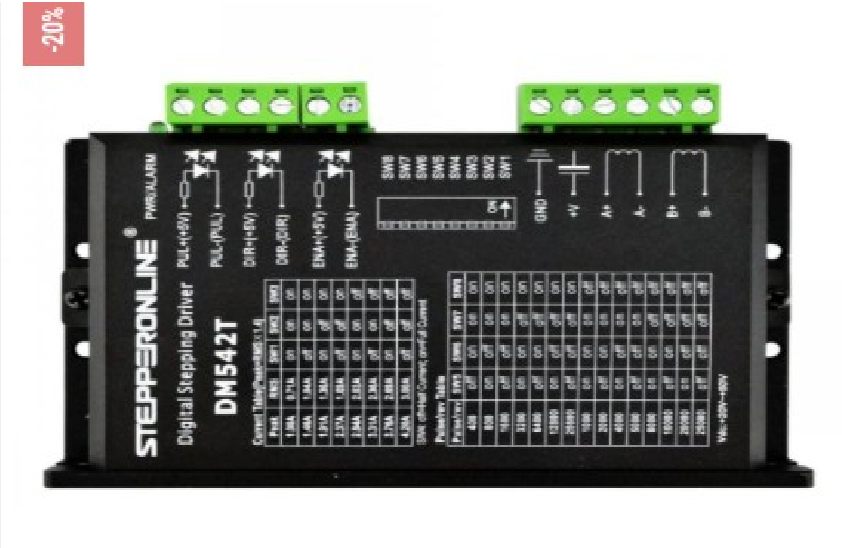


Motors and Drivers: In total 6 Stepper motors are used in the building of this project. And with each motor a stepper driver is Attached.

Specifications of Motor used

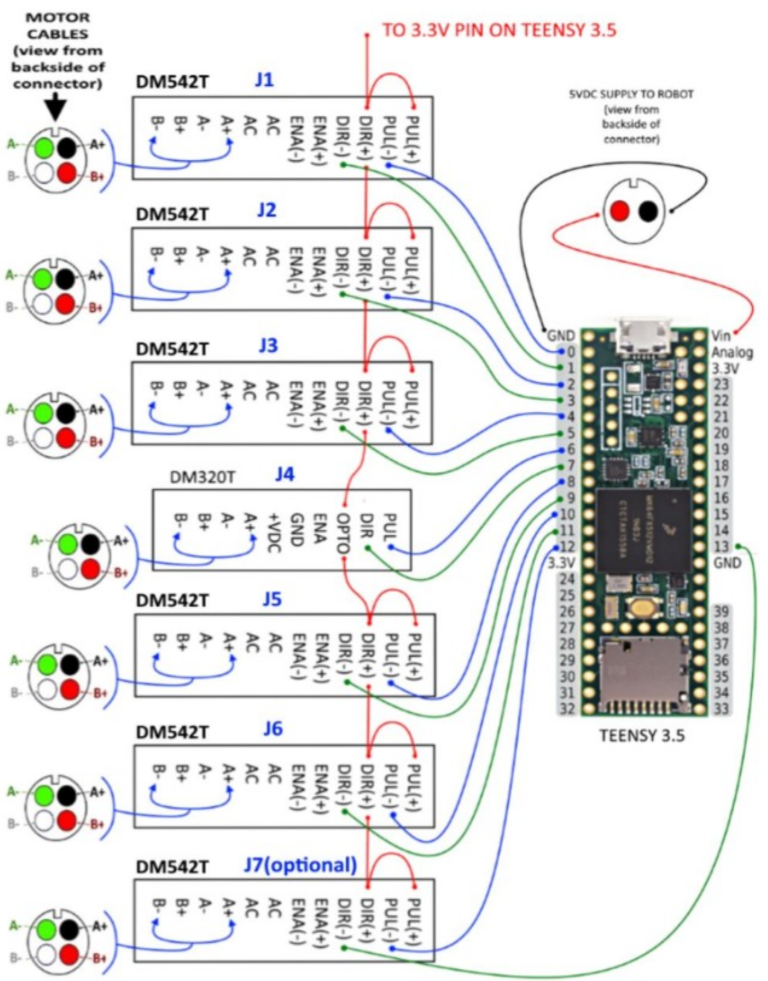
Components	Gear Ratio	Torque N/cm
Nema 17 Dual Shaft Stepper Motor L=39mm, 9.5mm Rear Shaft Length	10:1	150
Nema 23 Dual Shaft Stepper Motor L=56mm , 9.5mm Rear Shaft Length	50:1	250
Nema 17 Dual Shaft Stepper Motor L=39mm , 9.5mm Rear Shaft Length	50:1	150
Nema 11 Dual Shaft Stepper Motor L=51mm , 9.5mm Rear Shaft Length	14:1	30
Nema 17 External 48mm Stack, Length 200mm	14:1	44
Nema 14 Dual Shaft Stepper Motor Bipolar L=28mm ,9.5mm Rear Shaft Length	19:1	30

A **Motor Driver** is the driver circuit that enables the stepper motor to function the way it does. DM542T and DM320T are the digital stepper drivers used.



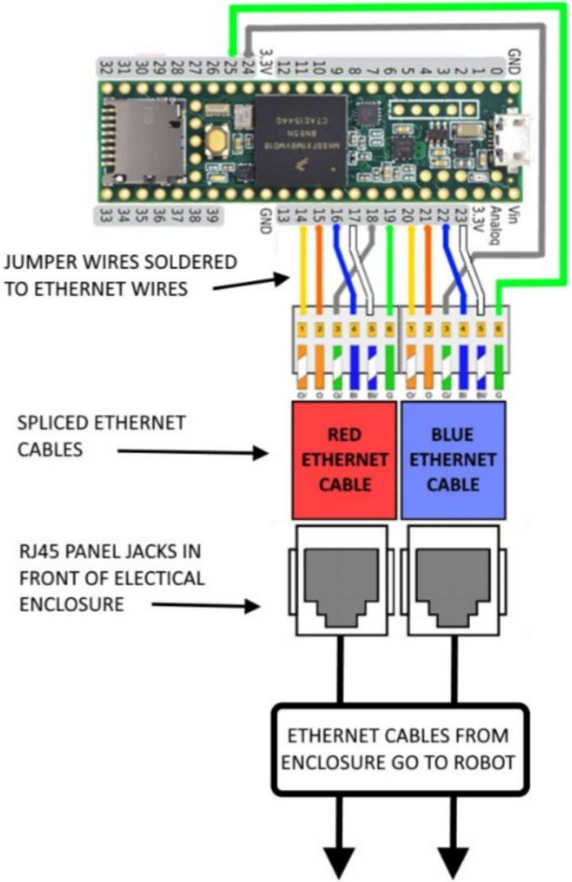
Circuit Diagrams:

Wiring for Drivers and Teensy 3.5



Wiring for Encoders

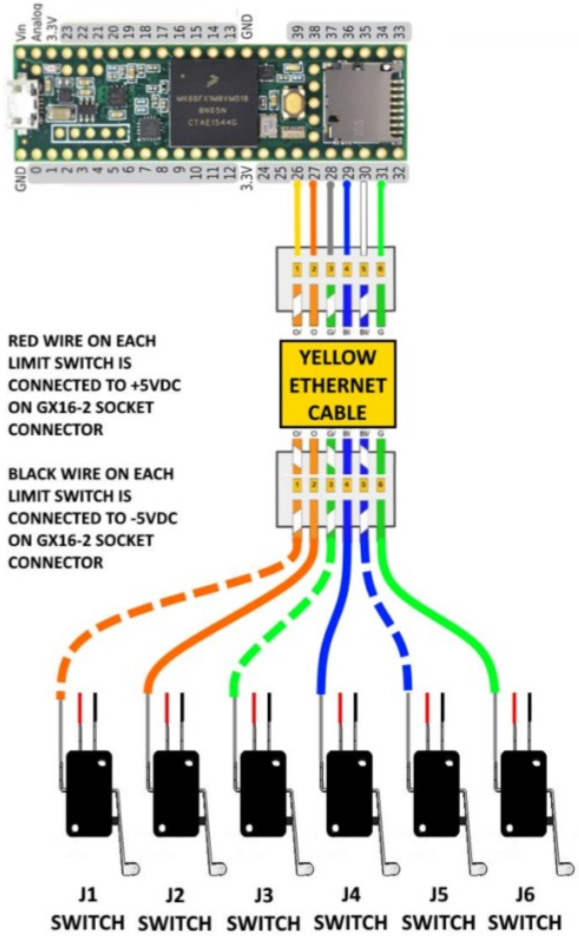
Encoders: An encoder is a sensor that detects rotation angle or linear displacement. Encoders are used in devices that need to operate in high speed and with high accuracy.



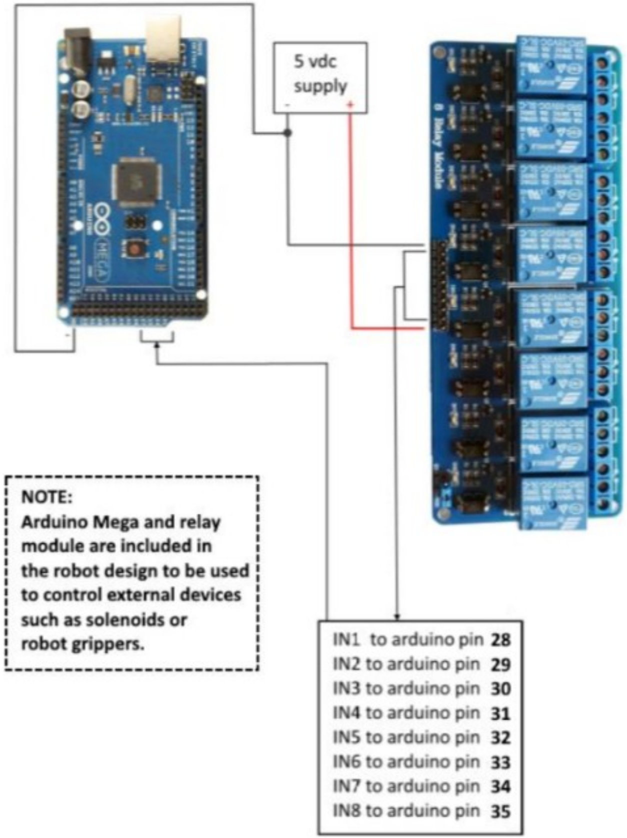
Wiring for limit Switches

Limit Switches : Limit switch is a electromechanical device which operates by the motion of a machine part or presence of an object.

Limit Switches are used to detect the presence of objects, thus allowing the system to take desired action.



Wiring for Controller Arduino Mega 2560



Final Picture of 6 DoF Robotic Arm

References

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Nellis, Michael David. *Integrating a Low-Cost Stereoscopic Vision System Into a Six Degree of Freedom Robotic Arm for Engineering Education*. Diss. University of Dayton, 2020

W. G. Hao, Y. Y. Leck and L. C. Hun, "6-DOF PC-Based Robotic Arm (PC-ROBOARM) with efficient trajectory planning and speed control," *2011 4th International Conference on Mechatronics (ICOM)*, Kuala Lumpur, Malaysia, 2011, pp. 1-7, doi: 10.1109/ICOM.2011.5937171.

Kinova Robotics -- compare with other specifications

Sivasankaran, P., and R. Karthikeyan. "Simulation of Robot Kinematic Motions using Collision Mapping Planner using Robo Dk Solver.", 2020 -- check if needed

Lin Li, Azadeh Haghighi, Yiran Yang, *A novel 6-axis hybrid additive-subtractive manufacturing process: Design and case studies*, Journal of Manufacturing Processes, Volume 33, 2018, Pages 150-160 -- looks alright

https://etd.ohiolink.edu/apexprod/rws_etd/send_file/send?accession=dayton1589283741252993&disposition=inline