# Design of Real-Time Cobot Planetary Gear System Interfacing with Stepper Motor

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**Abstract:** ***Now a days the rise of collaborative robots have became emerging technology across the globe. In this project , we have used additive manufacturing where we take 3D CAD files which are planetary gears, sun gears , base gear and we have connected Nema-17 Stepper motor along with A4988 stepper motor driver to control the position of the robot . This robot arm is (roughly) modeled after the UR3 industrial robot at a scale of 80 percent and it is attached between thorax and upper shoulder. It follows the same design principle of putting a motor/reducer actuator unit at each joint and stacking two actuators to produce a 4-axis arm. While the UR3's actuators are hollow torque motors with harmonic drives, this robot uses stepper motors with compound planetary actuators.***

**Keywords:** Arduino UNO, Nema-17 Stepper Motor, A4988 stepper driver, Additive manufacturing, Sun gear, planetary gear

## 1. Introduction

The human arm is one of the most advanced biological limbs known in wildlife, capable of performing a wide range of complex sensory-motor tasks, including payload lifting and carrying, precise manipulation, symbolic gesticulation with fine sensitivity and tactile perception, pressure feeling, texture, temperature, moisture, fluid stream sensing, and so on. By virtue of its own naturally adjusted structure of the musculoskeletal system, sensitive perceptive system, and fast and reactive nervous system whose peripheral terminations reach up every segment of the limb, a human arm with hand has exceptional dexterity and physical capabilities (weight bearing, impact, pulsation, and so on). The arm allows humans to perform the most difficult and delicate manipulating operations, which necessitate not only high speed and precision, but also natural resilience and longevity of operation even when loaded.

The Arduino UNO is used to control the speed. A stepper motor is a brushless motor that rotates in a controlled manner. Stepper Motor Control with Arduino is a straightforward project that uses a unipolar Stepper Motor with discrete steps. We can achieve exact location and speed that translates electrical pulses into distinct mechanical movements, such as the shaft of a stepper motor, because these steps are controlled by Arduino.

Because of its controllability, electric drive systems in many industrial applications require improved performance, reliability, and variable speed. In applications requiring precision and protection, the speed control of a steeper motor is critical. A motor speed controller's job is to take a signal that represents the required speed and operate a motor at that speed. A steeper motor can be easily controlled using a microcontroller.

A stepper motor is a type of DC motor that runs in discrete steps and can be found in everything from security cameras to advanced robotics and machinery. Stepper motors provide precise control and are classified according to torque, steps per revolution, and input voltage. We used Arduino to operate a 28-BYJ48 stepper motor in a prior project. The torque of the 28-BYJ48 is lower than that of NEMA 14, NEMA 17, and other stepper motors. The largest actuator (for arm base joints) is about 3.4" in diameter and uses 20 pitch helical gears. It is designed for use with higher torque NEMA 17 stepper motors.

## 2. Literature Review

The design of an automated PCB drilling machine is shown in this project. The low-cost automatic PCB drilling machine is designed to save money, time, and effort while increasing accuracy and productivity. The goal of this project is to design and build a low-cost PCB drilling machine that uses an Arduino controller to automatically recognise drill holes in a PCB layout. The most difficult process is determining the drill hole coordinates from the PCB layout. This system makes use of G code software. This job entails operating a CNC machine. Gcode is a machine language that is widely used.

[10] In this project, Jeff Kerr shows us how to make a six-axis robot arm that supports multi-axis coordinated motion. The arm is a scaled version of the industrial UR3 robot and includes several complex components.[11`] This study describes the design and implementation of a low-cost, user-friendly interface for controlling a slave tele-operated

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anthropomorphic robotic arm with six degrees of freedom. Six single-axis revolute joints are used to articulate the robotic arm: one for each shoulder abduction-adduction (abd-add), shoulder flexion-extension (flx-ext), elbow flexion- extension (flx-ext), wristflx-ext, wrist radial-ulnar (rad-uln), and gripper openclose. The master Tele-operator uses the Man Machine Interface (MMI) to control the robotic arm in real time. Simple motion capture devices in the MMI convert motion into analogue voltages, which are translated into actuation signals in the robotic arm.[12] An imaging Stokes polarimeter placed on a six-axis robot arm is described in this study, with the capacity to detect characteristics and structural variations in a sample under test at various incidence-reflection angles. More characteristics of a sample's reflected light may be retrieved utilizing Stokes polarisation sensing devices than with standard image analysis.[13] In this study, a multi-sensor glove controller is created for industrial operations to control a mobile robot and a 6-axis robot arm. The mobile robot arm is directed by a glove controller wirelessly to conduct many human jobs in order to apply safe working standards. The user may watch the scene in front of the mobile robot arm, as well as record the trajectory and position coordinate, thanks to the integration of the 6-axis robot arm, a mobile automobile, and the StarGazer indoor positioning system. This allows employees to do the activity without having to enter potentially hazardous workplaces.[14] The Kinematics approach may be used to operate the six-axis robot arm. In order to ensure continuity, a fifth-order polynomials approach is employed to restrict accelerations and velocity on each joint. Three points-arc interpolation can be used to create an arc route for the robotic arm. As a result, glueing path planning trajectories will be successfully constructed. In addition, following the laser engraving, vision equipment are employed to examine the work parts. The storage system also allows for the storage of unassembled and completed work pieces. Finally, all equipment will be fully integrated to create a bespoke multifunction glueing and assembly line using self-developed robotic arms. Automated Keywords[15] The motion trajectory in the motion space is analysed by static and dynamic forward and inverse mechanics in this paper, based on the motion model of the multi-link manipulator arm in space coordinates, in order to design and optimise the parallel traction control of the industrial robot six-axis manipulator. This technology can be used in robot applications involving mechanical joints with several degrees of freedom. The adaptive position/force controller described in this study is solved and assessed under static and dynamic operation circumstances using a system simulation model and a Matlab application. The linkage six-axis mechanical arm motion model has outstanding operation stability, test accuracy, and error range are maintained at a satisfactory level, which increases the space for the wide application of robots after numerous iterative testing.[16] A six-axis robot that can be controlled by gestures is built in this research. The robot has six degrees of freedom and is simple to manage because it does not need a lot of effort. A transceiver and flex sensors are incorporated into a human hand glove, and the flex sensor's resistance variation is sent to the robot axis. The robot may spin angularly or linearly around its axis depending on the variance. To regulate the signals delivered and received between the robotic arm and the human hand, a basic transceiver is employed. The system is controlled using Arduino programming.[17] A case study of the creation of a 6-axis robotic arm controller is presented in this work. A hydraulic pump provides power to the robot. The potentiometer voltage may be used to calculate the location of each axis. A servo-valve is used to regulate a servo motor on each of the axes. The servo-valve input affects its relative velocity. A microcontroller directs all axis motions using a 2nd order PID controller. The PID inputs are six potentiometer voltages, and the outputs are six DC voltages that control six servo-valves. The inverse kinematics problem is solved with certain (angular to digital value) transformations to produce a trajectory file. Closed form computation is used to tackle kinematics problems in this scenario. It only produces when specific constraints are met.[18] The AT90CAN128, made by the ATMEL Company, was used to operate the six-axis robotic arm. The robot's joints were driven by a DGServo servomotor, which included four 12 kg servomotors, two 1.8 kg servomotors with reduction gear, and various precision aluminium alloy components. The robotic arm, which was powered by servomotors, was capable of grabbing, pinching, catching, and releasing objects. The D–H method derivation findings were compared to the real control results of the robotic arm, and the source of mistake was explored.

## 3. Hardware Components

### Arduino Uno

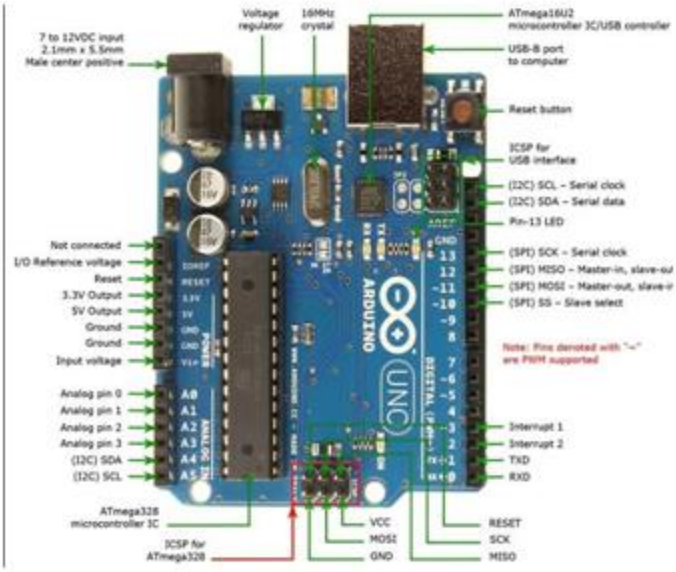


**Figure 1:** Serial pin ports in Arduino UNO R3

The Arduino Uno board serves as the system's controller. This is utilised to govern the entire system's process. The Arduino Uno is a board with 14 digital pins and six analogue pins. Arduino programming is straightforward and inexpensive, thus this controller is a good choice.

### Nema-17 Stepper Motor:

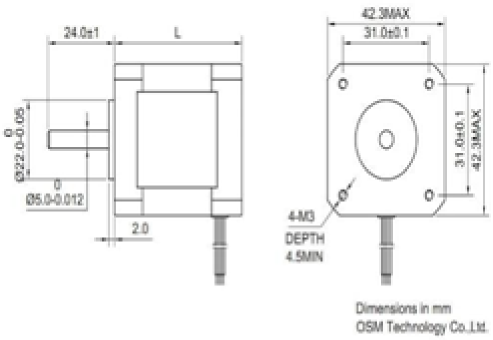


**Figure 2:** Circuit diagram of nema-17 stepper motor

**Figure 3** Stepper motor

A bipolar stepper motor is what this is. Mechanical energy is created by converting electrical energy. Stepper motors with a 12V power source are the most powerful and efficient. This stepper motor is used to control the signal sequence and rotate the stepper motor in a step-by-step manner. This stepper motor is inexpensive and widely accessible. In comparison to other motors, stepper motors have a higher load carrying capacity.

**A4988 stepper motor driver:**

The A4988 driver is built on an Allegro MicroSystems chip called the A4988 DMOS Microstepping Driver with Translator and Over current Protection. This integrated motor driver makes communicating with a microcontroller a breeze because it only requires two pins to control the stepper motor's speed and direction. The driver's maximum output capacity is 35 V and 2 A, making it ideal for controlling small to medium-sized bipolar stepper motors like the NEMA 17 bipolar stepper motor. Over current, short circuit, under-voltage lockout, and over-temperature protection are among the safety features integrated into the A4988 driver chip.

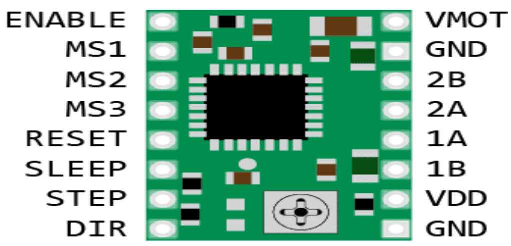


**Figure 4:** A4988 Stepper motordriver

**Table 1:** Full-step, haft-step, quarter-step, eight-step, and sixteenth-step resolutions are available in the Driver

| MS1 | MS2 | MS3 | Microstep resolution |
|---|---|---|---|
| Low | Low | Low | Full step |
| High | Low | Low | 1/2 step |
| Low | High | Low | 1/4 step |
| High | High | Low | 1/8 step |
| High | High | High | 1/16 step |

It also contains a potentiometer for changing the current output, as well as thermal shutdown for overheating and current crossover protection. The driver's pinout and how to connect it to the stepper motor and controller. So we'll start with the two pins on the right side of the button for powering the driver, the VDD and Ground pins, which we'll need to connect to a 3 to 5.5 V power source, which in our case will be our controller, the Arduino Board, which will deliver 5 V. The motor is connected to the next four pins. The 1A and 1B pins will be linked to one of the motor's coils, while the 2A and 2B pins will be connected to the other.

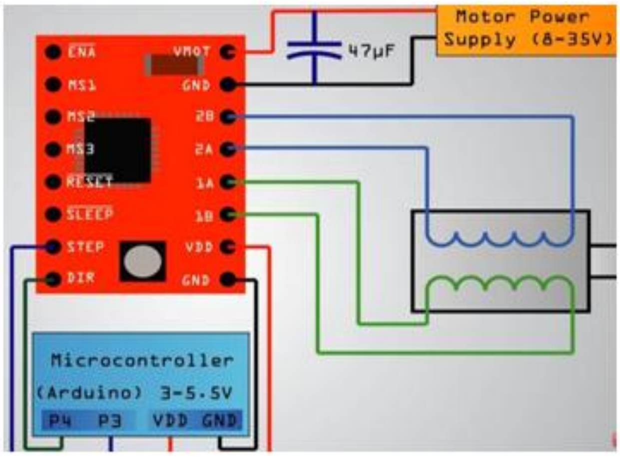


**Figure 5:** Circuit diagram of A4988 stepper motor driver

All three inputs have internal 100 kΩ pull-down resistors, so leaving the three microstep selection pins disconnected results in full-step mode.

**Additive Manufacturing**:

Additive manufacturing refers to industrial-scale 3D printing, as well as more sophisticated processes like Selective Laser Sintering (SLS). SLS is the method of laser sintering powdered material at spots in space determined by computer using a 3D design (creating a solid mass of material by heat before the point of liquefaction). This results in a more professional-looking completed product with fewer visible construction layers. AM produces outputs on a bigger scale, with more accuracy, and with a wider range of materials than FDM, but it is also significantly more expensive. SLS, like FDM, may be used for quick prototyping, but at a later stage in the development process when greater precision and quality are required.

## 4. Methodologies

A component that turns energy into motion is known as an actuator. It functions similarly to a sensor in that it accepts electrical impulses as input and outputs movement in the physical environment. Electric valves, clamps, and motors are examples.

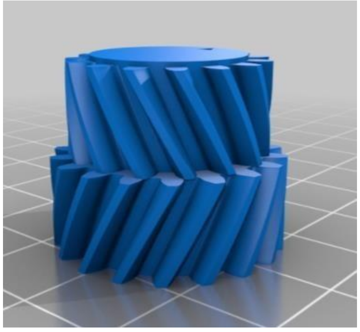

**Figure 6:** Planetary gear 20

We have a unique take on printing gears. We successfully printed the planetary gears — using AmazonBasics PLA — without the need for sanding. He used a Creality Ender 3, and his settings were as follows:

- Resolution: 0.2 mm
- Rafts: Yes
- Nozzle temperature: 200 °C
- Bed temperature: 65 °C
- Length:25.17mm
- Width:25.17mm
- Height:22.15mm

Three planetary gearboxes, each with a 38.4:1 compound planetary gearing ratio, serve as actuators for this project. The centres of one or more gears (the "planets") revolve around the centre of another gear (the "sun") in a planetary gear system. The ratio also refers to the tooth difference between the connecting gears. This sun gear is placed middle of the basic gear where we insert the rotatory shaft of the Nema-17 Stepper Motor.

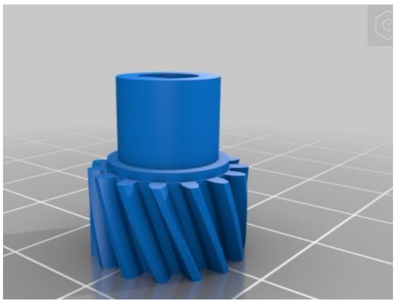

**Figure 7:** Sun Gear

- Height: :15.5mm
- Diameter: 73.83mm
- Length:73.83mm

The three actuators are powered by NEMA 17 stepper motors and are different sizes depending on the joints they control.

**Figure 8:** Final 3D printed part along with balls with 5mm

A conformal robot gripper is supposed to be installed on the robot arm. Jeff includes all important information, just like he did with the actuators (requirements, printing, and assembly).

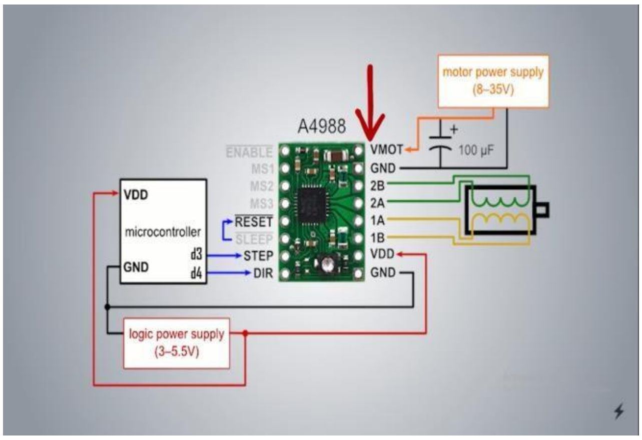


**Figure 9:** Circuit diagram of Arduino UNO CNC shield with Nema -17 Stepper motor:

From the above fig it describes about A4988 stepper driver interfacing with Microcontroller in order to control stepper motor.

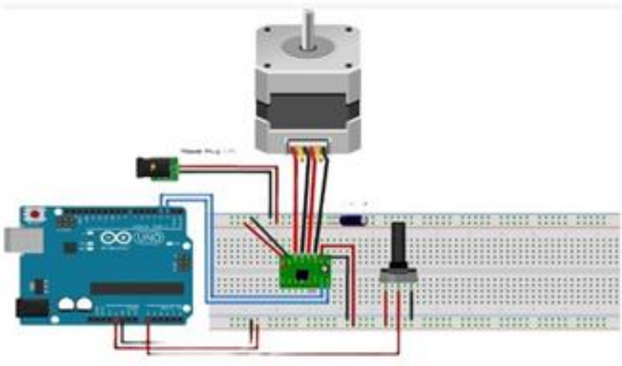

**Figure 10:** Circuit diagram of Controlling of Stepper motor

The arm's structural sections should be able to print without assistance.

- Resolution: 0.2 mm
- Infill: 25%
- Rafts: No
- Supports: No

In the loop portion, we'll first set the Direction pin to high, allowing the motor to drive in a certain direction. Using this as a loop, we'll get the motor to complete one full cycle spin. We need to send 200 pulses into the Step Pin to create one full cycle rotation because the driver is set to Full Step Mode and our Stepper Motor has a 1.8 degree step angle, or 200 steps. As a result, the for loop will run 200 times, with each iteration setting the Step pin to high and then low in order to generate pulses. We need to add a delay between each digitalWrite, from which the motor's speed will be determined.

After this entire cycle rotation, we'll wait one second, then change the direction of rotation by changing the dirPin to a low state, and repeat the loop for another 400 iterations. There is one additional second delay at the conclusion. Now it's time to post the code and see how it performs.

## 5. Conclusion

In conclusion we have controlled Nema-17 Stepper motor interfacing with CNC shield of AA4988 with Arduino UNO and it does have two degrees of freedom and got fitted between thorax and elbow.

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