RME 40002: Mechatronics Systems Design

Project Progress Report (PPR)

Project Title: Design and Development of Automated Goods Picking Machine

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Group: Group 5

1. Introduction

1.1 Tasks and Responsibilities

In this group project, as a person who is in charge of Electronics part, the main tasks and responsibilities are designing of electronic circuits using Fritzing, connecting electronic components to Arduino using connectors and soldering components into prototyping shield and Vero board.

1.2 Design Problems and Design Specifications

In this project, several design problems are noticed since the beginning. Firstly, choosing the type of power supply being connected to the Arduino input is one of the considerations as different power supply of different current ratings affect the cost of the project. Hence, the total estimated current being drawn from the circuit must be approximated and calculated based on the electronic components being used. For example, a 12V 10A power supply and a 12V 20A power supply have differences in not just the cost, but also the types of applications used. Secondly, safety factor is one of the most important considerations as the entire system is moving, hence it needs sensors to detect human motion nearby. Choosing the distance measuring sensors also considered as one of the design problems and constraint due to different accuracy and range of distance detected of the sensor.

In terms of design specifications, electric motors consisting of DC motor, stepper motors and servo motors serve as the main components in the mechanism of the system. DC motor moves the entire system from one place to another to grab different items from different columns in z direction. The 2 stepper motors move the robot arm gripper in both x and y directions for items grabbing in different rows. For the 2 servo motors, one of them is attached on the robot arm joint to allow swinging of the arm to grab the items and place it in the trolley, another servo motor is used to open and close the gripper arm. For these motors, since they can't be directly driven by the GPIO pins of Arduino, hence drivers or external power supply are required to use in order to prevent the Arduino SBC from being damaged from excessive sink current. This is due to the fact that the maximum sink current for each GPIO pins of Arduino is only 20 mA, whereby the current drawn from each motor is far greater than the maximum threshold value.

For the sensors, 2 IR sensors are used to detect the home position of the system and rack position, and a proximity sensor is used to measure the distance between the gripper and the items inside the rack for gripper opening purpose. 2 homing switches are installed on the structure in order to allow the gripper mechanism to move and stop at the home position whenever a 'click' sound is heard when the mechanism moves. Also, 2 ultrasonic sensors are placed at the front and back of the system to detect human motion. An emergency stop switch is to be implemented to stop the mechanism when an unforeseen accident occurs.

1.3 Tasks Completed, Currently Working on, and Tasks which are left/not started

Tasks Completed	✓ Block Diagram Finalisation. ✓ Circuit Diagram and Circuit schematic drawing using Fritzing. ✓ Planning and drawing of the Connector Routing Diagram ✓ Calculation of the estimated current being drawn for the entire mechatronics system. ✓ Finalisation of the electronic components to be used in this project.
Tasks which are currently in progress	➢ Choosing the type of connectors(R/A or S) for each components due to its soldered position. ➢ Tidying up of the Connector Route Diagram, in order to plan the best and most suitable routing for easy troubleshooting purpose.
Tasks which are left/not started yet	• Building and Assembling of the circuits for the entire system. • Estimation of the length of cable used for each components connecting it to the connector. • Soldering of the electronic components and connector headers. • Carry out testing and troubleshooting of the electronic components.

Table 1: Summary of the Tasks completed, in progress, and still left to carry out

2. Design

2.1 Electronic Components used(Motors, Sensors, and other components)

Components	Input/Output	Functions
Proximity Sensor	Analogue Input	Detects the distance from the gripper to the item placed on the shelf.
5V Voltage Regulator	N/A	Regulates 12 V input to 5V for some components such as sensors and servo motor
IR Sensors (x2)	Analogue Inputs	Detects rack position and home position of the system.
Bluetooth Module	Serial Pin - Pin 0 and 1 (TX and RX)	Allows customers to purchase items using an app.
Ultrasonic Sensors	PWM and Digital Pin	Detects human motion to ensure safety.
Emergency Stop Switch	Digital Input	To stop the machine in case of an emergency.
Homing Switch (x2)	Digital Inputs	To allow the stepper motor to return to its home position.
DC Motor Driver (L293D)	PWM and Digital Output	Drives and isolate the motor from the SBC which has a higher current drawn which may damage the SBC.
Stepper Motor Drivers (A4988)	Digital Outputs	Drives and isolate the stepper motor from directly connected to Arduino.
Servo Motors (x2)	PWM Output	1st servo motor used to control the gripper arm elbow joint movement, 2nd servo motor used to open/close the gripper for item grabbing
Stepper Motors (x2)	Output from A4988 Driver	Used to move the gripper mechanism in X and Y direction.
DC motor (x1)	Output from L293D	Used to move the entire machine to different shelf locations in Z direction.

Table 2: List of Components to be used for the project

2.2 Block Diagram

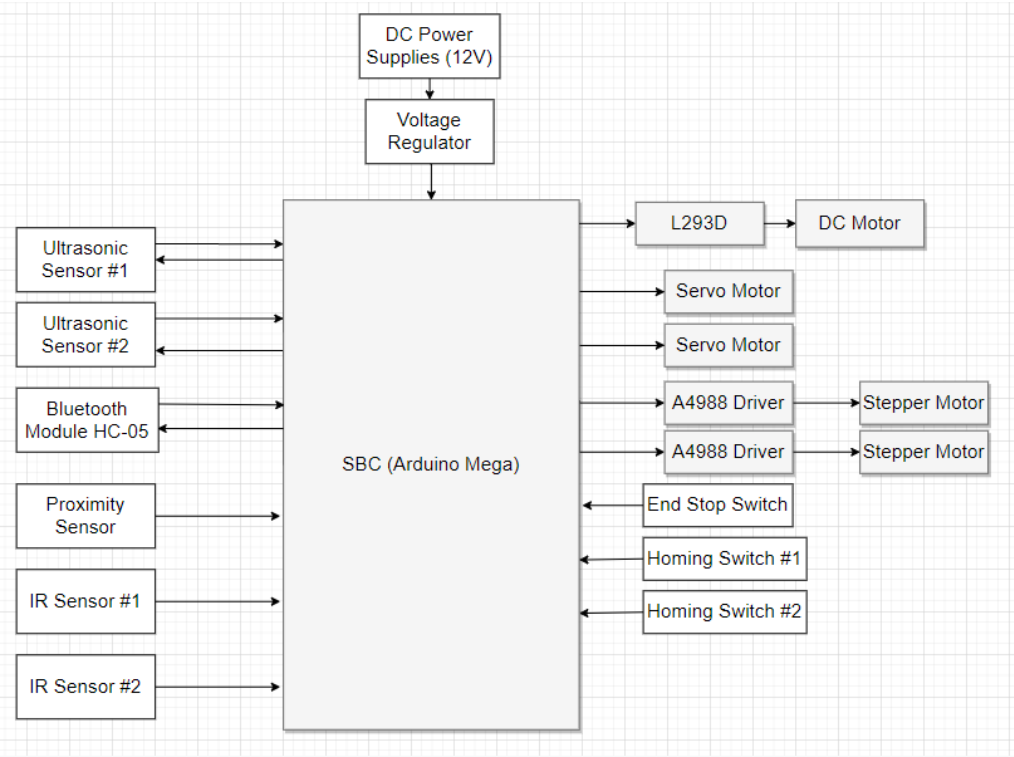

Figure 1: Block Diagram of the System

2.2 Calculation of the Estimated Current Drawn from the Project

For the current drawn from the circuit, DC motor, stepper and servo motors draw the most current compared to other components and sensors in which the current drawn by them are within 20 mA.

Types of Motors	**Stall Current (A)**	**Operating Voltage (V)**	**Typical Current (A)**	**Quantity**	**Total Current (A)**
DC Motors	2.1	12	1.8	1	1.8
Stepper Motors	1.8	12	1.7	2	3.4
Servo TD-8120 MG	2.1 (for 4.8 V operation)	4.8 to 7.6	1.5	1	1.5
Servo MG-996R	2.5 (for 6V operation)	4.8 to 7.2	1.8	1	1.8

Table 3: Estimated Current Drawn from each motors under normal condition.

From the table, the total current drawn is 1.8 + 3.0 + 1.5 + 1.8 = 8.1 A, which is less than the 10 A current rating of the 12V power supply. And for their respective operating voltages, DC motors and Servo motors require 12 V to operate, and stepper motor requires only 5 V to do so. It is assumed that not all motors operate at the same time the machine is starting. For example, when the DC motor is rotating, the servo motor and stepper motors are in idle mode(no current is drawn). And when the stepper motors and servo motors are rotating, DC motor will not be operating. Hence, the total current drawn for each machine activity will be less than 8.1 A(excluding current drawn from other components and sensors). Hence, a 12V 10A power supply is sufficient to be used for this project.

3. Preliminary Result

3.1 Circuit Diagram using Fritzing

Diagram below shows the circuit diagram being drawn using Fritzing:

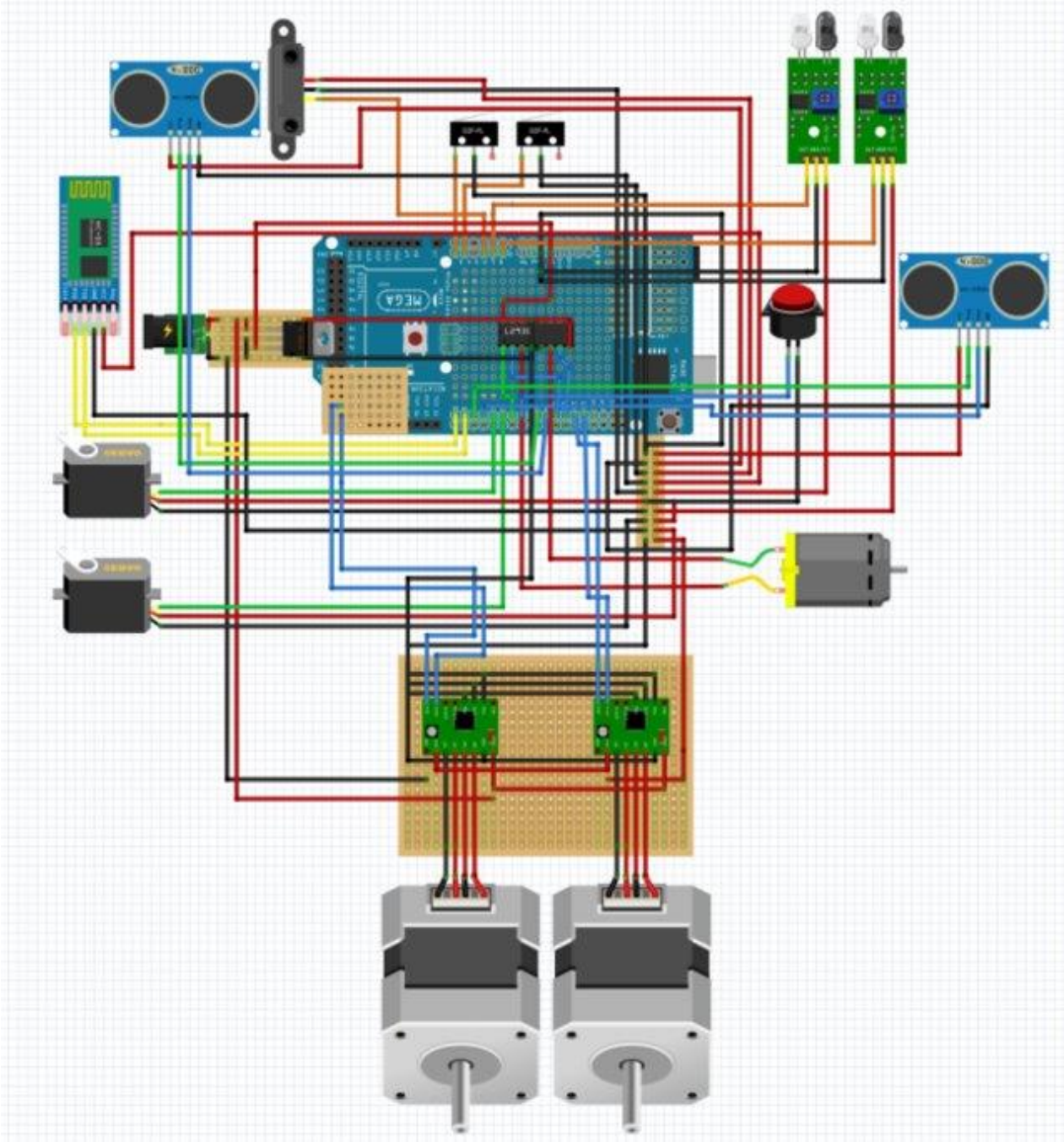

Figure 2: Circuit Diagram Illustration using Fritzing

From the circuit diagram, an Arduino prototyping shield will be used for the connection of the electronic components using the connectors. A few pieces of vero/stripped board will be used for connection such as A4988 driver, voltage regulator and additional 2 pins for the STEP and DIR pins for the second stepper motor. For the stepper motor driver, logic ‘0’ will be fed into the MS1, MS2, and MS3 pin for full step mode.

3.2 Schematic Diagram of the System

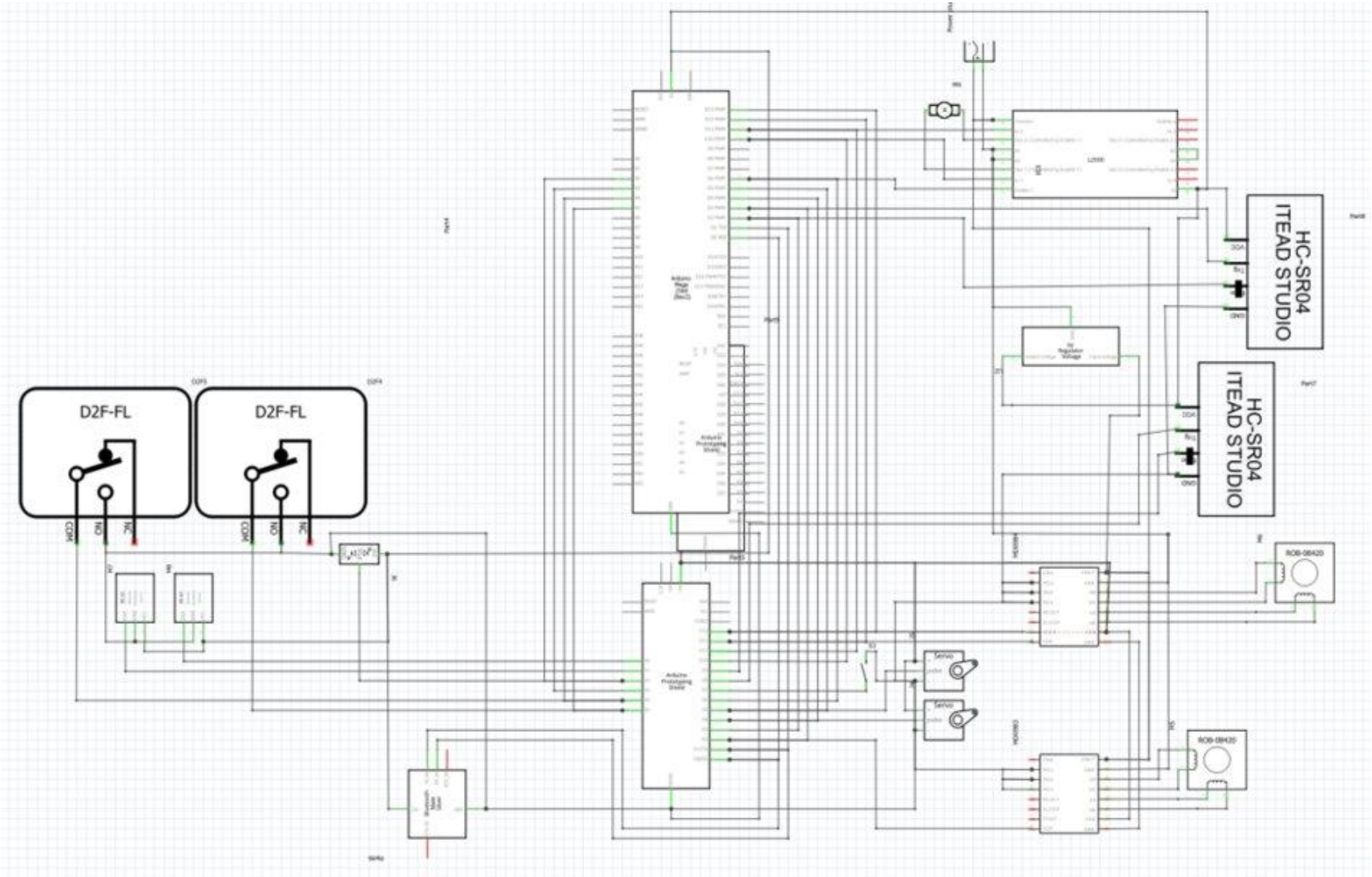

Figure 3: Schematic Diagram of the Circuit to be used

3.3 Connector Routing Diagram and Types of Connectors Used for different Components

For the type of connectors, 2 different types are used due to different current ratings, Type R/A Connector will be used for connecting components which are located on the edge of the prototyping shield and Type S will be used to connect components in the middle area of the prototyping shield.

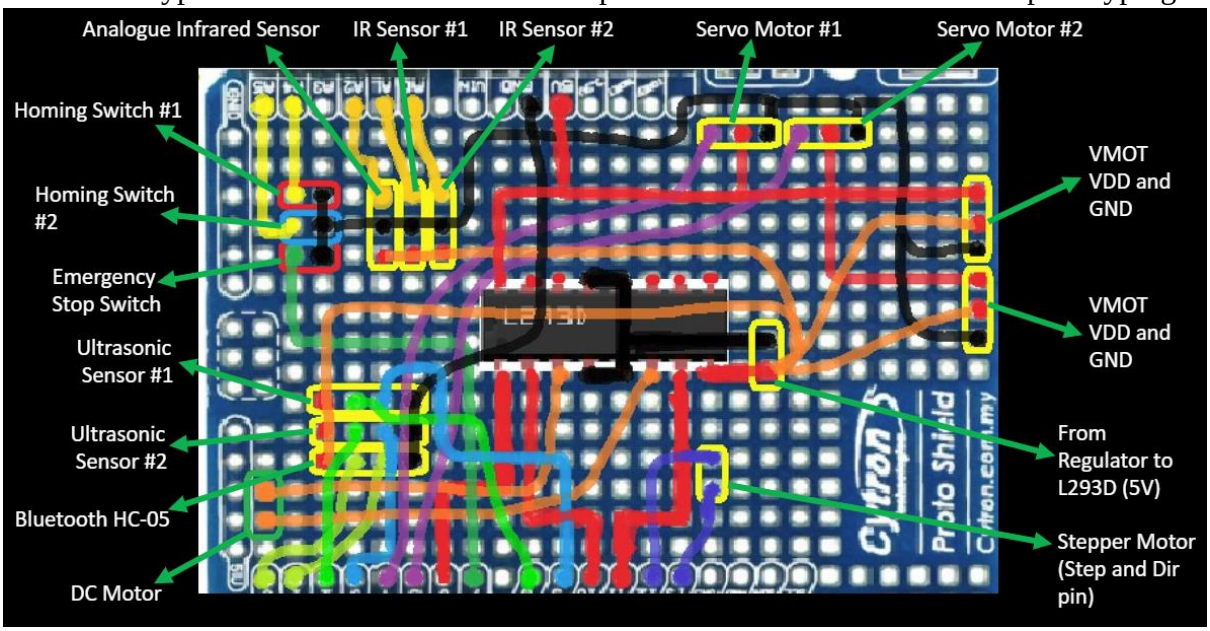

Figure 4: Connector Routing Diagram.

From the diagram, each coloured-box represents a 2/3/4-way connector to be connected. There are 16 connectors connected to the prototyping shield and 3 additional connectors which are to be connected to Vero boards. The type of connector(S or R/A) for each components is listed below:

Components	**Type of Connector(S or R/A)**
DC Motor	2-Way, Type R/A
Bluetooth Module HC-05	4-Way, Type S
Ultrasonic Sensors (#1 and #2)	4-Way, Type S
Emergency Stop Switch	2-Way, Type S
Homing Switches (#1 and #2)	2-Way, Type S
Analogue Infrared Sensor	3-Way, Type S
IR Sensors (#1 and #2)	3-Way, Type S
Servo Motors (#1 and #2)	3-Way, Type R/A
Stepper Motors (STEP and DIR pin) (x2)	2-Way, Type R/A
VMOT, VDD and GND (x2)	3-Way, Type R/A
From Regulator to L293D(5V)	2-Way, Type S
Stepper Motors (x2)	4-Way, Type R/A

Table 4: Type of Connectors used for each component.

4. Conclusion

In overall, the circuit diagram has been drawn using Fritzing software, as well as the connector routing diagram has been drawn by the student. The wire routing needs to be planned in more proper manner as some components such as ultrasonic sensors and proximity sensor are placed at the very top of the structure of system. Hence, proper wiring length must be considered when connecting these parts to the connector on the prototyping shield. Upon connecting the wire and the components together, testing of the soldered circuit must be carried out in order to ensure that the connection is not broken in the middle of the wiring. In terms of progress, it is considered as slightly behind the actual progress(1-2 weeks) due to the delay of the materials sourcing and ordering. As a result, some electronic components will be delivered in a slightly delayed time. Proper time management is a must, in order for the electronic circuits to be assembled, soldered, and tested properly in time.

5. References

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6. Appendix

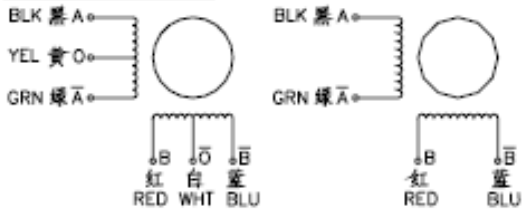
MotionKing

HB Stepper Motor Catalog

MotionKing (China) Motor Industry Co., Ltd.

2 Phase Hybrid Stepper Motor
17HS series-Size 42mm(1.8 degree)

Wiring Diagram:



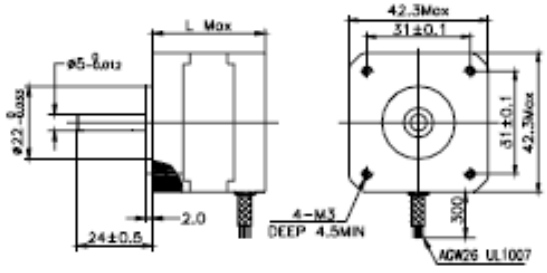
UNI-POLAR(6 LEADS) BI-POLAR(4LEADS)

Electrical Specifications:

Series Model	Step Angle (deg)	Motor Length (mm)	Rated Current (A)	Phase Resistance (ohm)	Phase Inductance (mH)	Holding Torque (N.cm Min)	Detent Torque (N.cm Max)	Rotor Inertia (g.cm²)	Lead Wire (No.)	Motor Weight (g)
17HS2408	1.8	28	0.6	8	10	12	1.6	34	4	150
17HS3401	1.8	34	1.3	2.4	2.8	28	1.6	34	4	220
17HS3410	1.8	34	1.7	1.2	1.8	28	1.6	34	4	220
17HS3430	1.8	34	0.4	30	35	28	1.6	34	4	220
17HS3630	1.8	34	0.4	30	18	21	1.6	34	6	220
17HS3616	1.8	34	0.16	75	40	14	1.6	34	6	220
17HS4401	1.8	40	1.7	1.5	2.8	40	2.2	54	4	280
17HS4402	1.8	40	1.3	2.5	5.0	40	2.2	54	4	280
17HS4602	1.8	40	1.2	3.2	2.8	28	2.2	54	6	280
17HS4630	1.8	40	0.4	30	28	28	2.2	54	6	280
17HS8401	1.8	48	1.7	1.8	3.2	52	2.6	68	4	350
17HS8402	1.8	48	1.3	3.2	5.5	52	2.6	68	4	350
17HS8403	1.8	48	2.3	1.2	1.6	46	2.6	68	4	350
17HS8630	1.8	48	0.4	30	38	34	2.6	68	6	350

*Note: We can manufacture products according to customer's requirements.

Dimensions: unit=mm



Motor Length:

Model	Length
17HS2XXX	28 mm
17HS3XXX	34 mm
16HS4XXX	40 mm
16HS8XXX	48 mm

Figure 5: Datasheet and Specifications of Stepper Motor NEMA 17HS Series 8401

Handson Technology

User Guide

MG996R Metal Gear Servo Motor

This High-Torque MG996R Digital Servo features metal gearing resulting in extra high 10kg stalling torque in a tiny package. It features upgraded shock-proofing and a redesigned PCB and IC control system that make it much more accurate than its predecessor MG995. The gearing and motor have also been upgraded to improve dead bandwidth and centering. This high-torque standard servo can rotate approximately 120º (60º in each direction). The MG996R Metal Gear Servo also comes with a selection of arms and hardware to get you set up nice and fast servo control projects!

SKU: EMH-1056

Brief Data:

- Stall torque: 9.4 kgf·cm (4.8V), 11 kgf·cm (6 V)
- Operating speed: 0.17 s/60º (4.8 V), 0.14 s/60º (6 V)
- Operating voltage: 4.8V a 7.2V
- Running Current: 500mA.
- Stall Current: 2.5A (6V).
- Dead band width: 5µs
- Stable and shock proof double ball bearing design.
- Weight: 55g.
- Dimension: 40.7 x 19.7 x 42.9 mm approx.

Figure 6: Specifications of Servo Motor MG 996R (for gripper)

Electrical Specification

Operating Voltage	4.8V	7.2V
Idle Current	mA	mA
No Load Speed	0.18sec/60°	0.14sec/60°
No-load Current;	210mA	260mA
Stall Torque	20.5kg.cm	22.8kg.cm
Stall Current	2100mA±10%	2700mA±10%
Working Voltage Range	4.8-7.2V	

Figure 7: Electrical Specifications of Servo Motor TD 8120 MG