Chapter 5

Component Selection

5.1 Introduction

After doing the necessary calculations and analysis on the project requirements and outputs, we select the project components.

This chapter describes the selected components which are used in this project the three DC servo actuators, Arduino, motor drivers, position sensor , encoder, 3-axis accelerometer with gyro , bearing, and power supply.

5.2 Electrical component

5.2.1 DC-servo actuator:

Its rotary actuator that allows for precise control of angular position, velocity and acceleration it consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system, see Figure 5.1.

Servomotors are used in applications such as Robots, CNC machinery or automated manufacturing.

Specification of servo motors:

1- The relation between speed and voltage must be linear, in order to simplify the control system, and improve the efficiency.

2- Fast response.

Agile Eye robot need three actuators to make the links and end effector move to the given position , we choose this type of motor because its characteristics and properties that give the best results than other type and it's properties are zero backlash, high positional accuracy and high stiffness, the encoder and controller of a servomotor are an additional cost, but they optimize the performance of the overall system (for all of speed, power and accuracy) relative to the capacity of the basic motor. With larger systems, where a powerful motor represents an increasing proportion of the system cost, servomotors have the advantage. Table 5.1 show the specification of the servo motor.

Figure 5.1 DC servo motor

Specification of servo motor:

Required motors:

Table 5.1 specifications of required motor

Rated Output Power [W]	18.5
Rated Voltage [V]	24
Rated Current [A]	1.8
Rated Output Torque [Nm]	5.9
Rated Output Speed [rpm]	30
Peak Current [A]	4.1
Maximum Output Torque [Nm]	20
Maximum Output Speed [rpm]	50
Torque Constant [Nm/A]	5.76
Voltage Constant (B.E.M.F.) [V/rpm]	0.60
Inertia at Output Shaft [Kgm^2]	$81.6*10^{-3}$
Mechanical Time Constant [ms]	7.0
Viscous Damping Constant [Nm/rpm]	$1.5\cdot10^{-1}$
Gear Ratio	100

Motor Rated Output [W]	30
Motor Rated Speed [rpm]	3000
Armature Resistance [Ω]	2.7
Armature Inductance [mH]	1.1
Electrical Time Constant [ms]	0.41
Starting Current[A]	0.43
No-Load Running Current[A]	0.91

Selection Procedure:

Requirements for Preliminary Selection:
Load Torque T_L [Nm] < Rated Torque T_N [Nm]
Load Speed n_L [rpm] < Rated Output Speed n_N [rpm]
Load Inertia J_L [kgm^2] < 3 J_A (Actuator Inertia) acceptable
Load Inertia J_L [kgm^2] < J_A (Actuator Inertia) for best Dynamic response.

Determination of the acceleration torque T_1 [Nm] :

$$T_1 = T_L + \frac{2\pi}{60} * \frac{(J_A + J_L) * n_L}{t_1}$$

- Acceleration Torque T_1 < Maximum Output Torque T_m.

Determination of the average torque T_A [Nm] :

$$T_A = \sqrt{\frac{T_1^2 * t_1 + T_2^2 * t_2 + T_3^2 * t_3}{t_1 + t_2 + t_3 + t_4}}$$

Where:
T_1: Acceleration Torque.
$T_2 = T_L$: Load Torque.
T_3: Braking Torque
$T_3 = T_2 - (T_1 - T_2)$ (if $t_1 = t_3$).
t_1: Acceleration Time.
t_2: Constant Speed Time.
t_3: Braking Time.
t_4: Idle Time.

- Average Torque T_A < Rated Torque T_N of the actuator.

Load and Operating Conditions:

Load Torque T_L = 5 Nm.
Load Speed n_L = 30 rpm.
Load Inertia J_L = 0.15 kgm^2.
Acceleration Time t_1 = 0.1 s.
Constant Speed Time t_2 = 0.2 s.
Braking Time t_3 = 0.1 s.
Idle Time t_4 = 0.6 s.

Actuator's Data:
T_N = 5.9 Nm
n_N = 30 rpm
J_A = 0.0816 kgm^2
T_m = 20 Nm

- The above procedure leads to the following selection
  Actuator RH - 14D - 3002 – E100AL

Available motors**:**

Table 5.2 specification of available motor

Reduction ratio	30.9:1
Maximum continuous torque(N·m)	0.431
No-Load speed (rad/s)	15.3
Peak Torque (N·m)	1.187
Torque constant(N·m/A)	0.044
Back EMFConstant(V/rad/s)	0.044
Resistance(Ω)	17
Inductance(mH)	9.35
Rated voltage(V)	24
Encoder	512 CPR

5.2.2 Motors Driver (H Bridge):

An H bridge is an electrical circuit that enables a voltage to be applied across a load in either direction, see Figure 5.3.

These circuits are often used in robotics and other applications to allow DC motors to run forwards and backwards, see Figure 5.2.

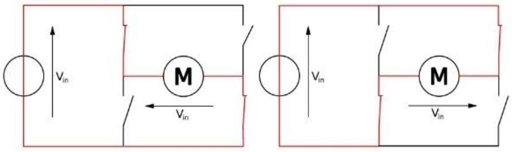

Figure 5.2 voltage direction in H-Bridge

Agile Eye robot need two H-bridge to control the direction and the operating of the three motors.

Motors Driver has the following characteristics:

1) Strong driving ability-low calorific value and strong anti-interference ability.
2) Logical voltage 5V. Drive voltage 5V-35V.
3) Drive current 2A (MAX single bridge), maximum power 25W
4) Large capacity filter capacitance, after flow protection diode, more stable and reliable.

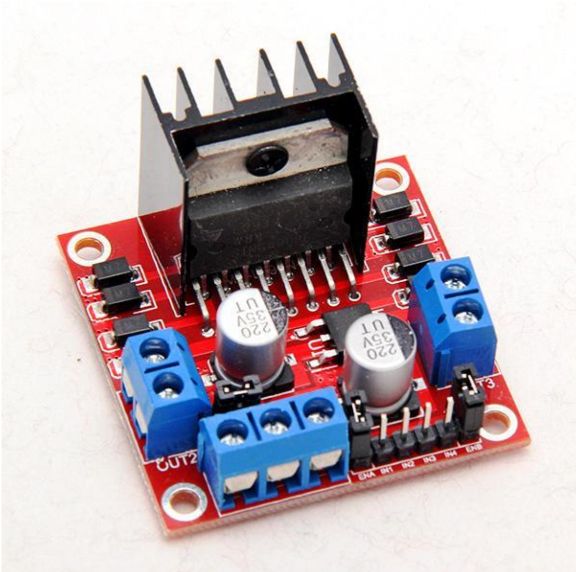

Figure 5.3 L298N Motor Driver Module3

5.2.3 Microcontroller

There were many choices of microcontroller to use, like PIC micro controller from microchip or Atmel microcontrollers, but in this project Arduino board based on Atmel is used. This is because it has some specifications not available on other micro controllers .For example PIC18F4550 has one Pulse with Modulation, but Arduino have 15 Pulse with Modulation. Also it's open source and one can deal with it easily, thus the Arduino Mega 2560 has been chosen to control the Agile Eye Robot, as shown in Figure 5.4.

Figure 5.4 Arduino Mega 2560

The Arduino Mega 2560 has 54 digital input/output pins (of which 15 can be used as pulse with modulation outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable to program and start using Arduino.

For the software environment, see Figure 5.5, the Arduino 1.0.5-r2 software is used to verify and download the code on Arduino board.

Figure5.5 Arduino 1.0.6-r2 software

5.2.4 Incremental rotary encoder

Is an electro –mechanical device that converts the angular position or motion of a shaft or axle to an analog or digital code.

There are two main types: absolute and incremental (relative), as shown in Figure 5.6. The output of absolute encoders indicates the current position of the shaft, making them angle transducers. The output of incremental encoders provides information about the motion of the shaft, which is typically further processed elsewhere into information such as speed, distance, and position.

Rotary encoders are used in many applications that require precise shaft unlimited rotation including industrial controls, robotics.

Servo motor use incremental encoders, the incremental encoder usually gives two types of squared waves out of phase for 90 electrical degrees. They are usually called channel A and B. The first channel gives information about the rotation speed while the second, basing on the states sequence produced by the two signals, provides the sense of rotation.

The incremental encoder precision depends on mechanical and electrical factors.

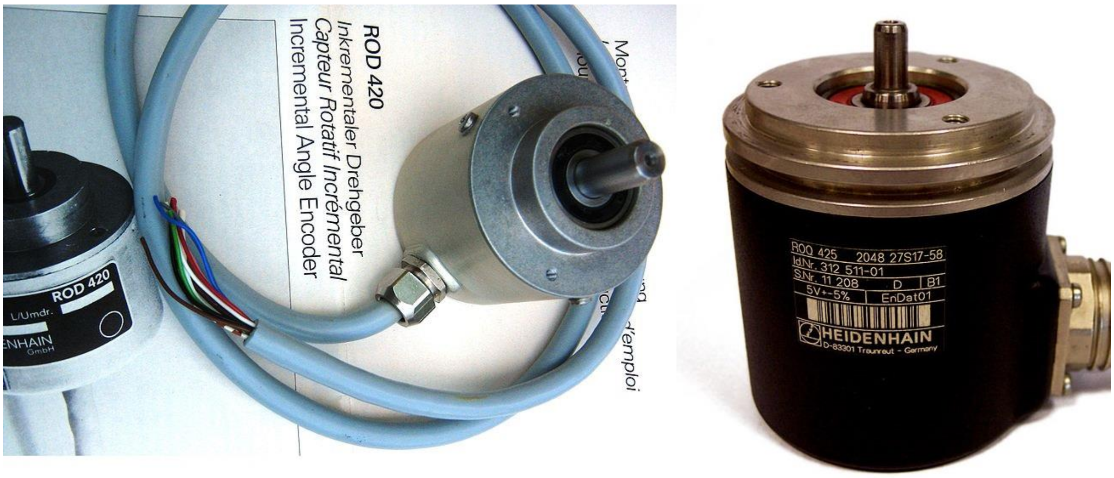

Figure 5.6 Incremental and Absolute rotary encoder

5.2.5 Power Supply

Power supply used to supply H-bridge 12V DC, as shown in Figure 5.7.

Figure 5.7 Power Supply

5.3 Mechanical component

There are many choices to use, like wood , echelon & aluminum , but in this project Aluminum used to build our prototype , we choose the aluminum because it has specifications which are not available in other material like : Light , relatively strong , workability , and soft.

The Figure 5.8 show the Agile Eye robot prototype.

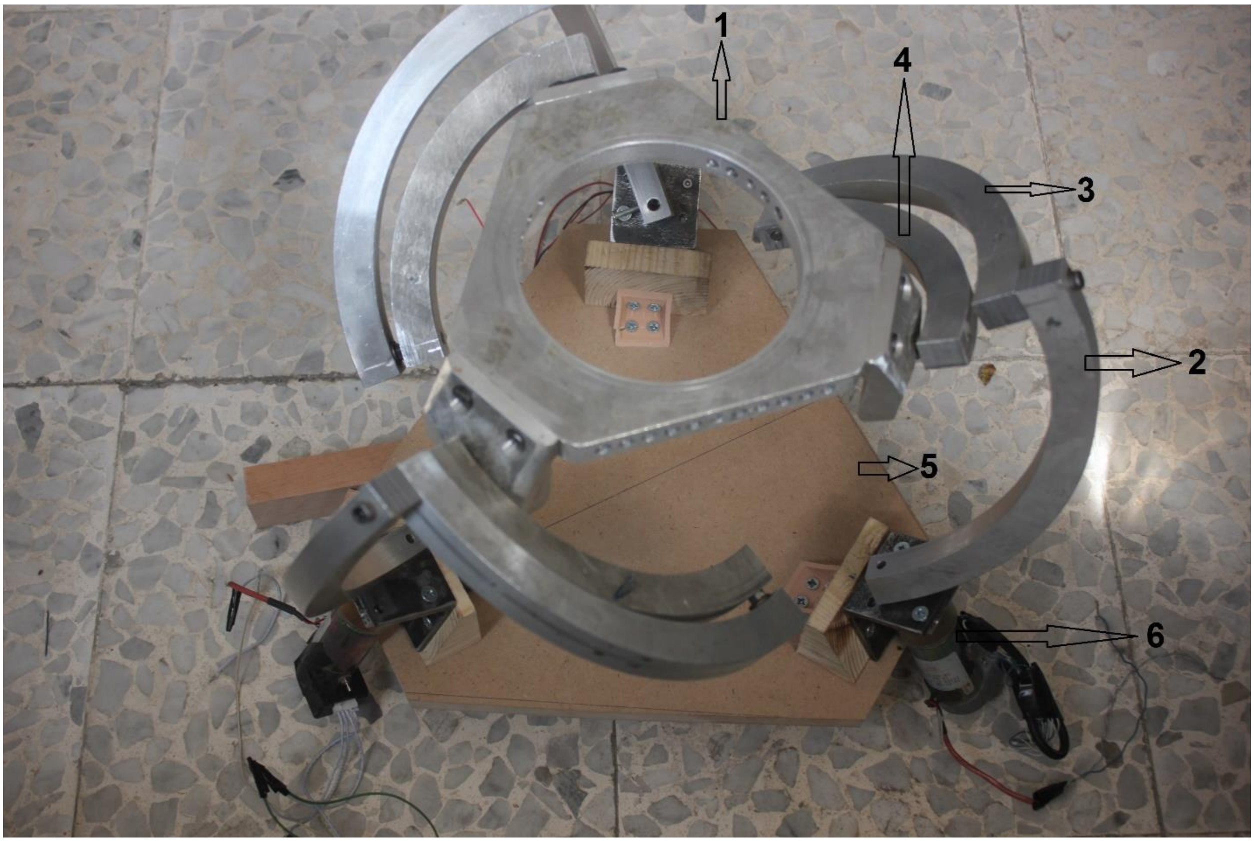

Figure 5.8: Agile Eye robot prototype.

Where

1: End-effector, Figure 5.9

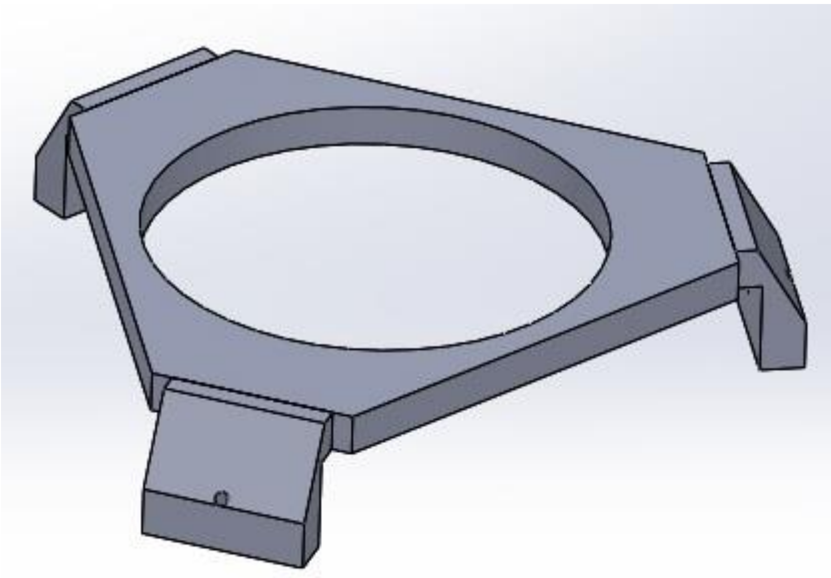

Figure 5.9: End effector

2: Active link, see Figure 5.10

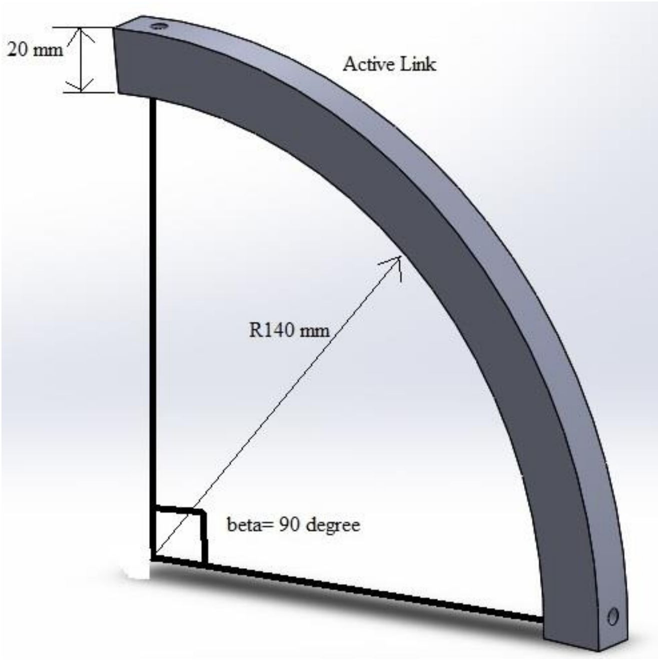

Figure 5.10: Active link.

3: Forearm link as shown in Figure 5.11

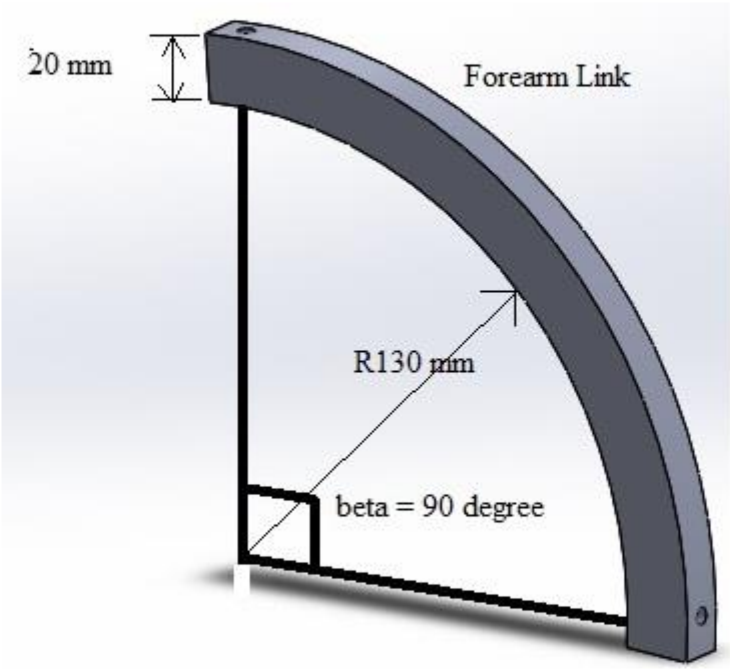

Figure 5.11: Forearm link.

4: Passive link, see Figure 5.12

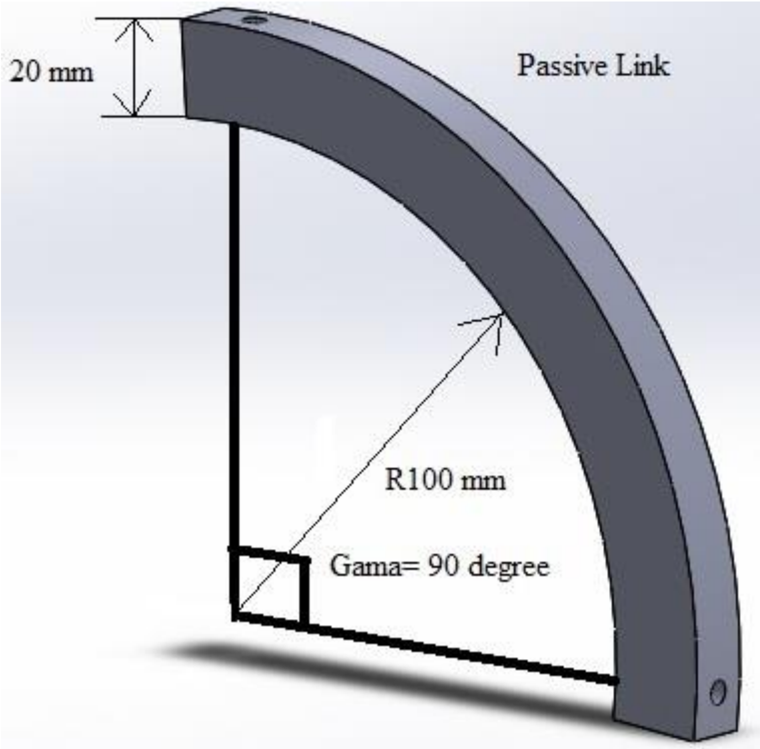

Figure 5.12: Passive link.

5: Base, as shown in Figure 5.13

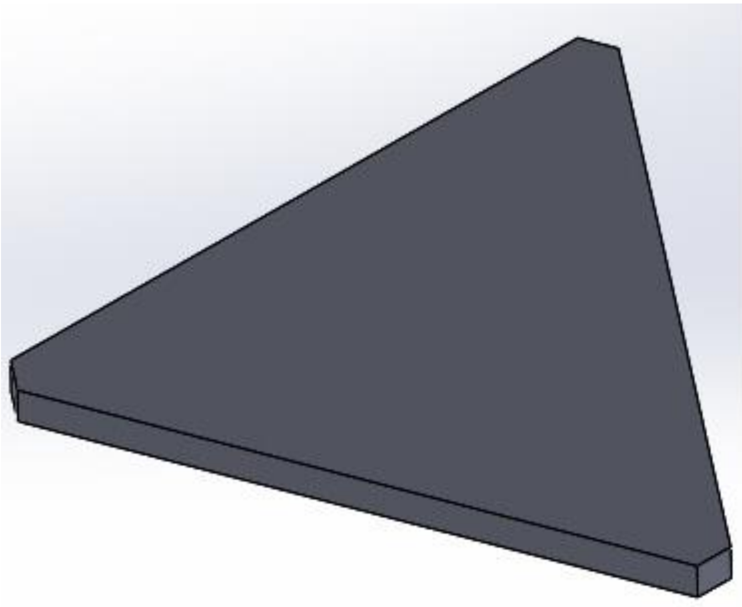

Figure 5.13: Base.

6: Motors