Mansoura University

Faculty of Engineering

Department of Computer Engineering and Systems

Control Engineering 1 (CSE 3116)

Analog DC motor position control

team 1

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Abstract

This report “Analog DC motor position control” aims to discuss how the project is made, the tools and components we used, the concept behind making this project. The project is about controlling the position of a DC motor analogically. This is also called servo-mechanism (servo motor).

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1. Introduction

There are several industrial, automatic, and other processes that require the control of angular position of a motor (or translation position), this aim is achieved by using dc motor which allow us to control the position at a wider range of speeds in both reverse and forward direction.

Position control systems are an important component of many industrial products. Examples are found in disc drives, automotive products, robotics, process control and many others.
The fundamental concepts of servo motion control have not changed significantly in the last 50 years. The basic reasons for using servo systems in contrast to open loop systems include the need to improve transient response times, reduce the steady state errors and reduce the sensitivity to load parameters.
Dc electric motor is used as a manipulative device in control systems; dc motors are extremely versatile drives capable of reversible operation over a wide band of speeds, with accurate control of the speed at all times; they can be controlled from zero speed to full speed in both directions in this project our goal is to control the motor position at a specific speed in both directions but the advantage of range of speeds give the motor a great importance in position control systems.

1.1 Problem Statement

The servo-mechanism is an application of position control. The target is to control the position of a physical object by a closed-loop feedback system using electronic components.

1.2 The meta behind the project

To apply what we studied in the course, Feel the meaning of a system and how to control it, create new systems and know how to execute them.

Know what is a servo-mechanism system, why is it used, and how to use it.

2. Steps of project Execution

We first searched for the appropriate design(circuit) to control the motor and we found:

- Control servomotor using pid controller
- Control motor using potentiometers as set point and the feedback sensor, and operational amplifier to differentiate between the output and the set point.

2.1 Choosing the circuit

The circuit with the amplifier is easier to execute.

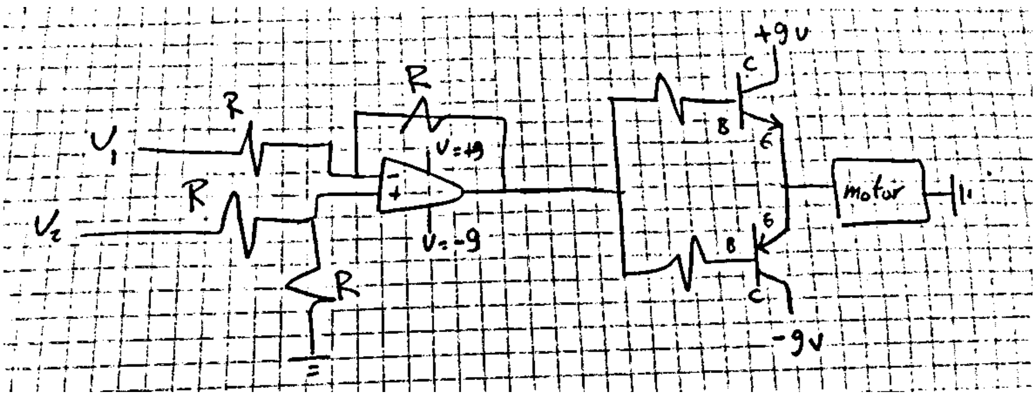


Figure 1-Circuit Diagram

2.2 Using Electronic Design tool (Proteus)

Proteus is an easy to use tool to implement a circuit and make sure it works correctly. We used it to test our circuit.

2.2.1 Schematic Design

In schematic design, we implemented our circuit using components and ICs we needed listed in proteus as shown in figure

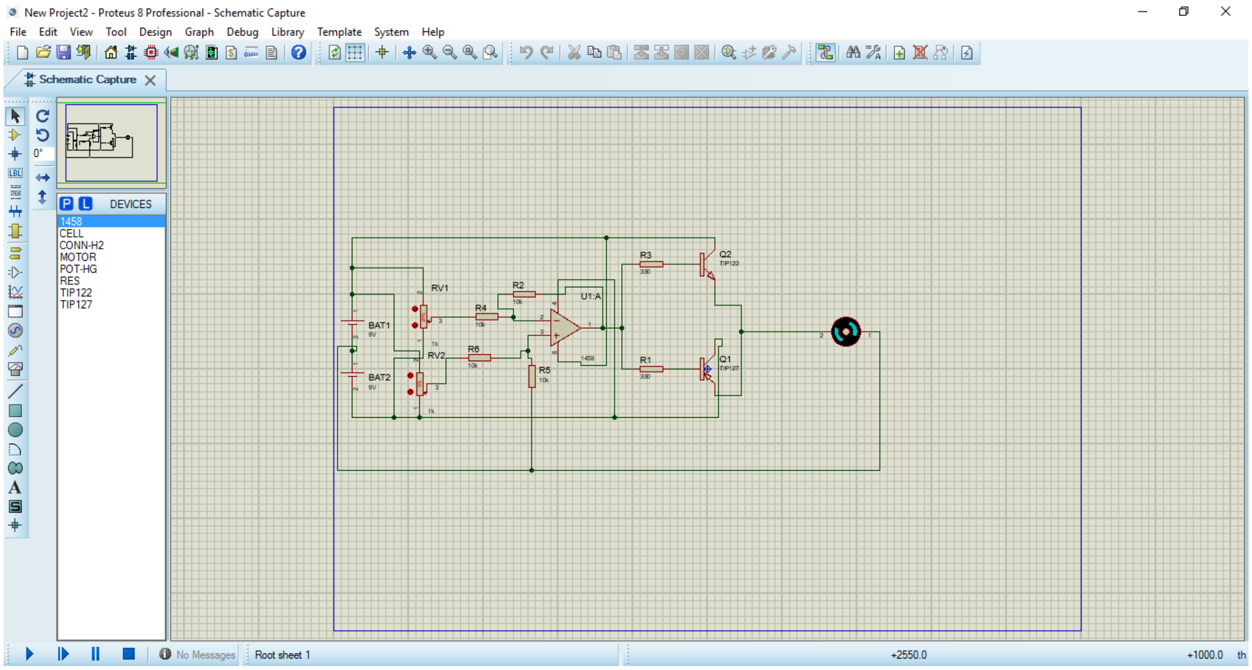


Figure 2-Shematic Design

2.2.2 ARIS

In ARIS it is a bit complicated, as first we have to define the voltage input(source), the potentiometers and the motor as blocks to be defined in ARIS as shown in figure

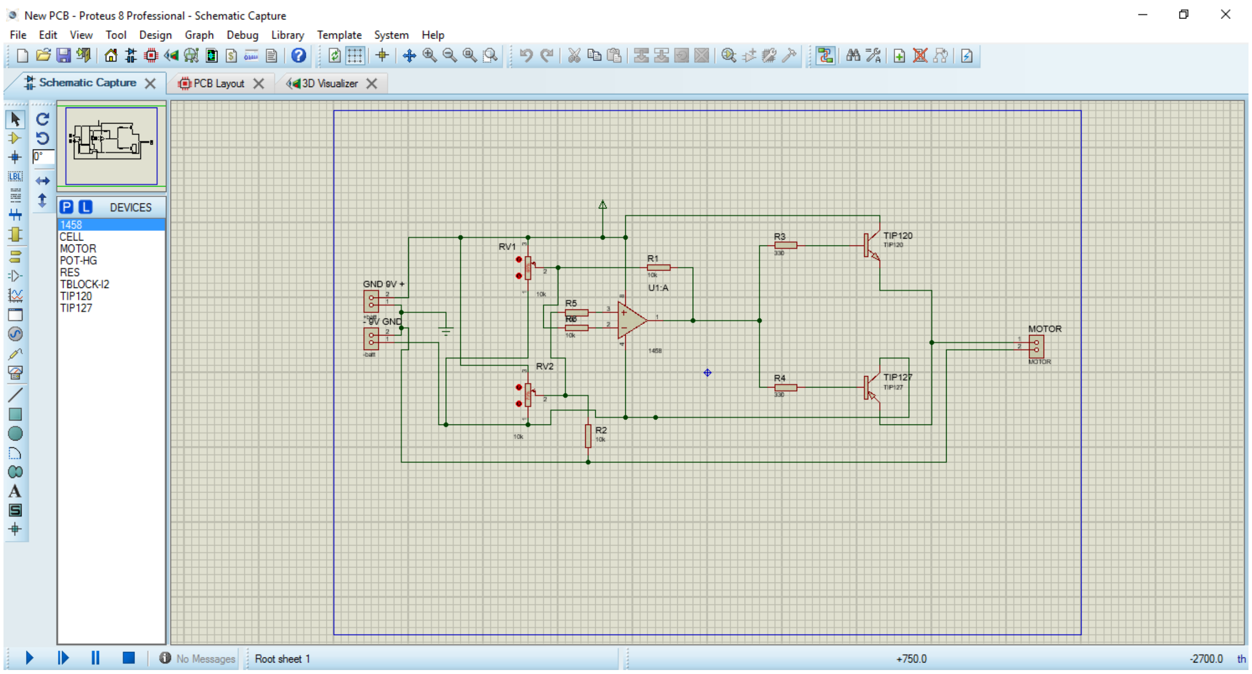


Figure 3-Define the blocks in Schematic design

Then insert the components in ARIS and begin routing as shown in figure

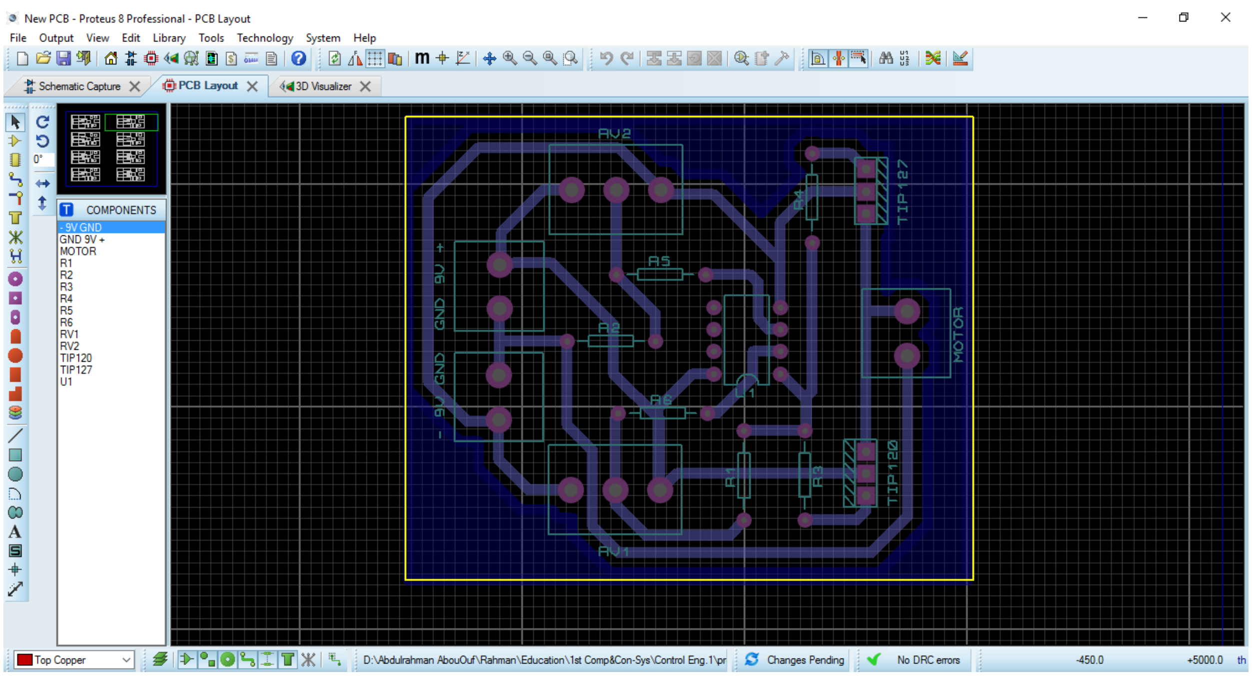


Figure 4-ARIS implementation

2.3 Test Board Experiment

Testboard experiment is an indicator whether the project is working or not as shown in figure.

Advantages:

- Easy to use and execute the project on it.
- Easy to fix and correct the problems.
- Can be implemented using protues schematic design directly.

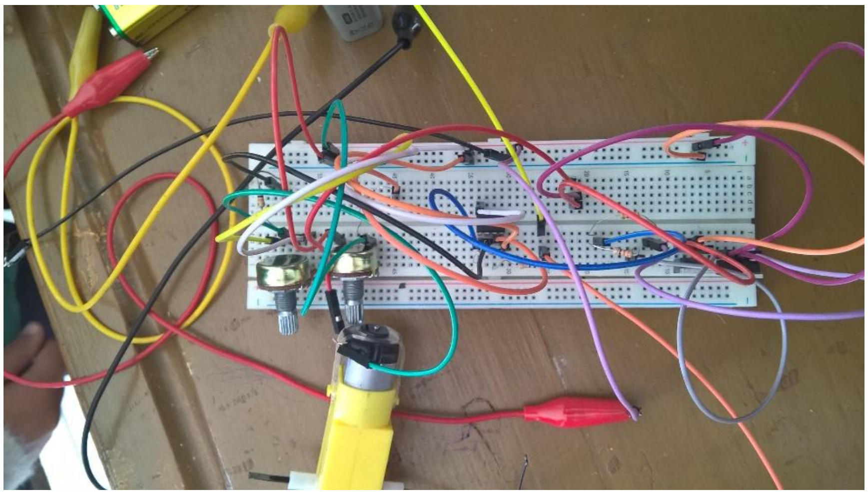


Figure 5 – TestBoard

2.4 Execute in PCB

Soldering components in PCB and check for the circuit, then attach one of the potentiometers as a feedback.

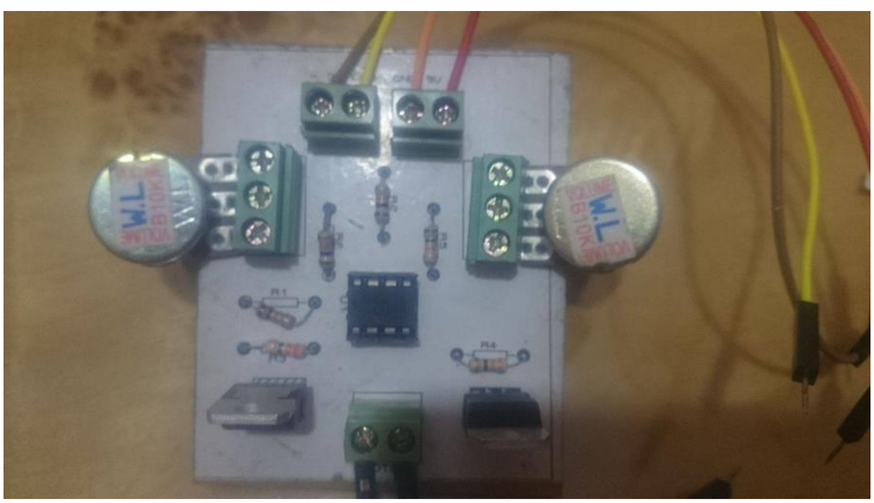


Figure 7 - PCB

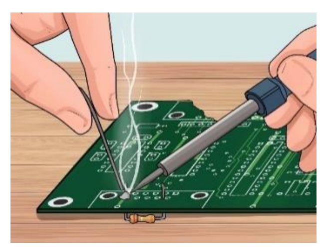


Figure 6 - soldering components in PCB

3. Components

We used simple electronic components:

- Potentiometers 10k
- Operational amplifier
- Transistors(TIP)
- DC Motor
- Resistors 330 for the transistor base
- Resistors 10k for the differential op amp
- 2-Batteries 9v

3.1 Potentiometers

A potentiometer, informally a pot, is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat. Potentiometers are commonly used to control electrical devices such as volume controls on audio equipment. We used 2 potentiometers to control the input voltage and current, one of them is controlled by the user and the other one is attached to the motor (mechanically feedback) and the op-amp differentiate between them

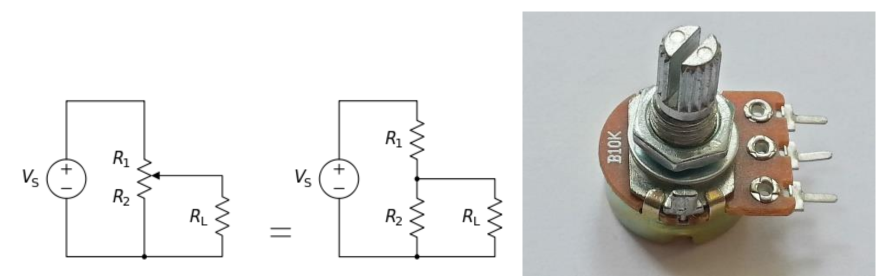


Figure 8 - Potentiometer Circuit

3.2 Operational Amplifier

An operational amplifier (often op-amp) is a DC-coupled high-gain electronic voltage amplifier with a differential input and, usually, a single-ended output.

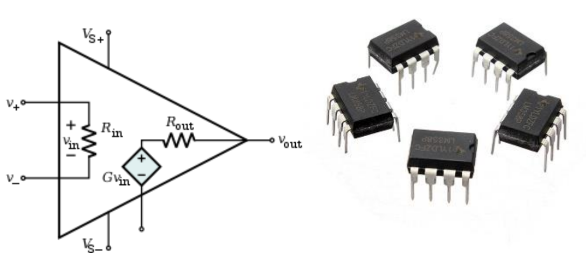


Figure 9 - Op-Amp Circuit

Differential amplifiers amplify the difference between two voltages making this type of operational amplifier circuit a **Subtractor** unlike a summing amplifier which adds or sums together the input voltages. This type of operational amplifier circuit is commonly known as a **Differential Amplifier** configuration and is shown below:

Differential Amplifier

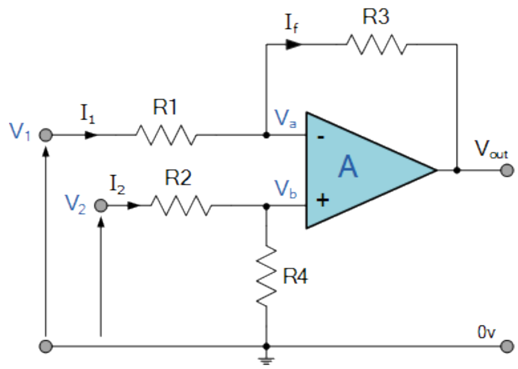


Figure 10 - Differential Amplifier

By connecting each input in turn to 0v ground we can use superposition to solve for the output voltage Vout. Then the transfer function for a **Differential Amplifier** circuit is given as

Equation 1 - Differential Amplifier

$$I_1 = \frac{V_1 - V_a}{R_1}, \quad I_2 = \frac{V_2 - V_b}{R_2}, \quad I_f = \frac{V_a - (V_{out})}{R_3}$$

$$\text{Summing point } V_a = V_b$$

$$\text{and } V_b = V_2\left(\frac{R_4}{R_2 + R_4}\right)$$

$$\text{If } V_2 = 0, \text{ then: } V_{out(a)} = -V_1\left(\frac{R_3}{R_1}\right)$$

$$\text{If } V_1 = 0, \text{ then: } V_{out(b)} = V_2\left(\frac{R_4}{R_2 + R_4}\right)\left(\frac{R_1 + R_3}{R_1}\right)$$

$$V_{out} = -V_{out(a)} + V_{out(b)}$$

$$\therefore V_{out} = -V_1\left(\frac{R_3}{R_1}\right) + V_2\left(\frac{R_4}{R_2 + R_4}\right)\left(\frac{R_1 + R_3}{R_1}\right)$$

3.3 Transistors

A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power. It is composed of semiconductor material usually with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals controls the current through another pair of terminals.

Figure 11 - Transistors

the NPN & PNP type bipolar transistors can be made to operate as "ON/OFF" type solid state switch by biasing the transistors Base terminal differently to that for a signal amplifier.

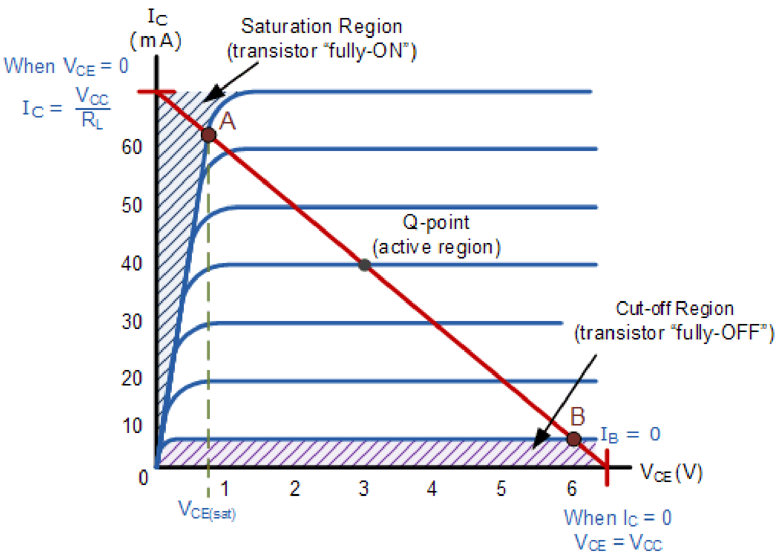
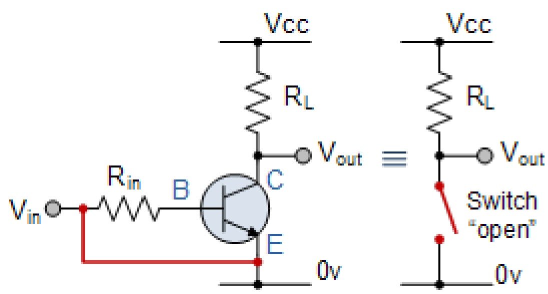
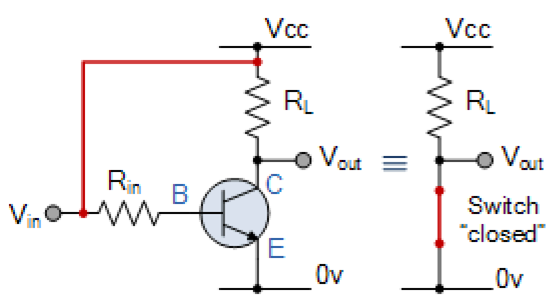


Figure 12 - Transistors Regions

 *Figure 13 - - Open Switch Transistor*	• The input and Base are grounded (0v) • Base-Emitter voltage $V_{BE} < 0.7v$ • Base-Emitter junction is reverse biased • Base-Collector junction is reverse biased • Transistor is "fully-OFF" (Cut-off region) • No Collector current flows ($I_C = 0$) • $V_{OUT} = V_{CE} = V_{CC}$ = "1" • Transistor operates as an "open switch"
 *Figure 14 - - Closed Switch Transistor*	• The input and Base are connected to V_{CC} • Base-Emitter voltage $V_{BE} > 0.7v$ • Base-Emitter junction is forward biased • Base-Collector junction is forward biased • Transistor is "fully-ON" (saturation region) • Max Collector current flows ($I_C = Vcc/R_L$) • $V_{CE} = 0$ (ideal saturation) • $V_{OUT} = V_{CE}$ = "0" • Transistor operates as a "closed switch"

3.3.1 Why using TIP

TIP produces high current up to 6 ampere

The Darlington Bipolar Power Transistor is designed for general purpose amplifier and low frequency switching applications. The TIP140, TIP141, TIP142, (NPN); TIP145, TIP146, TIP147, (PNP) are complementary devices.

Features

- High DC Current Gain
- Min hFE = 1000 @ IC
- = 5 A, VCE = 4 V
- Collector-Emitter Sustaining Voltage @ 30 mA
- VCEO(sus) = 60 Vdc (Min) TIP140, TIP145
- VCEO(sus) = 80 Vdc (Min) TIP141, TIP146
- VCEO(sus) = 100 Vdc (Min) TIP142, TIP147
- Monolithic Construction with Built-In Base-Emitter Shunt Resistor
- Pb-Free Packages are Available

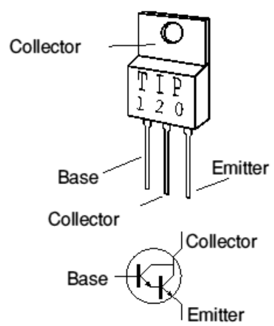


Figure 15 – TIP

3.4 DC Motor

A DC motor is any of a class of rotary electrical machines that converts direct current electrical power into mechanical power.

Figure 16 - DC Motor With GearBox

4. How System is controlled (How it Works)

Using potentiometers, we control the voltage input (one is set to be controlled by the user (controller), the another one is used as mechanical feedback(Sensor)). The input voltage is entered to the operational amplifier which differentiate between the two inputs and gives the output to the transistors. Depending on the output one transistor from the two works and gives a signal to the motor to rotate in one direction. Changing the potentiometer by the same concept the motor rotates in the other direction. To stop motor from rotating continuously we attach a potentiometer to the motor to work as a **feedback** to reach the **set point.**

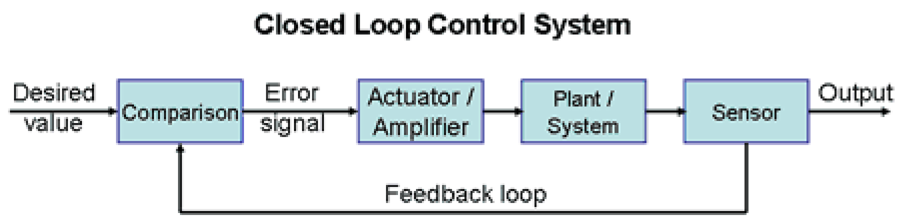


Figure 17 - Control System

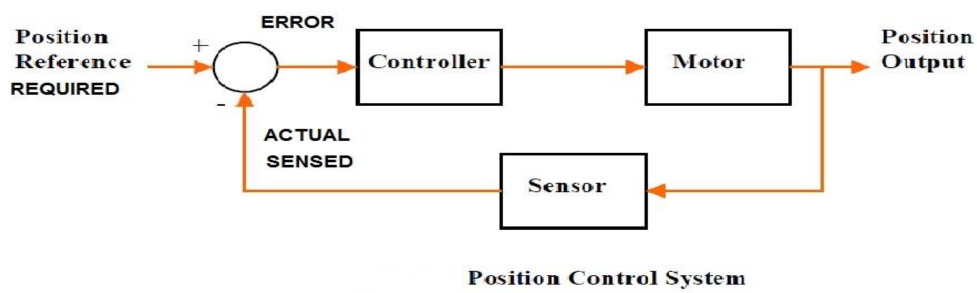


Figure 18 - Control System Diagram

5. Benefits of The Project

Servos are used in radio-controlled airplanes to position control surfaces like elevators, rudders, walking a robot, or operating grippers. Servo motors are small, have built-in control circuitry and have good power for their size.

In food services and pharmaceuticals, the tools are designed to be used in harsher environments, where the potential for corrosion is high due to being washed at high pressures and temperatures repeatedly to maintain strict hygiene standards. Servos are also used in in-line manufacturing, where high repetition yet precise work is necessary.

Servo motors are small and efficient but critical for use in applications requiring precise position control. The servo motor is controlled by a signal (data) better known as a pulse-width modulator (PWM). Here are several of the more common servo motor applications in use today.

- Robotics: A servo motor at every "joint" of a robot is used to actuate movements, giving the robot arm its precise angle.
- Conveyor Belts: Servo motors move, stop, and start conveyor belts carrying product along to various stages, for example, in product packaging/bottling, and labeling.
- Camera Auto Focus: A highly precise servo motor built into the camera corrects a camera's lens to sharpen out-of-focus images.
- Robotic Vehicle: Commonly used in military applications and bomb detonation, servo motors control the wheels of the robotic vehicle, generating enough torque to move, stop, and start the vehicle smoothly as well as control its speed.
- Solar Tracking System: Servo motors adjust the angle of solar panels throughout the day so that each panel continues to face the sun, harnessing maximum energy from sunup to sundown.
- Metal Cutting & Metal Forming Machines: Servo motors provide precise motion control for milling machines, lathes, grinding, centering, punching, pressing, and bending in metal fabrication for such items as jar lids to automotive wheels.
- Antenna Positioning: Servo motors are used on both the azimuth and elevation drive axis of antennas and telescopes such as those used by the National Radio Astronomy Observatory (NRAO).
- Woodworking/CNC: Servo motors control woodturning mechanisms (lathes) that shape table legs and stair spindles, for example, as well as augering and drilling the holes necessary for assembling those products later in the process.
- Textiles: Servo motors control industrial spinning and weaving machines, looms, and knitting machines that produce textiles such as carpeting and fabrics as well as wearable items such as socks, caps, gloves, and mittens.
- Printing Presses/Printers: Servo motors stop and start the print heads precisely on the page as well as move paper along to print multiple rows of text or graphics in exact lines, whether it's a newspaper, a magazine, or an annual report.
- Automatic Door Openers: Supermarkets and hospital entrances are prime examples of automated door openers controlled by servo motors, whether the signal to open is via

push plate beside the door for handicapped access or by radio transmitter positioned overhead.

The world would be a much different place without servo motors. Whether they're used in industrial manufacturing or in commercial applications, they make our lives better, easier, and in many cases provide us with more affordable products.

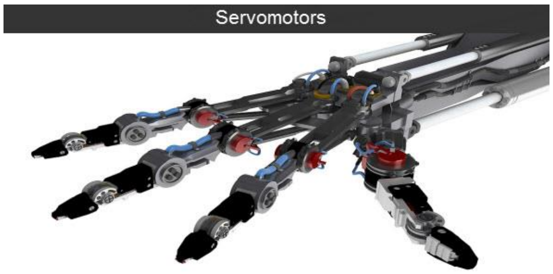


Figure 19 - Applications(Robots)

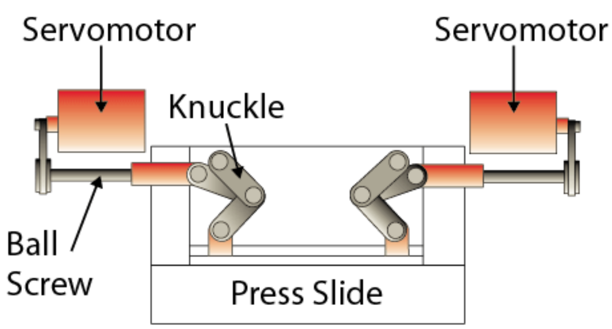


Figure 20 – Applications

6. References

- How to use protues. Youtube.com
- Potentiometers:
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- Operational Amplifier
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7. Index

Control system: A control system consists of subsystems and processes (or plants) assembled for the purpose of obtaining a desired output with desired performance, given a specified Output.

Closed loop system: The input transducer converts the form of the input to the form used by the
controller. An *output transducer,* or *sensor,* measures the output response and converts it into the form used by the controller. For example, if the controller uses electrical signals to operate the valves of a temperature control system, the input position and the output temperature are converted to electrical signals. The input position can be converted to a voltage by a *potentiometer,* a variable resistor, and the output temperature can be converted to a voltage by a *thermistor,* a device whose electrical resistance changes with temperature.

Feedback: Feedback loops take the system output into consideration, which enables the system to adjust its performance to meet a desired output response.

Set point: a setpoint (also set point, set-point) is the desired or target value for an essential variable of a system, often used to describe a standard configuration or norm for the system. Departure of a variable from its setpoint is one basis for error-controlled regulation, that is, the use of feedback to return the system to its norm, as in homeostasis. For example, a boiler might have a temperature setpoint, which is the temperature the boiler control system aims to maintain.

Servo-mechanism: An operational amplifier (often op-amp) is a DC-coupled high-gain electronic voltage amplifier with a differential input and, usually, a single-ended output.

Operational amplifier: An operational amplifier (often op-amp) is a DC-coupled high-gain electronic voltage amplifier with a differential input and, usually, a single-ended output.