

## LAB ASSIGNMENT NO: 1

### INTRODUCTION TO ROBOTEK II TRAINER AND ITS INTERFACING WITH THE COMPUTER

#### THEORY:

The word robot comes from the Slavic word robota, which is used to refer forced labor. Robotics is the branch of [technology](#) that deals with the design, construction, operation and application of [robots](#) and computer systems for their control, sensory feedback, and information processing. These technologies deal with automated machines that can take the place of humans, in hazardous or manufacturing processes, or simply just resemble humans.

A Robotek II trainer teaches us the basic robotic sensing and tells us that how we can study the external part of robot and how we can control mechanism to allow robots to move fluidly and efficiently.

Using this trainer, we can control the arm, jaw, base, shoulder and elbow. These are the parts of this particular robot that are movable and hence, these are used to make our work easy.

These parts can be moved in up, down, left and right direction. These parts are moving in their specific directions as it is built in by the manufacturer. These parts are very sensitive and can be destroyed due to movement of a little bit more than its required movement or robot can be damaged.

These are used in most of the industries because their use is really very economical. They are expensive a lot but this expenditure is done only for once and afterwards we can take a lot of work by them without any break.

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Robotek II is operated with a computer which has a LPT Line Print Terminal Port to connect the trainer.

At the back side of trainer, a port is installed in which a pin or cable is connected which comes from computer. All the communication or instruction to which trainer is operate comes from computer.

It has four movable parts and due to those parts, this Robotek II trainer can be recognized.



The robotic arm is the most important part of this trainer. It has the ability to move in four different directions which are:

Base

Shoulder

Elbow

Jaw

## CONTROL SYSTEM LAB REPORT

These are controlled by DC motor and we move with our desire. These components are moved in the following directions:

Base can rotate left and right up to range of  $120^{\circ}$

Shoulder moving range up to  $90^{\circ}$

Elbow moving range up to  $30^{\circ}$

The gripper is also known as the jaw of the Robotek II trainer arm. It is used to grip the load tightly. It is very useful part because it can hold the load and we can move that to the specific portion of our requirement.

The wrist of the Robotek II trainer can take a full round. It can move easily in a full circle. This can be rotated manually only.

The Robotek II trainer can not lift the weight more than 100gm. Its purpose is to give us the basic idea about the working of robots in different applications.

### **Senser:**

It is in pair and these are allocated on the conveyer belts. These are used to determine the position and presence of the load or weight present on the conveyer belts. These are optical or light sensors.

### **Conveyer Belts.**

These are also two in number in our practical. These belts are used to convey or to transport the things from one place to the other.

**Hurdles or Bottles or Load.**

These are basically the weights that we are using in this Robotek II trainer's practical. These are to be conveyed from one place to another by the use of Robotek II trainer and by conveyer belts.

Trainer has two sets of IR transmitter and receiver for the sensing of object moving on the conveyer belt.

This sensor can be adjusted at different positions across the assembly of conveyer belt.

IR sensor can moved up and down according to need. The figure below can illustrate about the sensors attached to the conveyer belt.

## LAB ASSIGNMENT NO: 2

### INTRODUCTION TO PROCESS CONTROL TRAINER

#### **THEORY:**

It is a trainer that controls multi process variables using different sensors. Mainly it controls the level, pressure, temperature and flow. It uses different sensors to sense these parameters. The sensor output is sent to the transducer to create the error signal that controls the actuator movement. This actuator controls the final energy flow to the process.

Process control is a statistics and engineering discipline that deals with architectures, mechanisms and algorithms for maintaining the output of a specific process within a desired range.

It is a model of industrial process control.

It consists of the following main parts that are as follows:

#### **Control Panel.**

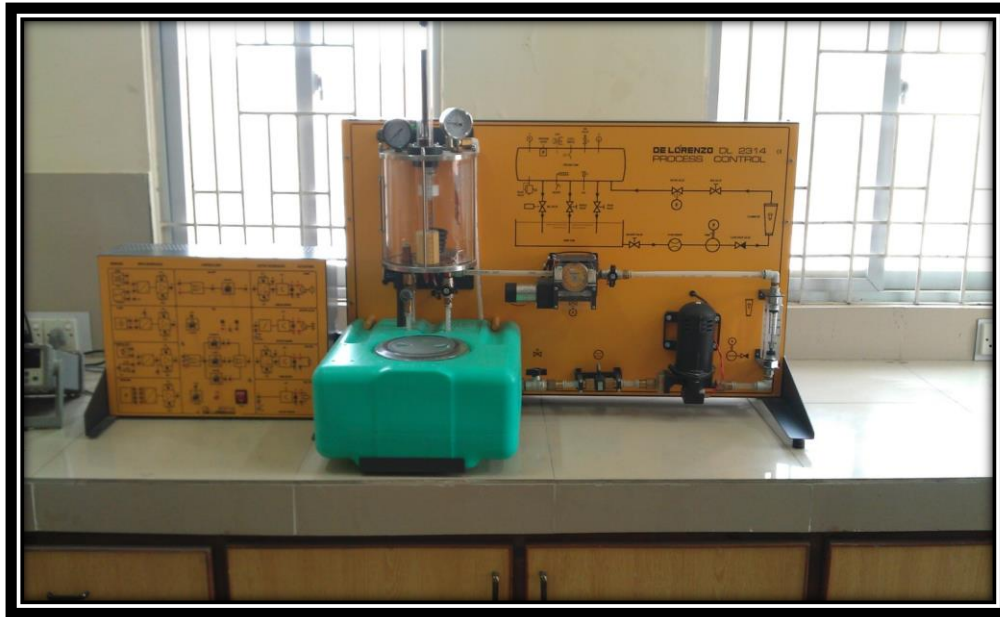
It is a panel on which on whole picture of industrial control is illustrated. Here is a complete and separate section for every individual control system.

#### **Process Tank.**

It is a tank in which all processes are monitored and controlled. It is just a replica of industrial process tank. More practically saying, it is like a boiler. It is a trainer that controls multi process variables using different sensors. Mainly it controls the level, pressure, temperature and flow. It uses different sensors to sense these parameters. The sensor output is sent to the transducer

## CONTROL SYSTEM LAB REPORT

to create the error signal that controls the actuator movement. This actuator controls the final energy flow to the process.



### **LVDT (Linear Variable Differential Transformer):**

The linear variable differential transformer (LVDT) also called just a differential transformer is a type of electrical [transformer](#) used for measuring linear displacement or position.

It is a transformer that varies its output voltage linearly with the differentiating area of core inside the transformer.

### **Rotameter:**

A rotameter is a device that measures the [flow rate](#) of [liquid](#) or [gas](#) in a closed tube. It belongs to a class of meters called [variable area meters](#), which measure flow rate by allowing the cross-sectional area the fluid travels through to vary, causing some measurable effect.

## CONTROL SYSTEM LAB REPORT

It is a flow sensor its cross section varies ,increases from bottom to top. A weight is floating inside it.

Flow rate scale is calibrated on it. It might be in metal or glass casing. It is always installed between the flow lines.

### **Solenoid valve.**

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid. in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Multiple solenoid valves can be placed together on a manifold.

Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids.

Other valves may have pneumatic or electric actuators but it is a special valve, which operates by electric solenoid. Inside the solenoid, there is a plunger that is pulled up or released down to control the flow in the control system.

### **Electric heater.**

It is a heater, used to maintain the temperature of the system according the signal received from the thermocouple.

It is just a spiral coil of tube. Inside the tube, there might be the hot steam or fire inside these tubes, to rise temperature of the process tank.

### **Air valve.**

An Air Operated Valve is a type of power operated valve that uses air pressure against a piston or diaphragm to produce linear or circular movement to operate a valve. Air Valves perform two important functions in a



*CONTROL SYSTEM LAB REPORT*

pipng system. They maintain system design efficiency and provide system protection.

It is just a manual operated pressure valve. There is always a set point or desired value. It is used to release the extra pressure built in the tank than that of the set point.

**Pressure Pump:**

It is a pump, used to generate pressure in the process line, to increase the flow rate.



## LAB ASSIGNMENT NO: 3

### INTRODUCTION OF DC MOTOR CONTROL TRAINER

#### THEORY:

D.C motor Speed control trainer built around a small permanent magnet D.C. motor is designed to bring out the salient features of such a system. Facilities are available to directly measure the principal performance features of the speed control system, viz, steady state error and load disturbance rejection, as a function of the forward path gain.

Every electric motor has to have some sort of controller. The motor controller will have differing features and complexity depending on the task that the motor will be performing.

The simplest case is a [switch](#) to connect a motor to a power source, such as in small appliances or power tools. The switch may be manually operated or may be a [relay](#) or [contactor](#) connected to some form of [sensor](#) to automatically start and stop the motor. The switch may have several positions to select different connections of the motor.

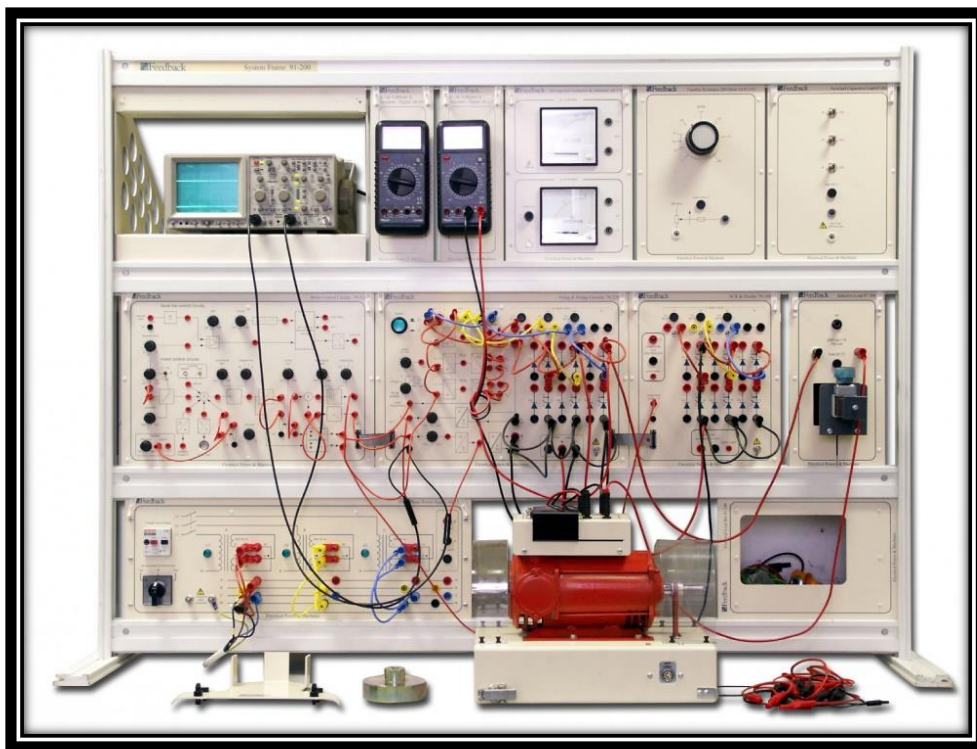
This may allow reduced-voltage starting of the motor, reversing control or selection of multiple speeds. Overload and over current protection may be omitted in very small motor controllers, which rely on the supplying circuit to have over current protection. Small motors may have built-in overload devices to automatically open the circuit on overload. Larger motors have a protective overload relay or temperature sensing relay included in the controller and [fuses](#) or [circuit breakers](#) for over current protection. An automatic motor controller may also include limit switches or other devices to protect the driven machinery.

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A motor controller is a device or group of devices that serves to govern in some pre-determined manner the performance of an electric motor.

A DC motor is designed to run on DC electric power. Two examples of pure DC designs are Michael Faraday's homopolar motor (which is uncommon), and the ball bearing motor, which is (so far) a novelty.

With the help of dc motor trainer we can be control the speed of motor and we can also vary the load. By changing the load we can observe the speed of motor.



### THYRISTOR CONTROL PANEL:

The operation of a thyristor can be understood in terms of a pair of tightly coupled bipolar junction transistors, arranged to cause the self-latching action.

A thyristor is a solid-state semiconductor device with four layers of alternating N and P-type material. They act as bistable switches, conducting

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when their gate receives a current trigger, and continue to conduct while they are forward biased that is, while the voltage across the device is not reversed.

From this panel of the trainer we can set the firing angles of the thyristors. From the firing angles we can easily set the output of the rectifier circuit which control the rpm of the dc motor.

### **3-phase Ac Supply:**

Three-phase electric power is a common method of [alternating-current electric power generation](#), [transmission](#), and [distribution](#).<sup>[1]</sup> It is a type of [polyphase system](#) and is the most common method used by [electrical grids](#) worldwide to transfer power. It is also used to power large [motors](#) and other heavy loads.

There is a 3 phase supply in the trainer provided with a power switch and a circuit breaker. From this portion we can supply power to any portion of the trainer.

### **DC Shunt Motor:**

Dc shunt motor is type of dc motor in which field winding is placed in parallel with the armature winding. In this Dc motor control trainer we also use a dc shunt motor for our experiments.

### **TECHOGENERATOR.**

Tachogenerators are AC or DC generators that output a voltage in proportion to the rotational speed of a shaft on a rotating electrical machine or electric motor, and thus are used to measure the speed and direction of rotation.

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Most commonly found in fractional horsepower (FHP) applications they are often referred to as 'sensors',

An electromechanical generator is a device capable of producing electrical power from mechanical energy, usually the turning of a shaft. When not connected to a load resistance, generators will generate voltage roughly proportional to shaft speed.

Tachogenerators can also indicate the direction of rotation by the polarity of the output voltage. When a permanent-magnet style DC generator's rotational direction is reversed, the polarity of its output voltage will switch.

### **VARIABLE INDUCTIVE LOAD 700MH.**

Variable inductive load is used to overcome the variation or fluctuations in the current. These variations in the current cause a jerking effect in the motor which reduce the efficiency of the motor.

### **FRICION BRAKE.**

In the trainer friction brake is used to increase the load on the dc motor. By tightening the screw of the brake show we can easily increase the load on the machine.

### **HAND TACHOMETER.**

A tachometer (revolution-counter, Tach, rev-counter, RPM gauge) is an instrument measuring the rotation speed of a shaft or disk, as in a motor or other machine. The device usually displays the revolutions per minute (RPM) on a calibrated analogue dial, but digital displays are increasingly common. The word comes from Greek  $\tau\alpha\chi\omicron\varsigma$ , tachos, "speed", and metron, "to measure".

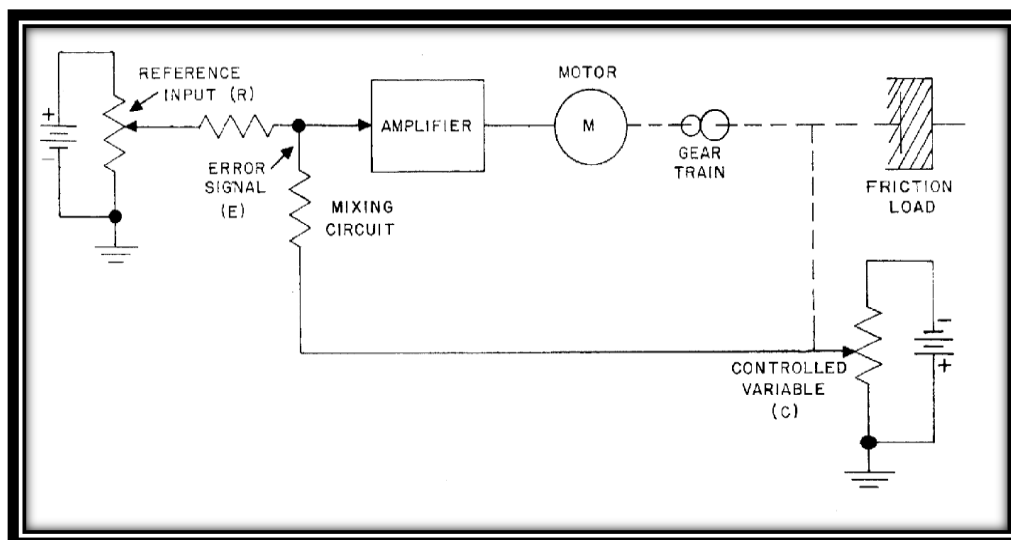
## LAB ASSIGNMENT NO: 4

### INTRODUCTION TO ANALOGUE/DIGITAL SERVO MOTOR TRAINER

#### **THEORY:**

In general, a low power device that adjusts or controls a more powerful device in response to the changes detected in one or more variables. servomechanism, automatic device used to correct the performance of a mechanism by means of an error-sensing feedback. The term servomechanism properly applies only to systems in which the feedback and error-correction signals control mechanical position or one of its derivatives such as velocity or acceleration.

In many applications, servomechanisms allow high-powered devices to be controlled by signals from devices of much lower power. The operation of the high-powered device results from a signal called the error, or difference, signal generated from a comparison of the desired position of the high-powered device with its actual position. The ratio between the power of the control signal and that of the device controlled can be on the order of billions to one.



## CONTROL SYSTEM LAB REPORT

All servomechanisms have at least these basic components: a controlled device, a command device, an error detector, an error-signal amplifier, and a device to perform any necessary error corrections or the [servomotor](#). This device must, therefore, have some means of generating a signal such as a voltage, called the [feedback signal](#), that represents its current position. This signal is sent to an error-detecting device. The command device receives information, usually from outside the system, that represents the desired position of the controlled device. This information is converted to a form usable by the system (such as a voltage) and is fed to the same error detector as is the signal from the controlled device. The error detector compares the feedback signal representing actual position with the command signal representing desired position. Any discrepancy results in an error signal that represents the correction necessary to bring the controlled device to its desired position. The error-correction signal is sent to an amplifier, and the amplified voltage is used to drive the servomotor, which repositions the controlled device.

A common type of servo provides position control. Servos are commonly electrical or partially electronic in nature, using an electric motor as the primary means of creating mechanical force. Other types of servos use hydraulics, pneumatics, or magnetic principles. Servos operate on the principle of negative feedback, where the control input is compared to the actual position of the mechanical system as measured by some sort of transducer at the output.

A servomotor is a [rotary actuator](#) that allows for precise control of angular position. It consists of a motor coupled to a sensor for position feedback, through a [reduction gearbox](#). It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

## CONTROL SYSTEM LAB REPORT

A servomotor is a [servomechanism](#). More specifically, it is a [closed-loop](#) servomechanism that uses position feedback to control its motion and final position. The input to its control is some signal, either analogue or digital, representing the position commanded for the output shaft.

The motor is paired with some type of [encoder](#) to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller. If the output position differs from that required, an [error signal](#) is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.

More sophisticated servomotors measure both the position and also the speed of the output shaft. They may also control the speed of their motor, rather than always running at full speed.

The type of motor is not critical to a servomotor and different types may be used. At the simplest, brushed permanent magnet DC motors are used, owing to their simplicity and low cost. For large industrial servomotors, AC induction motors are typically used, often with [variable frequency drives](#) to allow control of their speed. For ultimate performance in a compact package, brushless AC motors with permanent magnet fields are used.



Questions.

**What is servo motor? Explain different parts of servo motor along with their functioning.**

A servo motor is an electromechanical device in which an electrical input determines the position of the armature of the motor. The position of the armature of the motor is determined by the duty cycle of a periodic rectangular pulse train. A Servo is a small device that has an output shaft.

**Parts of servo motor:**

Electric motor      Position feedback potentiometer  
Reduction gear      Actuator arm

**Electric Motor:**

Servos use electric motor as the primary means of creating mechanical force.

**Position feedback potentiometer:**

Potentiometer is connected to the output shaft of the motor through gears. As the motor rotates the resistance of the pot changes, so that the circuit can measure exactly in what direction motor shaft is pointing. This pot allows the control circuitry to monitor the current angle of the servo motor. If the shaft is at the correct angle, then the motor shuts off. If the circuit finds that the angle is not correct, it will turn the motor the correct direction until the angle is correct.

### **Control Circuitry:**

The control circuitry contains a chip M51660L, which compares the error in positioning the motor. The chip contains a timer that produces pulse signals from the potentiometer. These signals are similar to the ones you supply. These two pulse signals the ones you are sending and the ones generated by the potentiometer are fed into a pulse width comparator. This comparator produces the signals indicating which direction the motor should turn in.

### **Explain different types of servo motor?**

AC Servo Motors based on Induction Motor Designs:

AC servos can handle higher current surges and tend to be used in industrial machinery.

AC Brushless Servo Motors based on Synchronous Motor Designs.

DC Servo Motors based on DC Motor Designs

DC servos are not designed for high current surges. Generally speaking, DC motors are less expensive than their AC counterparts

### **What are sensors? Search the web for different types of sensors used in control systems?**

A sensor is a quantity which converts one form of energy into another form of energy. Output in the form of electrical energy.

### **Transducer:**

A transducer is a device that converts one form of energy to another.

**Actuators:**

An actuator accepts energy and produces movement (action). The energy supplied to an actuator might be electrical or mechanical

**What is servo mechanism? Search for few practical examples of systems based on servomechanism?**

Servos operate on the principle of negative feedback where the control input is compared to the actual position of the mechanical system as measured by some sort of transducer at the output. Any difference between the actual and wanted values an "error signal" is amplified and used to drive the system in the direction necessary to reduce or eliminate the error.

A servomechanism may or may not use a servomotor. For example, a household furnace controlled by a thermostat is a servomechanism, yet there is no motor being controlled directly by the servomechanism. Servomechanisms were first used in military fire control and marine navigation equipment.

Also used in automatic machine tools, satellite tracking antennas, remote control air planes, automatic navigation systems in boats and planes, anti-air craft gun control systems. Opening and closing valves in furnaces.

**Explain the operation of an absolute encoder? In the trainer it is an encoder with 64 bit greyscale what can be the other code possibilities.**

The optical disk of the absolute encoder is designed to produce a digital word that distinguishes N distinct positions of the shaft. For example, if there are 8 tracks, the encoder is capable of producing 256 distinct positions or an angular resolution of  $1.406$  ( $360/256$ ) degrees. The most common types of numerical encoding used in the absolute encoder are gray and binary codes.

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The linear patterns and associated timing diagrams are what the photo detectors sense as the code disk circular tracks rotate with the shaft.

### **How does the magnetic brake works in the trainer?**

Magnetic brakes are used to create a condition when a system is loaded. Because in actual the brakes are applied and the condition that is created is same as when the load is applied on the system.

### **How does a tachogenerator work in the trainer?**

Tachogenerator are frequently used to power tachometers to measure the speeds of electric motors, engines, and the equipment they power. Generators generate voltage roughly proportional to shaft speed. With precise construction and design, generators can be built to produce very precise voltages for certain ranges of shaft speeds.

When we increase the voltage, the rpm is also increase, at the same time, the output of tachogenerator is also increases. Due to these effects, the current of armature is decreases and back emf is increase.

## LAB ASSIGNMENT NO: 5

### INTRODUCTION TO MAGNETIC LEVITATION TRAINER

#### THEORY:

First, a force is required directed vertically upwards and equal to the gravitational force, For levitation on Earth, second, for any small displacement of the levitating object, a returning force should appear to stabilize it.

Levitation from Latin levitas "lightness" is the process by which an object is suspended by a physical force against gravity, in a stable position without solid physical contact.

A number of different techniques have been developed to levitate matter, including the aerodynamic, magnetic, acoustic, electromagnetic, electrostatic, gas film, and optical levitation methods. The stable levitation can be naturally achieved by, for example, magnetic or aerodynamic forces.

Levitation techniques are useful tools in physics research. For example, levitation methods are useful for high-temperature melt property studies because they eliminate the problem of reaction with containers and allow deep undercooling of melts. The containerless conditions may be obtained by opposing gravity with a levitation force, or by allowing an entire experiment to freefall.

Although any electromagnetic force could be used to counteract gravity, magnetic levitation is the most common. Diamagnetic materials are commonly used for demonstration purposes. In this case the returning force appears from the interaction with the screening currents. For example, a superconducting sample, which can be considered either as a perfect diamagnet or an ideally hard superconductor, easily levitates in an ambient external magnetic field.

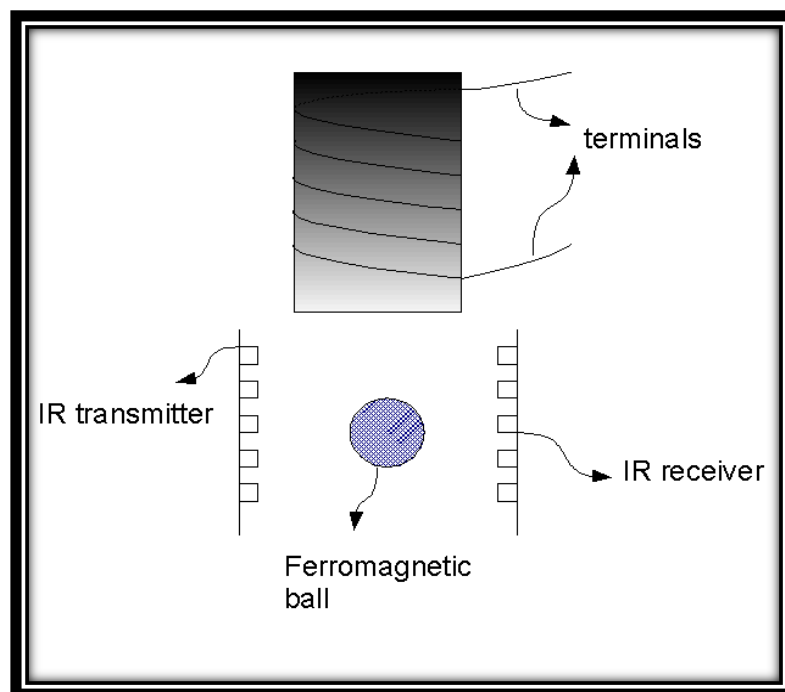
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In very strong magnetic field, by means of diamagnetic levitation even small live animals have been levitated.

Magnetic levitation is in development for use for transportation systems. For example the Maglev transportation includes trains that are levitated by a very large number of magnets and, due to the lack of friction on guide rails, they are potentially faster, quieter and smoother than wheeled mass transit systems.

### Questions :

Q. Draw the complete block diagram of magnetic levitation trainer? How does the loop work to keep the steel ball levitated?



When the current goes through the winding and electromagnetic force  $F$  will be generated.

By controlling the current in the electromagnet winding to balance the steel ball gravity force  $mg$  by the magnetic force, the steel ball will levitate in the air.

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Closed loop control is required for system stability and anti interference. The distance  $x$  from the steel ball to electromagnet is detected by the sensor system composed of light source and light sensor.

**Q. What type of magnetic materials exist which are suited best to make magnetic levitation System?**

Permanent magnet      Ferromagnetic materials  
Dimagnetism material

Dimagnetism is best suited to make magnetic levitation system.

A diamagnetic substance is one whose atoms have no permanent magnetic dipole moment. When an external magnetic field is applied to a diamagnetic substance such as bismuth or silver a weak magnetic dipole moment is induced in the direction opposite the applied field. All materials are actually diamagnetic, in that a weak repulsive force is generated by in a magnetic field by the current of the orbiting electron. Some materials, however, have stronger paramagnetic qualities that overcome their natural diamagnetic qualities. These paramagnetic materials, such as iron and nickel, have unpaired electrons.

**Q. Search examples of magnetic levitation systems from web?**

ElectroMagnetic Suspension (EMS). EDS electro dynamic suspension.

**Q.WHAT IS PID CONTROL?How do the performance of a control loop improved by the addition of proportional ,integration and derivative control?**

A PID controller is an algorithm used in closed loop control. It is a simple means to maintain an output variable, such as temperature, level, flow, current, within a limited range through feedback control.



## CONTROL SYSTEM LAB REPORT

It stands for

P : proportional, the inverse of gain; I : integral action, the inverse of "reset"

D: derivative action, aka, "rate"

*proportional band is defined as the amount of change in the controlled variable required to drive the loop output from 0 to 100%.*

*The integral component of a control loop has the effect of continuing to increase or decrease the output as long as any offset or droop continues to exist.*

*Derivative action adds the effect of the error's differential or rate of change.*

**Q. what are hall effect sensors?**

A Hall effect sensor is a [transducer](#) that varies its output [voltage](#) in response to a [magnetic field](#). [Hall effect](#) sensors are used for proximity switching, positioning, speed detection, and current sensing applications.

**Q.what are the other types of photoelectric sensors present?**

Opposed through beam, retro-reflective, and proximity *sensing* diffused.

**Q.how does a magnetic levitation trainer work ?what is drag regarding that?**

Magnetic levitation or magnetic suspension is a method by which an object is [suspended](#) with no support other than [magnetic fields](#). [Magnetic pressure](#) is used to counteract the effects of the [gravitational](#) and any other accelerations. Magnetic Levitation means the support and propulsion of objects or vehicles by the use of magnets. The magnets provide support without contact or friction, allowing for fast, quiet operation.

Transients in the lift and drag forces on a NdFeB permanent magnet were observed as the magnet passed over various discontinuities in a rotating aluminum disk at velocities of 4 to 25 m/s. For full cuts in the disk, the amplitude of the lift and drag transients and the wave form of the drag transient depend on the width, and the amplitudes are much larger than for partial cuts. The use of a backing plate to join two cut segments is ineffective.

**Q.what are magnetic bearings and what are their advantages?**

A magnetic bearing is a [bearing](#) that supports a load using [magnetic levitation](#). Magnetic bearings support moving machinery without physical contact.

**Advantages :**

Since there is no friction, no lubrication is necessary.

They can run in a vacuum .

They have no known relative speed limit.

It's possible for them to be free from contamination.

**Q.Explain the working of a magnetically levitated wind turbine?**

It's a vision of a magnetically levitated wind turbine that can generate one gigawatt of power enough to power 750,000 homes. This is the device proposed by a new Arizona-based company, [MagLev Wind Turbine Technologies](#). The company claims that it can deliver clean power for less than one cent per kilowatt hour using this wind turbine.

Magnetic levitation is a very efficient method of capturing wind energy. The blades of the turbine are suspended on a cushion of air, and the energy is directed to linear generators with minimal friction losses. But the big advantage with maglev is that it reduces maintenance costs, and increases the lifespan of the generator.

## LAB ASSIGNMENT NO: 6

### TO CONTROL THE LEVEL PARAMETERS OF CONTROL SYSTEM

#### **THEORY:**

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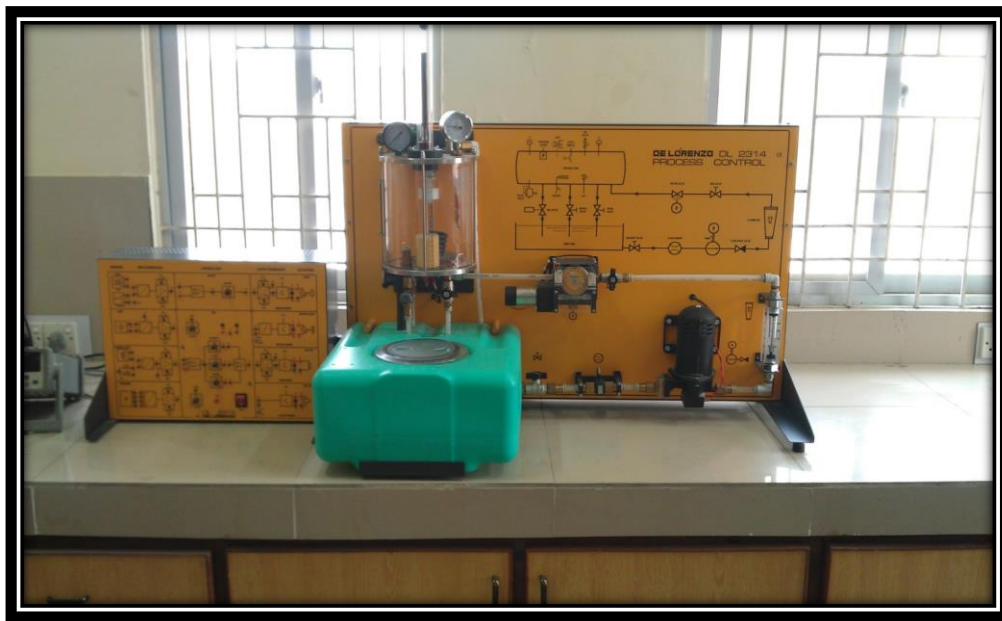
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Now, in this lab our job was to control the temperature and level of this system. According to the level set point, control system generates an error signal that actuates the actuator to operate the solenoid valve or pressure pump to meet the desired level. Pump is on to supply the more flow, to increase the level, whereas, solenoid valve is opened to drain out the flow to the reservoir.

A common way of measuring the level of liquid in a tank places a low-pressure sensor at the bottom. The use of a float attached to a nearly friction-free linear-variable-displacement transducer (LVDT) offers a reasonable

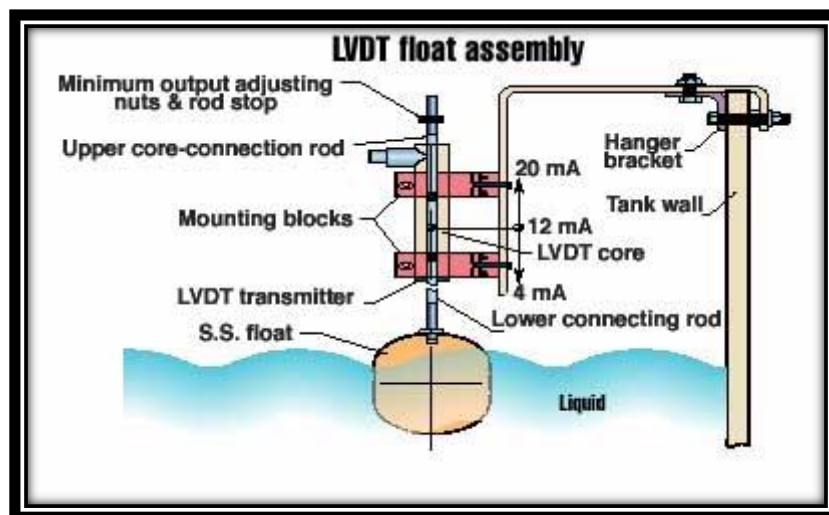
## CONTROL SYSTEM LAB REPORT

replacement. LVDTs can measure liquid-level changes from a few inches to several feet.

In the typical LVDT level sensor, a stainless-steel float coupled to a nonmagnetic stainless-steel rod is attached to the high-permeability armature core of the LVDT. The 4 to 20-mA loop-powered LVDT position transmitter senses the position of the core and, thus, the level of the float. Sensitivity to the change in level depends on the length of LVDT. The most common units measure level changes from 0 to 2, 12, or 20 in. (50, 300, or 500 mm) with the shorter lengths providing greatest sensitivity.

As water level changes, the float moves up or down, bringing the LVDT core with it. A threaded stainless-steel rod protrudes from the other end of the core. It carries two jam nuts to adjust the position sensor output at the desired low water level. The nuts also prevent the core from falling out of the LVDT housing if the liquid level drops too low.

A nonmagnetic clamp block attaches the stainless-steel body of the LVDT to a flat hook. The hook hangs the level-sensor assembly over the tank edge.



## CONTROL SYSTEM LAB REPORT

Float Sensor is an electrical ON/OFF Switch, which operates automatically when liquid level goes up or down with respect to specified level. The Signal thus available from the Float Sensor can be utilized for control of a Motor Pump or an allied electrical element like Solenoid, Lamps, and Relays etc.

Float Sensors contain hermetical sealed Reed Switch in the stem and a permanent Magnet in the Float. As the Float rises or falls with the level of liquid the Reed Switch is activated by Magnet in the Float.

Hamilton Float Sensors are available in wide range according to operation / material/ mounting methods to suit variety of individual application. These Float sensors are rugged, accurate and reliable in operation.



Output from these sensor goes to the control section where the set point & level is compared and amplified. Then this amplified signal operate the actuators, i.e pump or solenoid valve.

CONTROL SYSTEM LAB REPORT

**Calculations:**

Reference Voltage = 10

Sensor Voltage (V)	Water Level (CM)
0	5.6
1	6.5
2	7.3
3.06	8.4
4.04	9.2
5	10
6.01	10.7
7	11.6
8.03	12.5
9	13.3
10.1	14.2



## LAB ASSIGNMENT NO: 7

### TO STUDY PID CONTROLLER AND CONTROL LEVEL OF PROCESS TANK

#### **THEORY:**

It is a trainer that controls multi process variables using different sensors. Mainly it controls the level, pressure, temperature and flow. It uses different sensors to sense these parameters. The sensor output is sent to the transducer to create the error signal that controls the actuator movement. This actuator controls the final energy flow to the process.

Process control is a statistics and engineering discipline that deals with architectures, mechanisms and algorithms for maintaining the output of a specific process within a desired range.

It is a model of industrial process control.

It consists of the following main parts that are as follows:

#### **Control panel.**

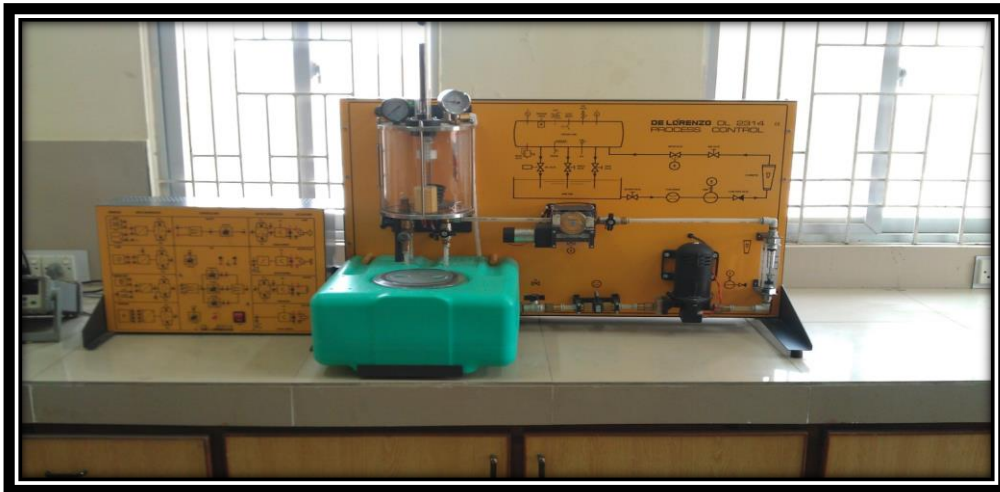
It is a panel on which on whole picture of industrial control is illustrated. Here is a complete and separate section for every individual control system.

#### **Process Tank.**

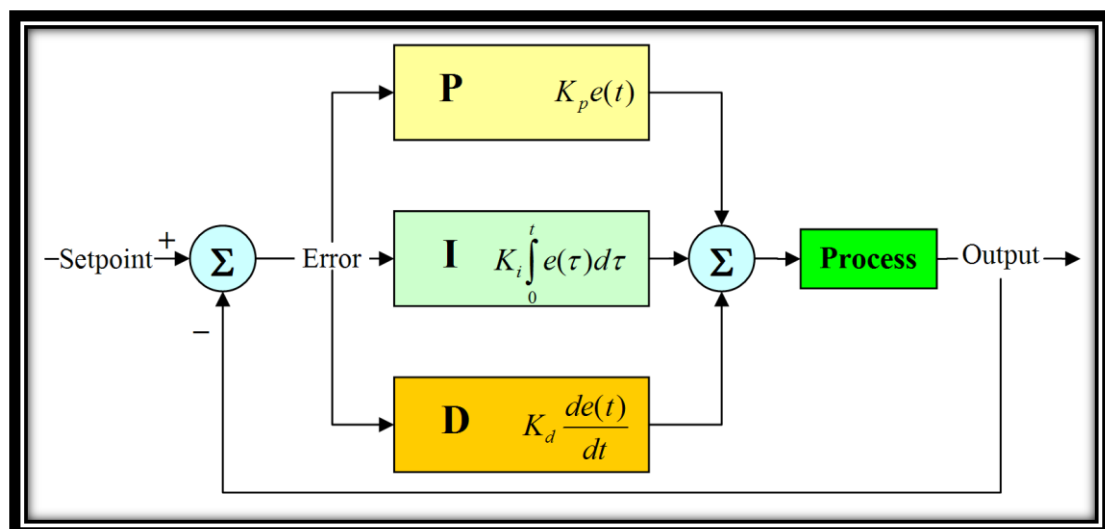
It is a tank in which all processes are monitored and controlled. It is just a replica of industrial process tank. More practically saying, it is like a boiler.

## CONTROL SYSTEM LAB REPORT

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PID controllers can be viewed as three terms – a proportional term, and integral term and a derivative term – added together. PID controllers are also known as three-term controllers and three-mode controllers. Here's a block diagram representation of the PID.



## CONTROL SYSTEM LAB REPORT

There are three controllers acting in concert.

A proportional                      An Integral                      A Derivative

The proportional, integral and derivative outputs are added together.

The PID controller can be thought of as having a transfer function.

The PID controller transfer function can be obtained by adding the three terms.

$$\text{PID}(s) = K_p + K_i/s + sK_d$$

The transfer function can be combined into a pole-zero form.

$$\text{PID}(s) = [sK_p + K_i + s^2K_d]/s$$

Since there is a quadratic in the numerator, there are two zeroes in this transfer function as well as the obvious pole at the origin,  $s = 0$ .

PID controller is the most common control methodology in process control. It is a continuous feedback loop that keeps the process flowing normally by taking corrective action whenever there is any deviation from the desired value of the process variable.

PID is the most commonly used feedback controller. Intuitively, the PID loop tries to automate what an intelligent operator with a gauge and a control knob would do. The operator would read a gauge showing the output measurement of a process, and use the knob to adjust the input of the process until the process's output measurement stabilizes at the desired value on the gauge. As the controller reads a sensor, it subtracts this measurement from the set point to determine the error. It then uses the error to calculate a correction to the process's input variable so that this correction will remove the error from the process's output measurement.

The proportional term produces an output value that is proportional to the current error value. The proportional response can be adjusted by multiplying the error by a constant  $K_p$ , called the proportional gain constant. The proportional term is given by:

## CONTROL SYSTEM LAB REPORT

$$P_{\text{out}} = K_p e(t)$$

A high proportional gain results in a large change in the output for a given change in the error. If the proportional gain is too high, the system can become unstable.

The contribution from the integral term is proportional to both the magnitude of the error and the duration of the error. The integral in a PID controller is the sum of the instantaneous error over time and gives the accumulated offset that should have been corrected previously. The accumulated error is then multiplied by the integral gain ( $K_i$ ) and added to the controller output.

The integral term is given by:

$$I_{\text{out}} = K_i \int_0^t e(\tau) d\tau$$

The integral term accelerates the movement of the process towards set point and eliminates the residual steady-state error that occurs with a pure proportional controller. However, since the integral term responds to accumulated errors from the past, it can cause the present value to overshoot the set point value.

The derivative of the process error is calculated by determining the slope of the error over time and multiplying this rate of change by the derivative gain  $K_d$ . The magnitude of the contribution of the derivative term to the overall control action is termed the derivative gain,  $K_d$ .

The derivative term is given by:

$$D_{\text{out}} = K_d \frac{d}{dt} e(t)$$

The derivative term slows the rate of change of the controller output. Derivative control is used to reduce the magnitude of the overshoot produced by the integral component and improve the combined controller-process stability. However, the derivative term slows the transient response of the controller.

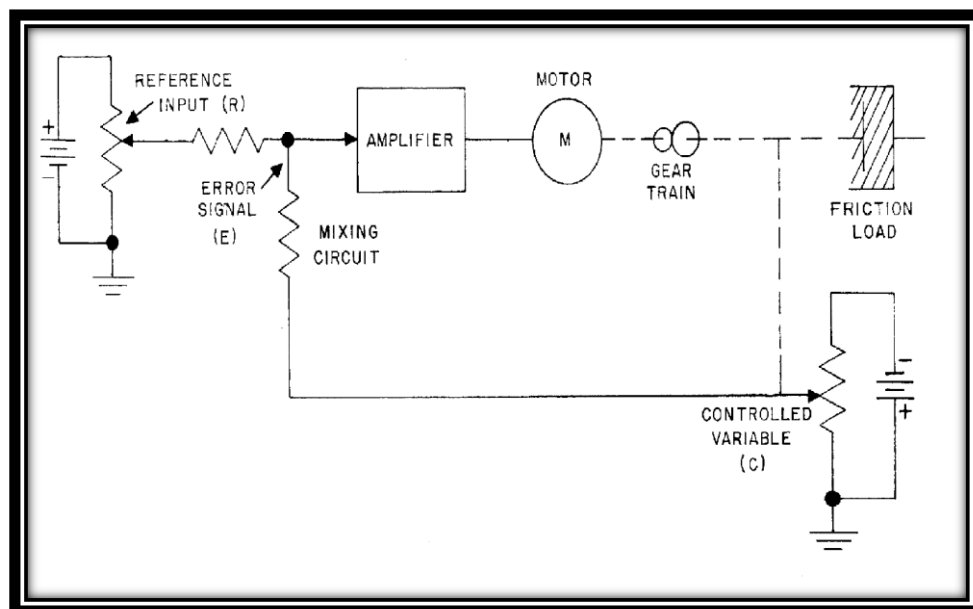
## LAB ASSIGNMENT NO: 8

### CLOSED LOOP SPEED CONTROL AND IMPACT OF GAIN ON TRANSIENT RESPONSE

#### THEORY:

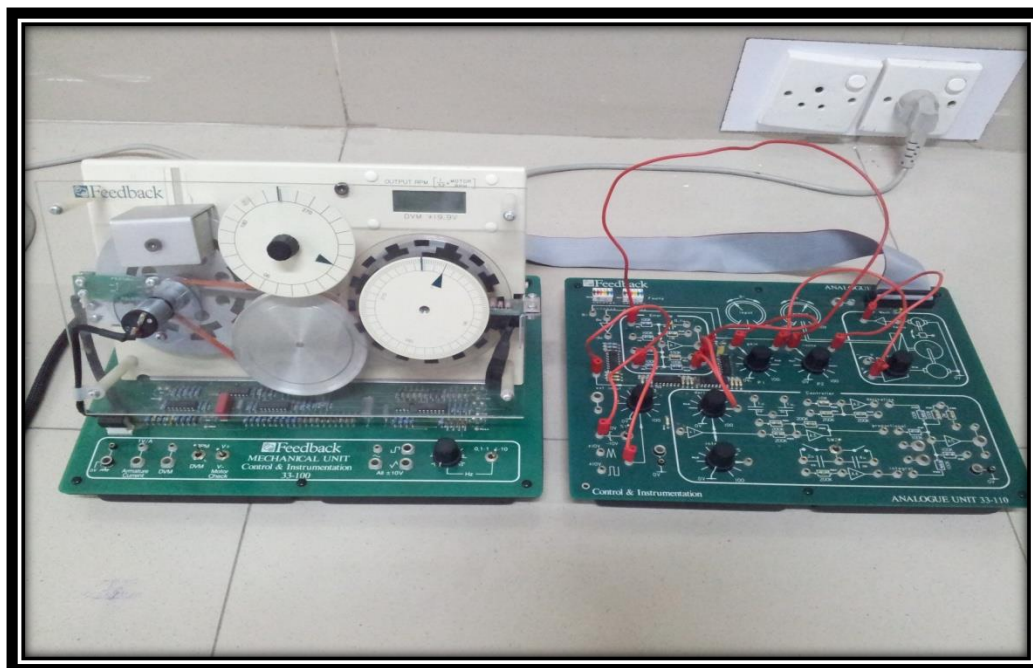
In general, a low power device that adjusts or controls a more powerful device in response to the changes detected in one or more variables. servomechanism, automatic device used to correct the performance of a mechanism by means of an error-sensing feedback. The term servomechanism properly applies only to systems in which the feedback and error-correction signals control mechanical position or one of its derivatives such as velocity or acceleration.

In many applications, servomechanisms allow high-powered devices to be controlled by signals from devices of much lower power. The operation of the high-powered device results from a signal called the error, or difference, signal generated from a comparison of the desired position of the high-powered device with its actual position. The ratio between the power of the control signal and that of the device controlled can be on the order of billions to one.



## CONTROL SYSTEM LAB REPORT

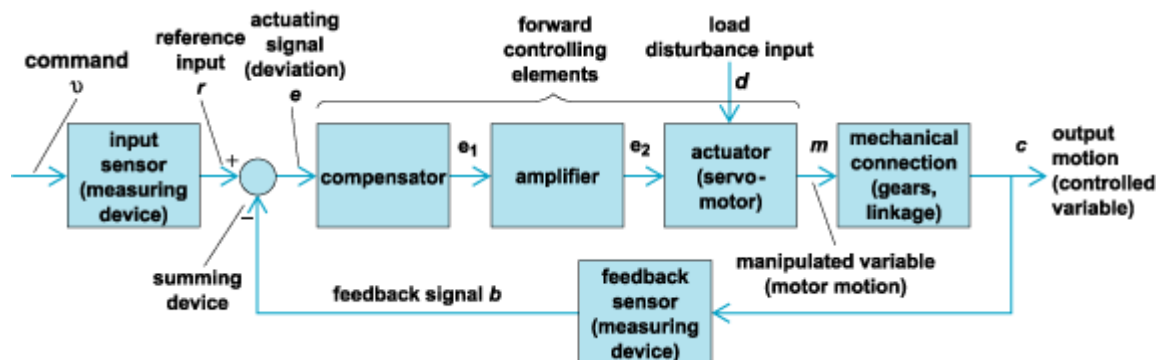
All servomechanisms have at least these basic components: a controlled device, a command device, an error detector, an error-signal amplifier, and a device to perform any necessary error corrections or the [servomotor](#). This device must, therefore, have some means of generating a signal such as a voltage, called the [feedback signal](#), that represents its current position. This signal is sent to an error-detecting device. The command device receives information, usually from outside the system, that represents the desired position of the controlled device. This information is converted to a form usable by the system (such as a voltage) and is fed to the same error detector as is the signal from the controlled device. The error detector compares the feedback signal representing actual position with the command signal representing desired position. Any discrepancy results in an error signal that represents the correction necessary to bring the controlled device to its desired position. The error-correction signal is sent to an amplifier, and the amplified voltage is used to drive the servomotor, which repositions the controlled device.





### Questions

Q-Draw the complete block diagram of the system



Q- Explain the operation of magnetic brake and tachogenerator in the system

Magnetic brakes are made up of one or two rows of very strong neodymium magnets. When a metal shaft of motor passes between the rows of magnets, eddy currents are generated in the fin, which creates a magnetic field opposing the fin's motion. The resultant braking force is directly proportional to the speed at which the fin is moving through the brake element.

Tachogenerators are also called as rate generators. These are electromechanical transducers which convert angular velocity of shaft into electrical signal. Tachogenerator is used in the system to convert angular velocity of shaft into electrical signal. So these are used in control system as speed transducers, as damping devices and as electro mechanical integrator. Tachogenerators can also indicate the direction of rotation by the polarity of the output voltage

Q-Different types of speed and position sensors practically available?

**Position Sensor:**

1-Capacitive displacement sensors “are non-contact devices capable of high-resolution measurement of the position and/or change of position of any conductive target”. They are also able to measure the thickness or density of non-conductive materials.



## CONTROL SYSTEM LAB REPORT

2-A Hall effect sensor is a transducer that varies its output voltage in response to a magnetic field. Hall effect sensors are used for proximity switching, positioning, speed detection, and current sensing applications. In its simplest form, the sensor operates as an analog transducer, directly returning a voltage. With a known magnetic field, its distance from the Hall plate can be determined. Using groups of sensors, the relative position of the magnet can be deduced.

3- Ultrasonic sensors also known as transceivers when they both send and receive work on a principle similar to radar or sonar which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object.

### **Speed Sensors:**

1-A wheel speed sensor or vehicle speed sensor (VSS) is a type of tachometer. It is a sender device used for reading the speed of a vehicle's wheel rotation. It usually consists of a toothed ring and pickup.

2- **Variable reluctance** magnetic speed sensors are most often self-generating. In other words, they do not require an external power source. When a magnetic surface is passed in close proximity to the sensor, a small voltage is induced.

### **Q-How do you control the speed in the closed loop set up?**

In a feedback control system, information about performance is measured and that information is used to correct how the system performs. Here in servo motor a tachogenerator is used in backward path which provide the voltage to comparator and copmparator generate error signal which drive motor. Load changes on the motor shaft in the system are automatically compensated.

**Q-Explain the dependency of transient response and stability of system on the system gain?**

The gain of the system helps in improving the transient response by reducing deadband. Increasing the gain causes a faster response but if too much gain is applied the response may overshoot and take several oscillations before settling mean stability of the system decreases.

**Q-State importance and application of control mechanism?**

Means by which a set of variable quantities is held constant or caused to vary in a prescribed way. Control systems are intimately related to the concept of [automation](#). Familiar control systems have the basic closed-loop configuration. In industry, there are controls for speed, process temperature and pressure, position, thickness, composition and quality, among many others. Speed control mechanism are commonly used for high-precision feed and digital control.

A governor is a practical example of speed control mechanism, also known as [speed limiter](#), is a [device](#) used to measure and regulate the [speed](#) of a [machine](#), such as an [engine](#). A classic example is the [centrifugal governor](#), also known as the [Watt](#) or fly-ball governor, which uses weights mounted on spring-loaded arms to determine how fast a shaft is spinning, and then uses [proportional control](#) to regulate the shaft speed.

**Q-Clarify the use of operational amplifiers in the whole set up?**

Operational amplifiers are used to give gain to the system. Gain is required to increase the input or error signal so that it can drive the motor to meet the required position. Sometimes there are cases when the error signal will insufficient to drive the motor hence amplifier must be required.

*CONTROL SYSTEM LAB REPORT*

Calculations:

Open loop speed control:

LOAD (%)	$N_{RPM}$
0	54
25	53.0
50	43.7
75	35.9
100	32.2

Closed loop speed control:

LOAD (%)	P = 30	P = 60	P = 100
	$N_{RPM}$	$N_{RPM}$	$N_{RPM}$
0	41.5	30	28.7
25	39.5	29	27.9
50	33.7	26.4	25.2
75	28.3	22.9	22.4
100	24.7	21.1	20.5

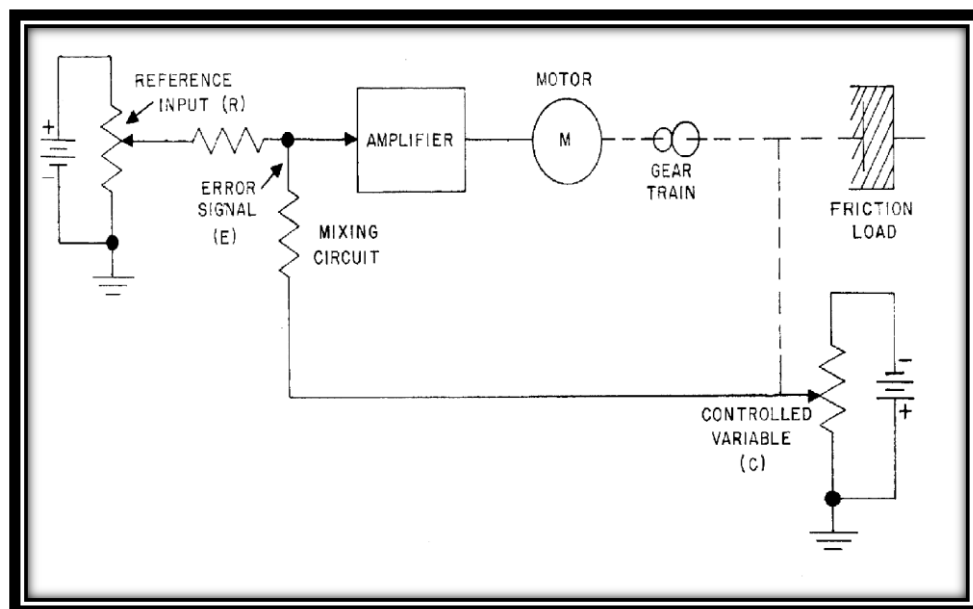
## LAB ASSIGNMENT NO: 9

### THE EFFECT OF VELOCITY FEEDBACK SIMULTANEOUSLY WITH POSITION FEEDBACK ON TRANSIENT AND STEADY STATE RESPONSE OF THE SYSTEM

#### THEORY:

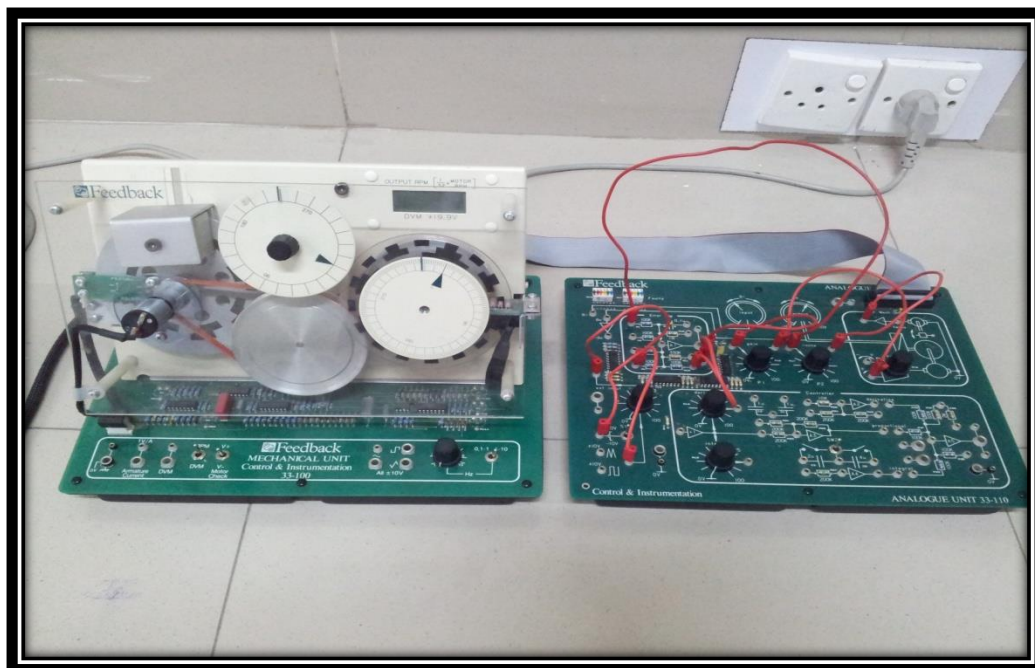
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In many applications, servomechanisms allow high-powered devices to be controlled by signals from devices of much lower power. The operation of the high-powered device results from a signal called the error, or difference, signal generated from a comparison of the desired position of the high-powered device with its actual position. The ratio between the power of the control signal and that of the device controlled can be on the order of billions to one.



## CONTROL SYSTEM LAB REPORT

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Questions

**Q – Clearly explain the operation of simultaneous use of velocity feedback with position feedback on system errors?**

Initially when the motor is just started error voltage ( $V_e$ ) is max and with increase in gain its transient response increases very well but the motor overshoot the required final position. But when motor speed up, velocity feedback signal increases with increase in speed of the motor. So it can be said that initially  $V_e = \text{max}$  and  $V_s = 0$ , it is subtracted from  $V_e$  to give control voltage  $V_c = V_e - V_s$ , which is less than  $V_e$ .

Ultimately the polarity of  $V_c$  reverses, At this stage motor drive goes to zero and reverses to overcome overshoot before the  $V_e$  goes to zero. This means that motor begins to slow up before the initial alignment, greatly reducing or even preventing any overshoot.

**Q- What will happen to the system if the polarity of velocity feedback is reversed?**

In closed-loop systems, feedback signals may be either Regenerative or Degenerative. Regenerative feedback exists when the feedback polarity or phase relationship acts to aid or boost the main control signal. If the amplitude of the feedback is sufficiently large oscillations will be developed. This is the principal used in the operation of radio frequency oscillators. When regenerative feedback is used in control systems, such in the case of IR Compensation, the effect of excessive feedback must limited, otherwise instability will result.

Degenerative feedback, on the other hand, will dampen oscillations and produce system stability. In degenerative feedback, the phase relationship or polarity of the feedback signal acts to cancel or reduce that of the main control signal.

Feedback polarity is critical and proper feedback polarity must be determined when commissioning equipment which consists of separate

## CONTROL SYSTEM LAB REPORT

control and feedback devices. This is not a concern to the installer of a packaged system where the control and feedback devices are pre-wired as a complete system.

**Q-What is the impact of tachogenerator gain on the system output?**

If the tachogenerator gain increases then the feedback velocity signal will be amplified and then when it will be subtracted from the set point, an error signal will be generated in such a way that drives the motor to the required position without overshoot

**Q-How is the system overshoot related to the system gain and tachogenerator gains?**

In the system gain used to amplify the signal and tachogenerator is used for velocity feedback. It serves the purpose of modifying the error signal so that the modified signal goes to zero before the desired position is reached. This prevents the motor from accelerating right up to the desired position so that inertia causes it to overshoot.



*CONTROL SYSTEM LAB REPORT*

**Observations & Calculations**

P2	P1 = 20		P1 = 50		P1 = 100	
	Time To Align	Overshoot	Time To align	Overshoot	Time To Align	Overshoot
10	3.29	No	3.22	Yes	3.52	Yes
30	3.52	No	3.25	Yes	3.44	Yes
50	3.62	No	2.39	No	2.10	Yes
80	3.30	No	2.20	No	1.42	No
100	3.25	No	1.98	No	1.24	No

## LAB ASSIGNMENT NO: 10

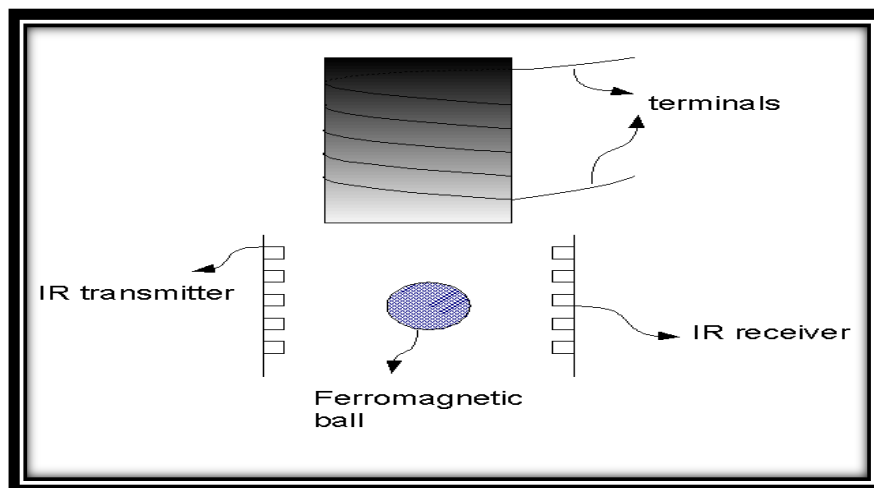
### TO UNDERSTAND THE 3 TERM PID (PROPORTIONAL, INTEGRAL AND DERIVATIVE ) CONTROL ON PID CONTROL UNIT

#### THEORY:

First, a force is required directed vertically upwards and equal to the gravitational force, For levitation on Earth, second, for any small displacement of the levitating object, a returning force should appear to stabilize it.

Levitation from Latin levitas "lightness" is the process by which an object is suspended by a physical force against gravity, in a stable position without solid physical contact.

A number of different techniques have been developed to levitate matter, including the aerodynamic, magnetic, acoustic, electromagnetic, electrostatic, gas film, and optical levitation methods. The stable levitation can be naturally achieved by, for example, magnetic or aerodynamic forces.



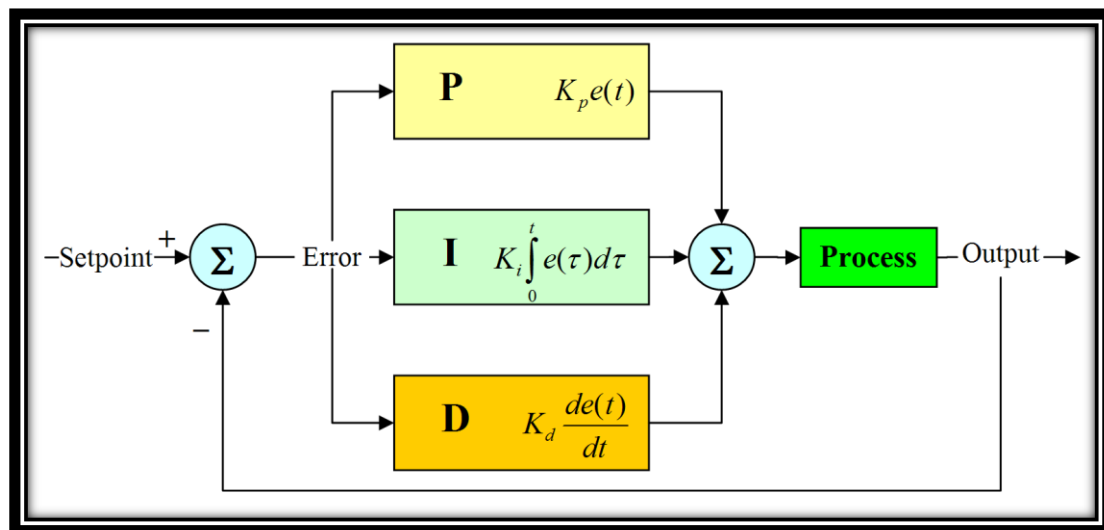
Levitation techniques are useful tools in physics research. For example, levitation methods are useful for high-temperature melt property studies because they eliminate the problem of reaction with containers and allow deep undercooling of melts. The containerless conditions may be obtained by

## CONTROL SYSTEM LAB REPORT

opposing gravity with a levitation force, or by allowing an entire experiment to freefall.

Although any electromagnetic force could be used to counteract gravity, magnetic levitation is the most common. [Diamagnetic](#) materials are commonly used for demonstration purposes. In this case the returning force appears from the interaction with the [screening currents](#). For example, a [superconducting](#) sample, which can be considered either as a perfect diamagnet or an [ideally hard superconductor](#), easily levitates in an ambient external magnetic field.

PID controllers can be viewed as three terms – a proportional term, and integral term and a derivative term – added together. PID controllers are also known as three-term controllers and three-mode controllers. Here's a block diagram representation of the PID.



There are three controllers acting in concert.

A proportional

An Integral

A Derivative

The proportional, integral and derivative outputs are added together.

The PID controller can be thought of as having a transfer function.

The PID controller transfer function can be obtained by adding the three terms.

$$\text{PID}(s) = K_p + K_i/s + sK_d$$

The transfer function can be combined into a pole-zero form.

## CONTROL SYSTEM LAB REPORT

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$$P_{\text{out}} = K_p e(t)$$

A high proportional gain results in a large change in the output for a given change in the error. If the proportional gain is too high, the system can become unstable.

The contribution from the integral term is proportional to both the magnitude of the error and the duration of the error. The integral in a PID controller is the sum of the instantaneous error over time and gives the accumulated offset that should have been corrected previously. The

## CONTROL SYSTEM LAB REPORT

accumulated error is then multiplied by the integral gain ( $K_i$ ) and added to the controller output.

The integral term is given by:

$$I_{\text{out}} = K_i \int_0^t e(\tau) d\tau$$

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The derivative term is given by:

$$D_{\text{out}} = K_d \frac{d}{dt} e(t)$$

The derivative term slows the rate of change of the controller output. Derivative control is used to reduce the magnitude of the overshoot produced by the integral component and improve the combined controller-process stability. However, the derivative term slows the transient response of the controller.

Questions

Q-Completely illustrate electronic diagram of each and every block of the analog controller unit used in the lab containing proportional, inertial, integral, derivative, subtraction and summation blocks.

The major components of analog control system are

Signal Source Module, Signal setting module

Signal connector module, Power Supply

Subtraction element, Summation element

Inertial element, Proportional element

Integration element, Differential element

**Signal Source Module.**

The unit contains ICL8038 which produces square, triangular and sinusoidal wave through tuning the adjustable resistance RP2 to change the frequency of three output signals.

**Signal Setting Module.**

It can change the scale of the given signal through tuning the adjustable resistance RP1.

**Signal Connector Module.**

This module is specifically designed for magnetic levitation. H2 is sensor connector and H1 is the control output for magnetic levitation. Details for DB9 connector are as:

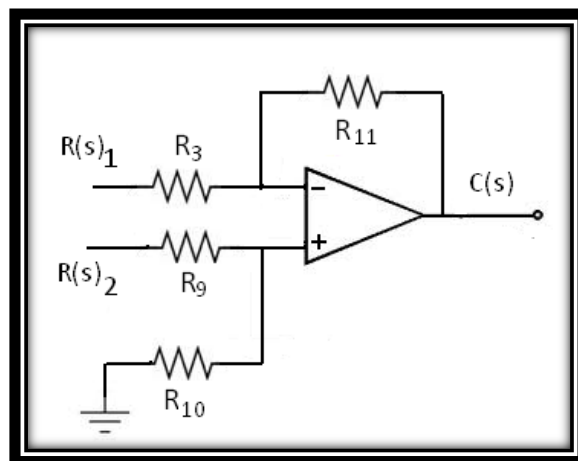
1 feet	2 feet	3 feet	4 feet	5 feet	6 feet	7 feet	8 feet	9 feet
none	none	none	GND	none	H1	H2	-12V	+12V

**Power Supply:**

The module is composed by the power supply switch and the power supply plug. The power supply plug from the experiment chamber connecting to the play line board (220V) provides the power for the switch power supply of the experiment chamber.

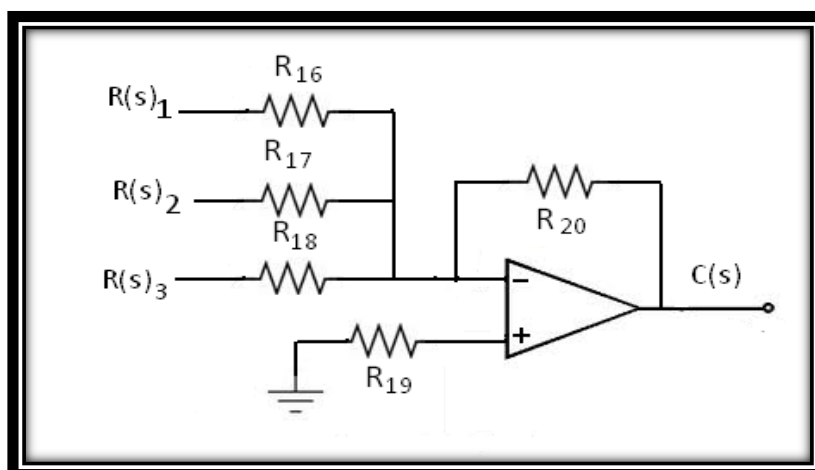
**Subtraction element:**

Subtraction circuit is made using op-amp and it is used to perform the operation  $V^+ - V^-$



**Summation element:**

The summer circuit is used to add the input voltages applied on its terminal and is used to add the outputs from PID controller and fed to process.

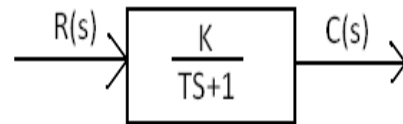
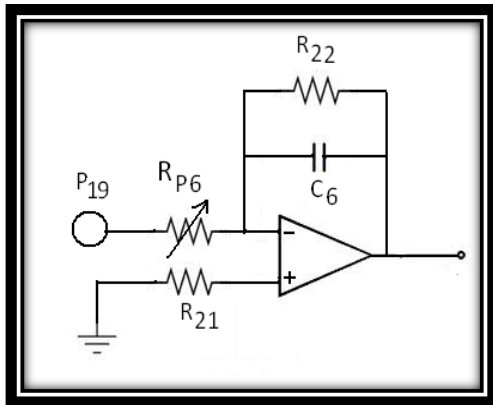




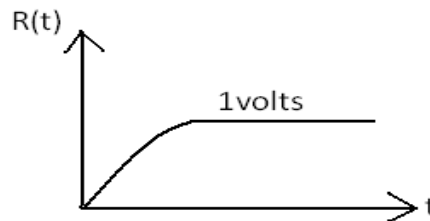
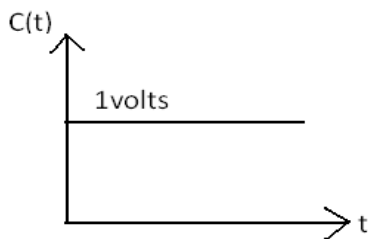
**Inertial element:**

Its diagram is shown as

The block diagram of inertia element is

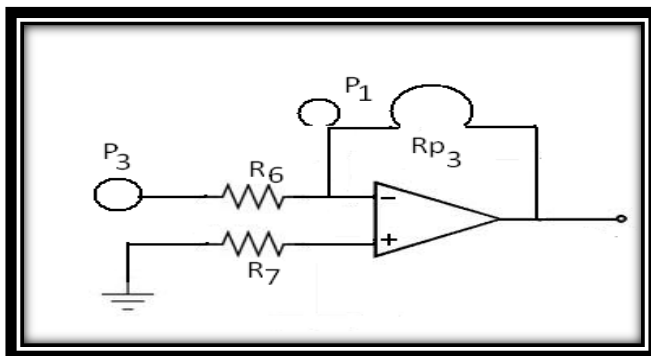


The unit step response plot of inertia element is

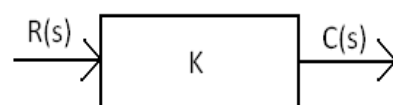


**Proportional element:**

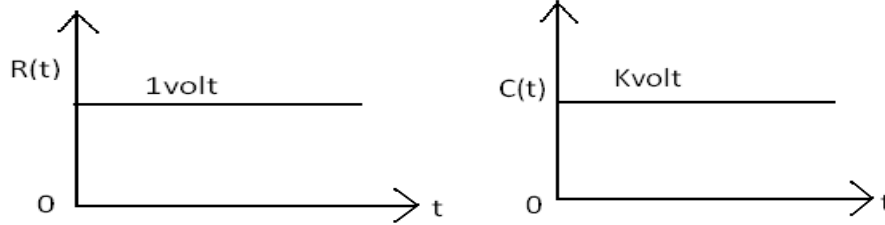
An inverting op-amp with a variable output resistance which gives the input signal variable gain on moving knob and multiply the input with the value of gain to give output.



Block Diagram

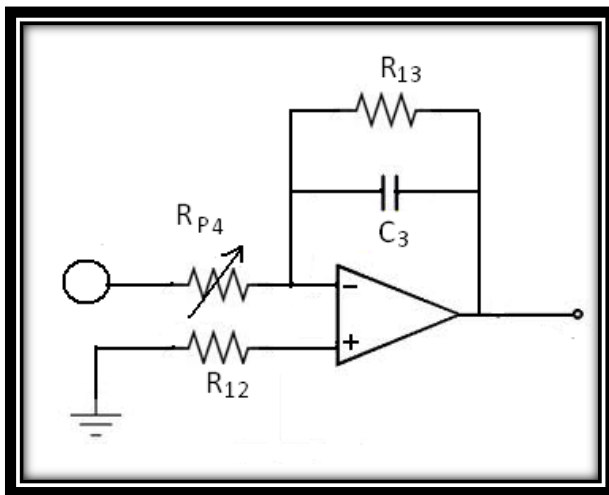


## CONTROL SYSTEM LAB REPORT

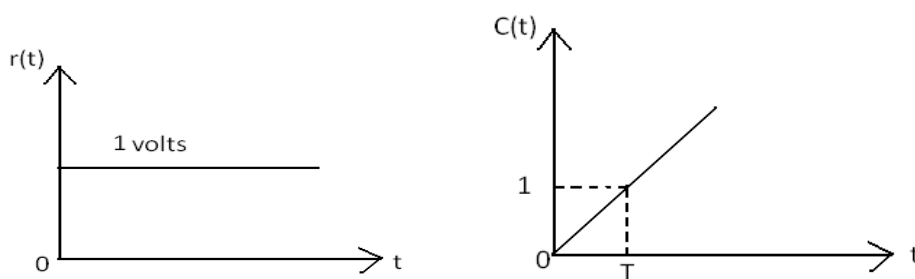
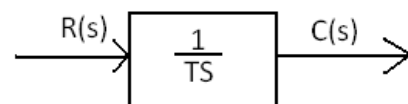


### Integration element:

To integrate the input so the output obtained is integrated and inverted. Function of integrator in PID control is to slow down. In other words, it is responsible to determine the speed of process.



The block diagram is



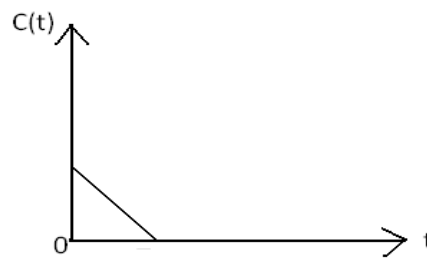
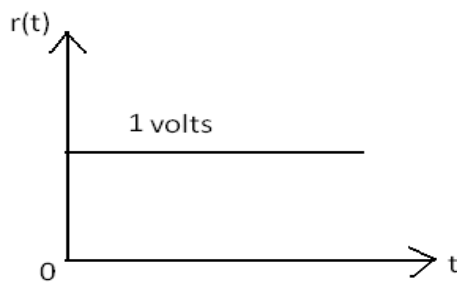
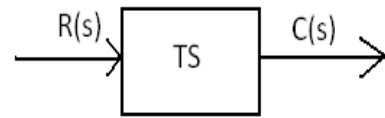
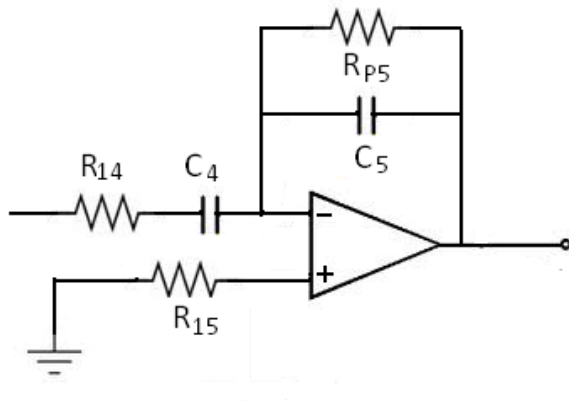
### Differential element:

Differential control is the element of PID controller the differential element is made using op-amp and is used to fasten the unit differential element can eliminate the error immediately can minimize overshoot, overcome oscillation, thus make the system stable.

CONTROL SYSTEM LAB REPORT

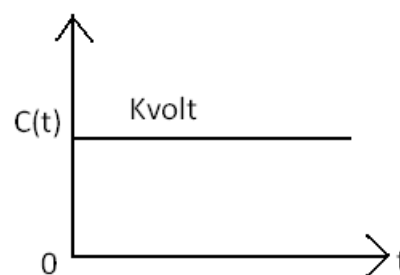
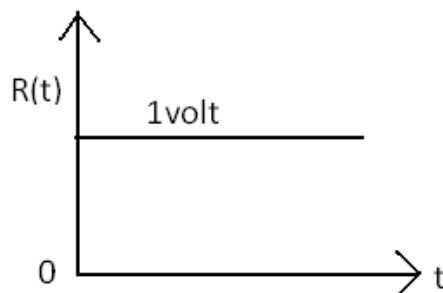
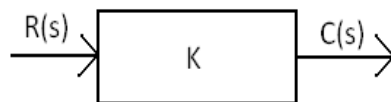
The diagram of differential element is

The block diagram is

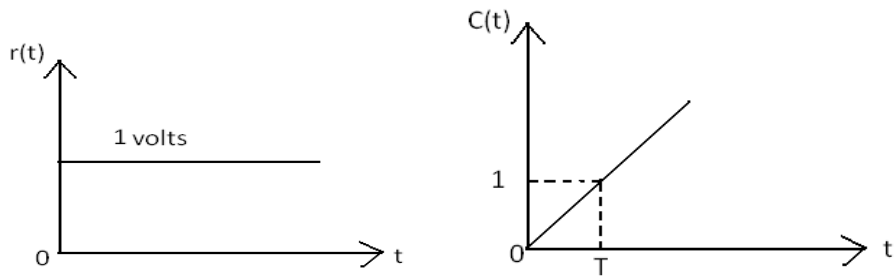
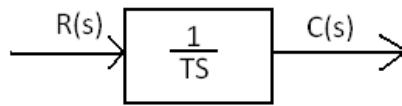


Q-Also represent the Laplace transformation of each block and find step response in time and frequency domain.

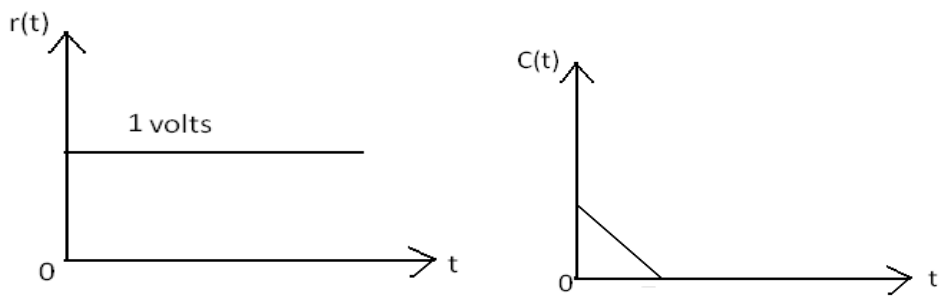
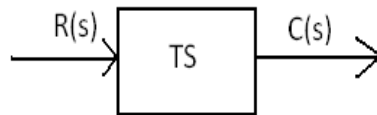
Proportion element.



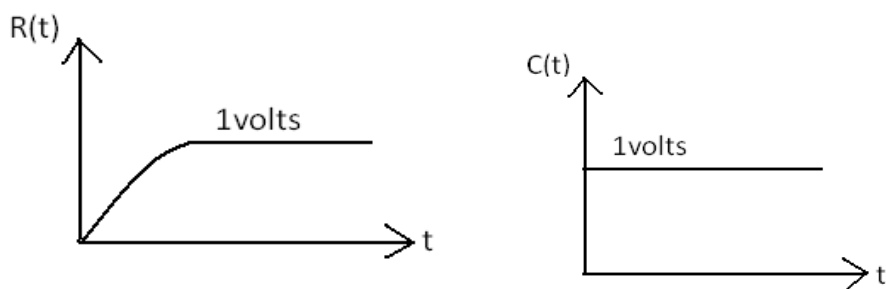
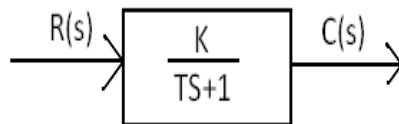
**Integral element.**



**Differential element.**



**Inertial element.**



**Q-Prepare the tables given in the text. Discuss the impact of values of K, K<sub>p</sub>, and K<sub>d</sub> obtained through the experimental procedure on loop tuning.**

**Proportional gain(k<sub>p</sub>):**

Larger values typically mean faster response since the larger the error, the larger the Proportional term compensation. An excessively large proportional gain will lead to process instability and oscillation.

**Integral gain (K<sub>i</sub>):**

Larger values imply steady state errors are eliminated more quickly. The trade-off is larger overshoot: any negative error integrated during transient response must be integrated away by positive error before we reach steady state.

**Derivative gain(K<sub>d</sub>) :**

Larger values decrease overshoot, but slows down transient response and may lead to instability due to signal noise amplification in the differentiation of the error.

**Q-What is the importance and limitations of PID control.**

A PID controller is used in closed loop control. It is a simple means to maintain an output variable, such as temperature, level, flow, current, within a limited range through feedback control. The PID control scheme is named after its three correcting terms, whose sum constitutes the manipulated variable (MV). The proportional, integral, and derivative terms are summed to calculate the output of the PID controller. Defining  $u(t)$  as the controller output, the final form of the PID algorithm is:

$$u(t) = MV(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{d}{dt} e(t)$$

## CONTROL SYSTEM LAB REPORT

$K_p$ : Proportional gain, a tuning parameter

$K_i$ : Integral gain, a tuning parameter

$K_d$ : Derivative gain, a tuning parameter

e: Error = SP – PV,      t: Time or instantaneous time

### **Q-Search for some practical industrial applications of PID control.**

A very common application of the control system is the regulating temperature of a chemical process. The flow of a chemical reactant to a process is controlled by valve. The reactor causes the temperature in the vat to change. This temperature is sensed and compared to a desired set point temperature in closed loop, where the flow of reactant is adjusted to yield the desired temperature by controlling the three elements of PID controller whose function is actually to control valve opening according to the error.

We can control the mixing of hot water with cold water in appropriate proportion to give the desired temperature of water in bathing implementing PID controller.

PID controller for levitation purposes these three elements proportion, integral and differential unit combine to minimize the static error and keep the steel ball levitated there in levitation zone

CONTROL SYSTEM LAB REPORT

### Proportional Control

$RP_3$	$R_{22}$	Constant $K_p$
2	100 K	20
2	70 K	15
2	50 K	5

### Integral control

$RP_4$	$C_3$	$T = RP_4.C_3$
50 K	1 $\mu$ F	0.05
30 K	1 $\mu$ F	0.03
10 K	1 $\mu$ F	0.01

### Differential Control

$RP_5$	$C_4$	$T = RP_5.C_4$
20 K	1 $\mu$ F	0.02
40 K	1 $\mu$ F	0.04
60 K	1 $\mu$ F	0.06



## LAB ASSIGNMENT NO: 11

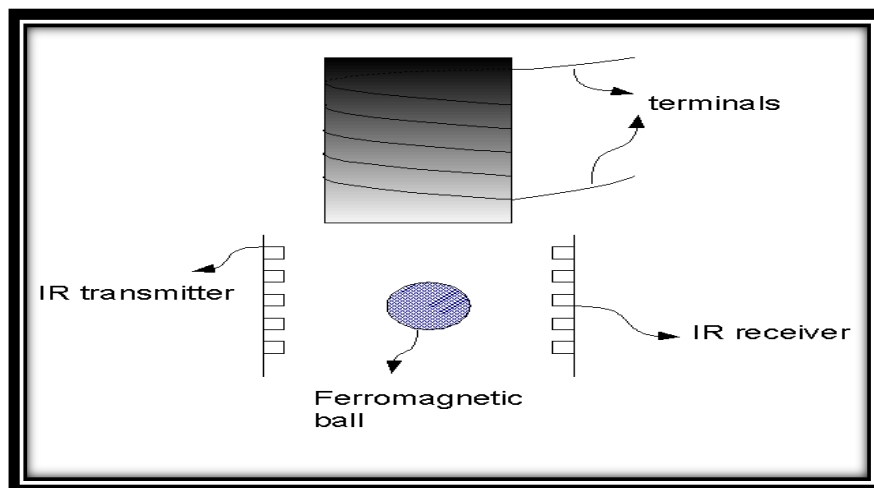
### TO UNDERSTAND THE ANALOG PID CONTROL OF MAGNETIC LEVITATION EQUIPMENT IN THE LAB THROUGH PID CONTROL UNIT

#### THEORY:

First, a force is required directed vertically upwards and equal to the gravitational force, For levitation on Earth, second, for any small displacement of the levitating object, a returning force should appear to stabilize it.

Levitation from Latin levitas "lightness" is the process by which an object is suspended by a physical force against gravity, in a stable position without solid physical contact.

A number of different techniques have been developed to levitate matter, including the aerodynamic, magnetic, acoustic, electromagnetic, electrostatic, gas film, and optical levitation methods. The stable levitation can be naturally achieved by, for example, magnetic or aerodynamic forces.



Levitation techniques are useful tools in physics research. For example, levitation methods are useful for high-temperature melt property studies because they eliminate the problem of reaction with containers and allow deep undercooling of melts. The containerless conditions may be obtained by

## CONTROL SYSTEM LAB REPORT

opposing gravity with a levitation force, or by allowing an entire experiment to freefall.

Although any electromagnetic force could be used to counteract gravity, magnetic levitation is the most common. [Diamagnetic](#) materials are commonly used for demonstration purposes. In this case the returning force appears from the interaction with the [screening currents](#). For example, a [superconducting](#) sample, which can be considered either as a perfect diamagnet or an [ideally hard superconductor](#), easily levitates in an ambient external magnetic field.

### Questions.

Q-What are the effects of system control quality when  $K_p$ ,  $T_i$ , &  $T_D$  are changed?

The basic equation is

$$u(t) = MV(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{d}{dt} e(t)$$

The PID controller acts upon the error signal generated by subtracting the set point voltage from the sensor voltage.

Proportional control ensures that the controller output is proportional to the amount of error.

Integral control takes into account the error signal's time duration as well as magnitude and completely eliminates steady state offset.

Derivative control ensures that the corrective action taken by the controller is proportional to the rate of change of error. Hence, an early corrective action is initiated.

**Q-What is the effect of the system when integration co-efficient is increased or decrease?**

The integration gain is inversely related to the time constant of the network. So, If integration time constant  $T_i$  increase the integration function weakens and vice versa. Increasing  $T_i$  will slow the procedure of eliminating the static error but can decrease over shoot and improve stability. The cost of introducing integration adjustor is reducing the rapidity of the system.

Decreasing the value of time constant increases the gain by decreasing the value of R & C. Now, the decrease in time constant results the system to achieve the steady state more rapidly but certainly leaves a probability that the system may overshoot from its steady state value.

**Q-What is the impact of increasing or decreasing proportion element?**

The proportion adjustor is the response of error immediately. If error appears, adjustor can control immediately, and make the error smaller. Control power is strong or weak is related to the proportion coefficient ( $K_p$ ). Proportion adjustor is easy and fast, but there exists a static error when the system response is of a finite value. Increase  $K_p$  can minimize the static error but if  $K_p$  is too large it can make the dynamic performance worse and the output oscillating, so the closed loop system is unstable finally.

For example, in case of a levitation apparatus increasing the value of proportion element means to increase the strength of electromagnet by controlling the current flowing through it. Similarly, decreasing the value of proportion element means to decrease the strength of electromagnet and decrease the force of attraction.

**Q-Explain the effect of change of proportional element?**

The proportion adjustor is the response of error immediately. The function of this control is to multiply the error quantity by a certain value Gain and actually consists of an inverting op-amp. If error appears, adjustor can control immediately, and make the error smaller. The major portion of error is controlled by proportion element. Control power is strong or weak is related to the proportion coefficient ( $K_p$ ). Proportion adjustor is easy and fast, but there exists a static error when the system response is of a finite value. Increase  $K_p$  can minimize the static error but if  $K_p$  is too large it can make the dynamic performance worse and the output oscillating, so the closed loop system is unstable finally.

**Q-Give some practical examples of system with PID controller?**

A very common application of the control system is the regulating temperature of a chemical process. The flow of a chemical reactant to a process is controlled by valve. The reactor causes the temperature in the vat to change. This temperature is sensed and compared to a desired set point temperature in closed loop, where the flow of reactant is adjusted to yield the desired temperature by controlling the three elements of PID controller whose function is actually to control valve opening according to the error.

We can control the mixing of hot water with cold water in appropriate proportion to give the desired temperature of water in bathing implementing PID controller.

PID controller for levitation purposes these three elements proportion, integral and differential unit combine to minimize the static error and keep the steel ball levitated there in levitation zone

**Q-What are programmable logic controllers ?**

A programmable logic controller (PLC) or programmable controller is a digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures.

PLCs are used in many industries and machines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. A PLC is an example of a hard real time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation will result.

When the water level drops enough so that the Low Level float switch is off , the PLC will open the valve to let more water in. Once the water level rises enough so that the High Level switch is on (up), the PLC will shut the inlet to stop the water from overflowing. This rung is an example of seal-in (latching) logic. The output is sealed in until some condition breaks the circuit.

**Q-What are the other types of control mechanism available?**

Proportion integral control (PI control).

Proportion integral differential control (PID control).

On-Off Controllers      PLC controller etc

Proportional Control      Proportional Differential control.

## LAB ASSIGNMENT NO: 12

### TO PERFORM LOADING & UNLOADING TASKS USING CONVEYER BELTS & ROBOTIC TRAINER

#### THEORY:

The word robot comes from the Slavic word robota, which is used to refer forced labor. Robotics is the branch of [technology](#) that deals with the design, construction, operation and application of [robots](#) and computer systems for their control, sensory feedback, and information processing. These technologies deal with automated machines that can take the place of humans, in hazardous or manufacturing processes, or simply just resemble humans.

A Robotek II trainer teaches us the basic robotic sensing and tells us that how we can study the external part of robot and how we can control mechanism to allow robots to move fluidly and efficiently.

Using this trainer, we can control the arm, jaw, base, shoulder and elbow. These are the parts of this particular robot that are movable and hence, these are used to make our work easy.

These parts can be moved in up, down, left and right direction. These parts are moving in their specific directions as it is built in by the manufacturer. These parts are very sensitive and can be destroy due to movement of a little bit more than its required movement or robot can be damaged.

These are used in most of the industries because their use is really very economical. They are expensive a lot but this expenditure is done only for once and afterwards we can take a lot of work by them without any break.

## CONTROL SYSTEM LAB REPORT

Robotek II is operated with a computer which has a LPT Line Print Terminal Port to connect the trainer.

At the back side of trainer, a port is installed in which a pin or cable is connected which comes from computer. All the communication or instruction to which trainer is operate comes from computer.

It has four movable parts and due to those parts, this Robotek II trainer can be recognized.



The robotic arm is the most important part of this trainer. It has the ability to move in four different directions which are:

Base

Shoulder

Elbow

Jaw



## CONTROL SYSTEM LAB REPORT

These are controlled by DC motor and we move with our desire. These components are moved in the following directions:

Base can rotate left and right up to range of  $120^{\circ}$

Shoulder moving range up to  $90^{\circ}$

Elbow moving range up to  $30^{\circ}$

### CODING:

```
Move B72 S30 E62 J100
Conveyer_1_On
Wait 4700
Conveyer_1_Off
Move B72 S70 E62 J100
Move B33 S70 E62 J100
Move B33 S39 E62 J100
Move B33 S39 E62 J1
Move B33 S70 E62 J1
Move B121 S70 E62 J1
Move B121 S39 E62 J1
Move B121 S39 E62 J100
Move B121 S70 E62 J100
Conveyer_2_On
Wait 3500
Conveyer_2_Off
```



## CONCLUSION:

The jaw is also known as the gripper of the Robotek II trainer arm. It is used to grip the load tightly. It is very useful part because it can hold the load and we can move that to the specific portion of our requirement.

To hold the load or hurdle, jaw is closed by giving command J1, when load or hurdle is to be placed jaw is opened by giving command j100.

Jaw is fully open at j127, and completely closed when j0. In fully open condition both the parts of jaw are 1.2 inch away from each other.

The wrist of the Robotek II trainer can take a full round. It can move easily in a full circle. This can be rotated manually only. Because it is manually operated therefore wrist is set once initially before giving any command to the trainer.

The Robotek II trainer can not lift the weight more than 130gm. Its purpose is to give us the basic idea about the working of robots in different applications.

We observe in this experiment that such type of robotic trainer can be used in industrial area where heavy load is transferred from one place to another. We observe that load is to be placed at one particular place on the conveyer belt for its working, if we place the load other than that particular place robot will be unable to handle it & can be cause of serious damage of load as well as system itself.

## LAB ASSIGNMENT NO: 13

### TO REPLICATE INDUSTRIAL LOADING & UNLOADING TASKS USING CONVEYER BELTS, OPTICAL SENSORS & ROBOTIC TRAINER

#### THEORY:

The word robot comes from the Slavic word robota, which is used to refer forced labor. Robotics is the branch of [technology](#) that deals with the design, construction, operation and application of [robots](#) and computer systems for their control, sensory feedback, and information processing. These technologies deal with automated machines that can take the place of humans, in hazardous or manufacturing processes, or simply just resemble humans.

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These parts can be moved in up, down, left and right direction. These parts are moving in their specific directions as it is built in by the manufacturer. These parts are very sensitive and can be destroy due to movement of a little bit more than its required movement or robot can be damaged. These are used in most of the industries because their use is really very economical. They are expensive a lot but this expenditure is done only for once and afterwards we can take a lot of work by them without any break.

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The robotic arm is the most important part of this trainer. It has the ability to move in four different directions which are:

Base

Shoulder

Elbow

Jaw

## CONTROL SYSTEM LAB REPORT

These are controlled by DC motor and we move with our desire. These components are moved in the following directions:

Base can rotate left and right up to range of  $120^{\circ}$

Shoulder moving range up to  $90^{\circ}$

Elbow moving range up to  $30^{\circ}$

### **CODING:**

```
Move B72 S30 E62 J100
Label A
If Sensor_1_On
Conveyer_1_On
Goto A
EndIf
Conveyer_1_Off
Move B72 S70 E62 J100
Move B33 S70 E62 J100
Move B33 S39 E62 J100
Move B33 S39 E62 J1
Move B33 S70 E62 J1
Move B121 S70 E62 J1
Move B121 S39 E62 J1
Move B121 S39 E62 J100
Move B121 S70 E62 J100
Conveyer_2_On
Wait 3500
Conveyer_2_Off
Goto A
```

## CONCLUSION:

We observe in this experiment that it is advanced form of pervious experiment. In previous experiment we perform loading and unloading hurdle & move from one conveyer belt to another conveyer belt. During this operation we had to place load on particular location on conveyer belt, otherwise its operation failed.

This operation needs to be improved; in this experiment we introduce sensors in system.

It is in pair and these are allocated on the conveyer belts. These are used to determine the position and presence of the load or weight present on the conveyer belts. These are optical or light sensors.

In this way we get better result, now we can place load or hurdle anywhere on the conveyer belt, optical sensors are also allocated on this conveyer belt, when this hurdle or load passes between the sensor and light, light cut off and sensor is off in this condition and according to coding conveyer belt stops, this position is achieved by robotic arm and saved.

Every time when load or hurdle comes, it cuts off light and sensor stops, robotic arm reach on the same position & hold the load and transfer it to the other conveyer belt.

This method can also be implemented to sorting of two different size or height of load. For this purpose we need to allocate sensor on higher position on conveyer belt. In this way when higher body or load comes it cuts of light and turns off sensor, conveyer belts stops and robotic arm will hold and transfer this higher body to any other place.

*CONTROL SYSTEM LAB REPORT*

When smaller body or load will come on conveyer belt, it will not cut off light because sensors are allocated on higher position, as a result conveyer belt will not stop and this smaller body will go down to the conveyer belt and can be collected from there manually.

In this method two different height bodies can be separated, higher body is stored by robotic arm and smaller body go down to the conveyer belt.

## LAB ASSIGNMENT NO: 14

### SINGLE PHASE HALF WAVE SIMPLE MOTOR CONTROL

#### THEORY:

D.C motor Speed control trainer built around a small permanent magnet D.C. motor is designed to bring out the salient features of such a system. Facilities are available to directly measure the principal performance features of the speed control system, viz, steady state error and load disturbance rejection, as a function of the forward path gain.

Every electric motor has to have some sort of controller. The motor controller will have differing features and complexity depending on the task that the motor will be performing.

The simplest case is a [switch](#) to connect a motor to a power source, such as in small appliances or power tools. The switch may be manually operated or may be a [relay](#) or [contactor](#) connected to some form of [sensor](#) to automatically start and stop the motor. The switch may have several positions to select different connections of the motor.

This may allow reduced-voltage starting of the motor, reversing control or selection of multiple speeds. Overload and over current protection may be omitted in very small motor controllers, which rely on the supplying circuit to have over current protection. Small motors may have built-in overload devices to automatically open the circuit on overload. Larger motors have a protective overload relay or temperature sensing relay included in the controller and [fuses](#) or [circuit breakers](#) for over current protection. An automatic motor controller may also include limit switches or other devices to protect the driven machinery.

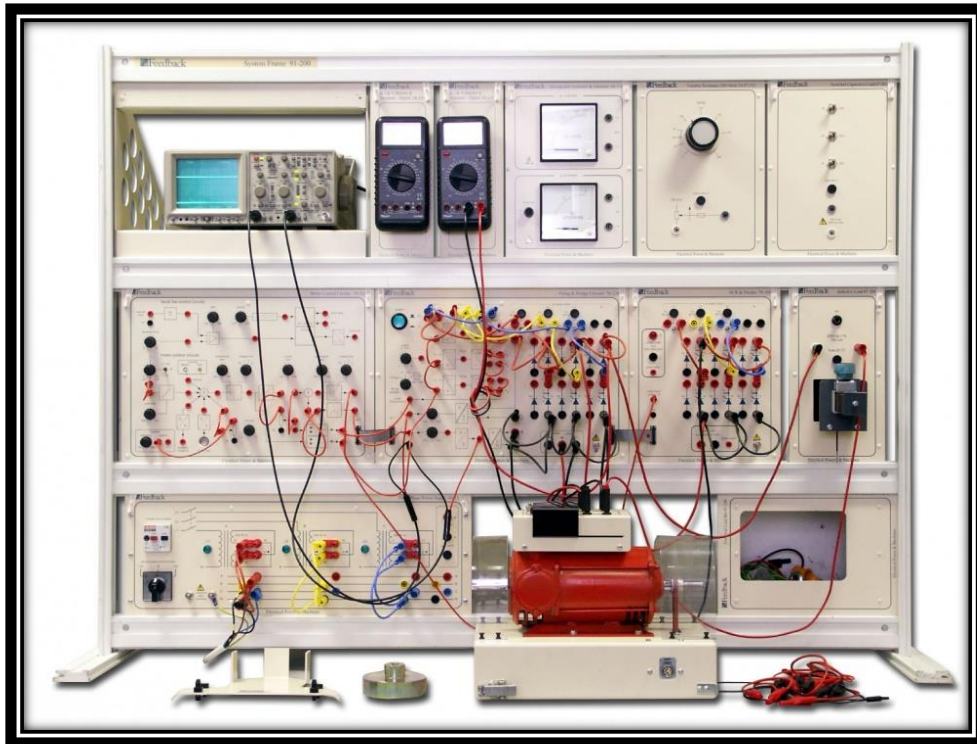


## CONTROL SYSTEM LAB REPORT

A motor controller is a device or group of devices that serves to govern in some pre-determined manner the performance of an electric motor.

A DC motor is designed to run on DC electric power. Two examples of pure DC designs are Michael Faraday's homopolar motor (which is uncommon), and the ball bearing motor, which is (so far) a novelty.

With the help of dc motor trainer we can be control the speed of motor and we can also vary the load. By changing the load we can observe the speed of motor.



### **THYRISTOR CONTROL PANEL:**

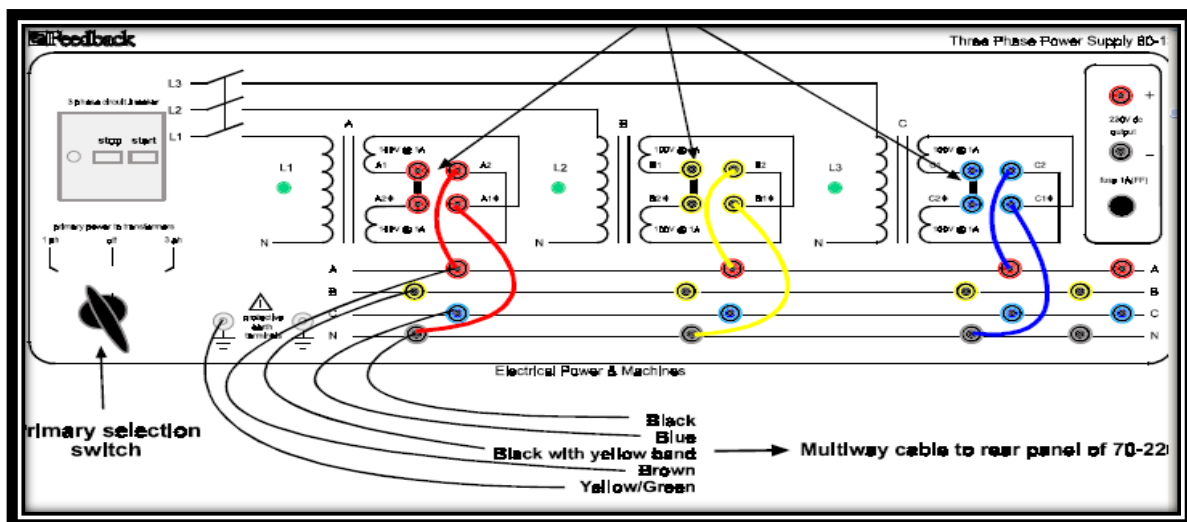
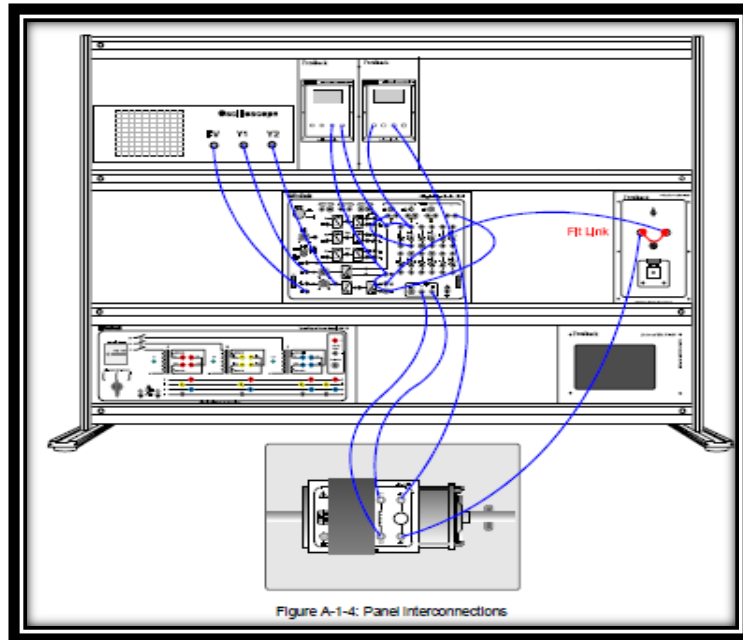
The operation of a thyristor can be understood in terms of a pair of tightly coupled bipolar junction transistors, arranged to cause the self-latching action.

A thyristor is a [solid-state semiconductor device](#) with four layers of alternating [N](#) and [P-type](#) material. They act as [bistable](#) switches, conducting when their gate receives a current trigger, and continue to conduct while they are forward biased that is, while the voltage across the device is not reversed.



## CONTROL SYSTEM LAB REPORT

From this panel of the trainer we can set the firing angles of the thyristors. From the firing angles we can easily set the output of the rectifier circuit which control the rpm of the dc motor.

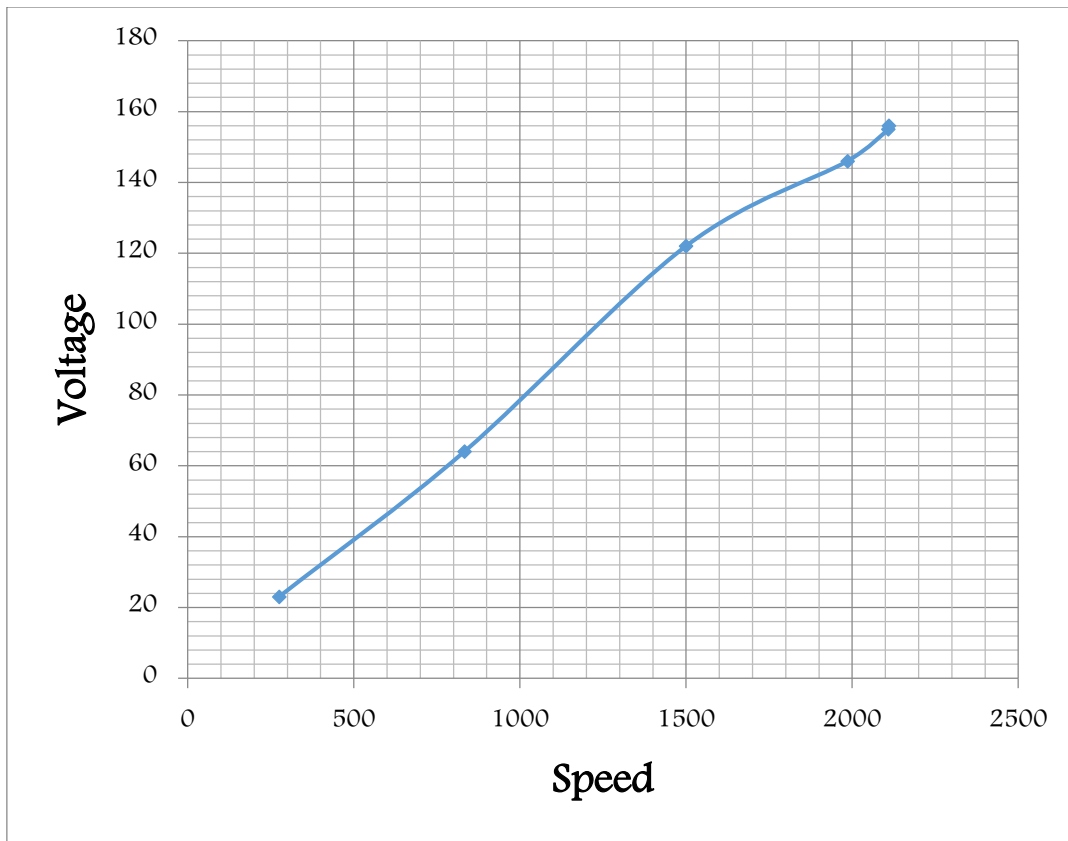


CONTROL SYSTEM LAB REPORT

Calculations.

Reference voltage (V)	Speed rev/min	Armature voltage (v)	Armature current (mA)
2	275	23	0.24
3	833	64	0.32
4	1500	122	0.33
5	1986	146	0.34
6	2109	155	0.34
7	2110	156	0.34

CONTROL SYSTEM LAB REPORT

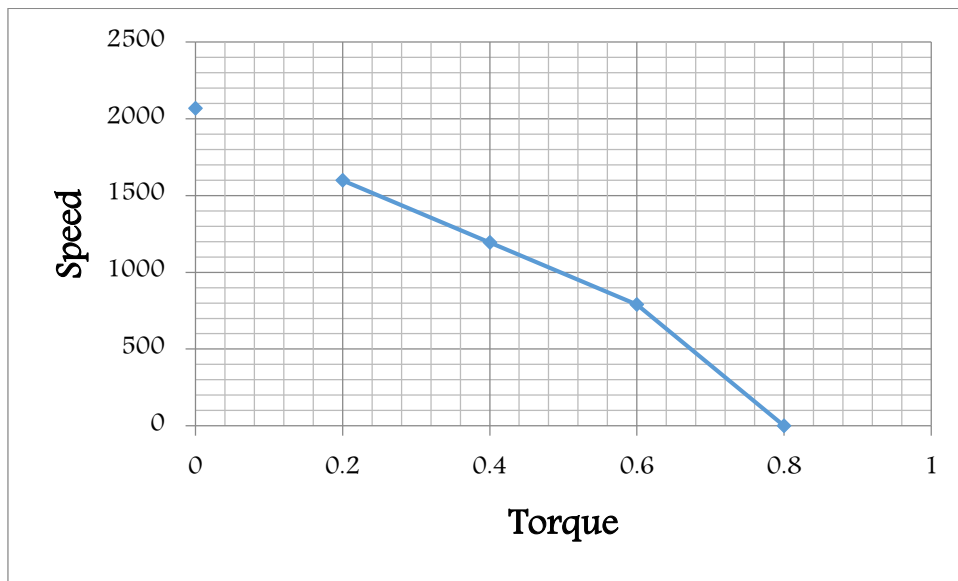


**TORQUE SPEED CHARACTERISTICS:**

Torque (Nm)	Speed (rpm)	Armature voltage (v)	Armature Current (A)	Field voltage (v)	Field current (A)	Input power (W)	output power (W)	Efficiency (%)
0	2070	165	0.33	223	0.3	121.35	0	0
0.2	1599	122	0.56	223	0.3	135.22	33.4724	24

CONTROL SYSTEM LAB REPORT

0.4	119 5	97	0.7	223	0.3	134.8	50	37
0.6	790	78	1	223	0.3	144.9	50	34
0.8	0	68	1.35	223	0.3	158.7	0	-



**Conclusions.**

We conclude from the graph of speed against torque that they have inverse relationship by increasing torque the speed is going to decrease.

Efficiency is going to increase as the torque increases and the speed decreases. The torque is almost proportional to the armature current. At higher speed motor efficiency is low due the factors such as air resistance, which result in loss of most of the power.

As compare to full wave rectified supply, the motor driven at half wave rectified supply has less efficiency. The efficiency is low in half wave case this is because in the negative half of the cycle the armature voltage is zero and motor will unable to do useful work.

However during this time current still flows through the dc field windings, and this result in the resistive power loss

## LAB ASSIGNMENT NO: 15

### SINGLE PHASE FULL WAVE SIMPLE MOTOR CONTROL

#### THEORY:

D.C motor Speed control trainer built around a small permanent magnet D.C. motor is designed to bring out the salient features of such a system. Facilities are available to directly measure the principal performance features of the speed control system, viz, steady state error and load disturbance rejection, as a function of the forward path gain.

Every electric motor has to have some sort of controller. The motor controller will have differing features and complexity depending on the task that the motor will be performing.

The simplest case is a [switch](#) to connect a motor to a power source, such as in small appliances or power tools. The switch may be manually operated or may be a [relay](#) or [contactor](#) connected to some form of [sensor](#) to automatically start and stop the motor. The switch may have several positions to select different connections of the motor.

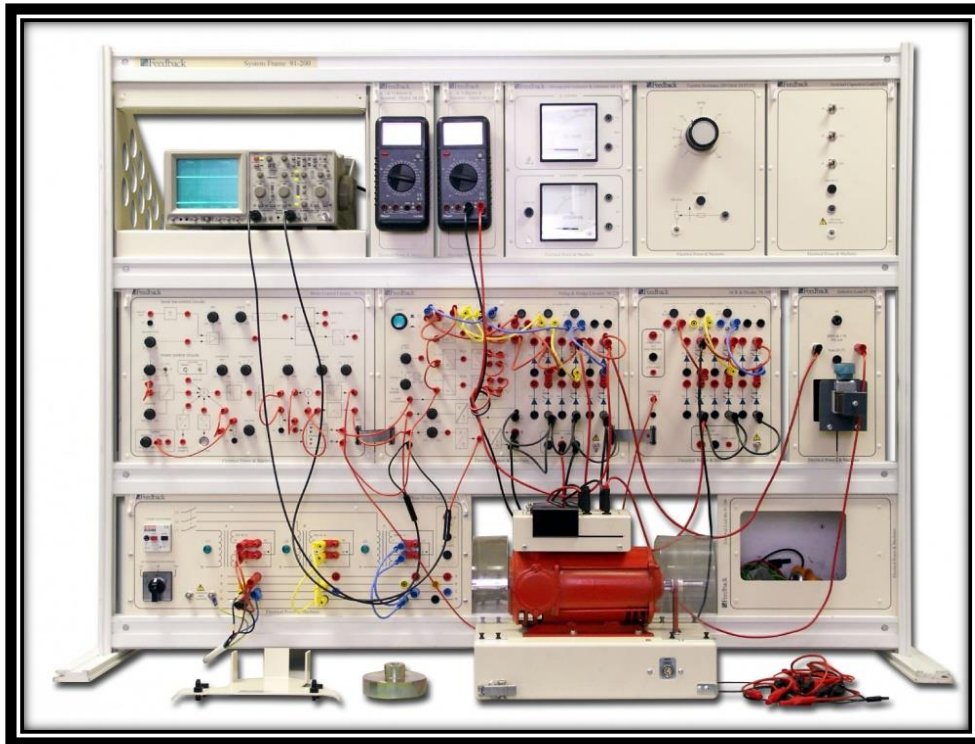
This may allow reduced-voltage starting of the motor, reversing control or selection of multiple speeds. Overload and over current protection may be omitted in very small motor controllers, which rely on the supplying circuit to have over current protection. Small motors may have built-in overload devices to automatically open the circuit on overload. Larger motors have a protective overload relay or temperature sensing relay included in the controller and [fuses](#) or [circuit breakers](#) for over current protection. An automatic motor controller may also include limit switches or other devices to protect the driven machinery.

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A DC motor is designed to run on DC electric power. Two examples of pure DC designs are Michael Faraday's homopolar motor (which is uncommon), and the ball bearing motor, which is (so far) a novelty.

With the help of dc motor trainer we can be control the speed of motor and we can also vary the load. By changing the load we can observe the speed of motor.

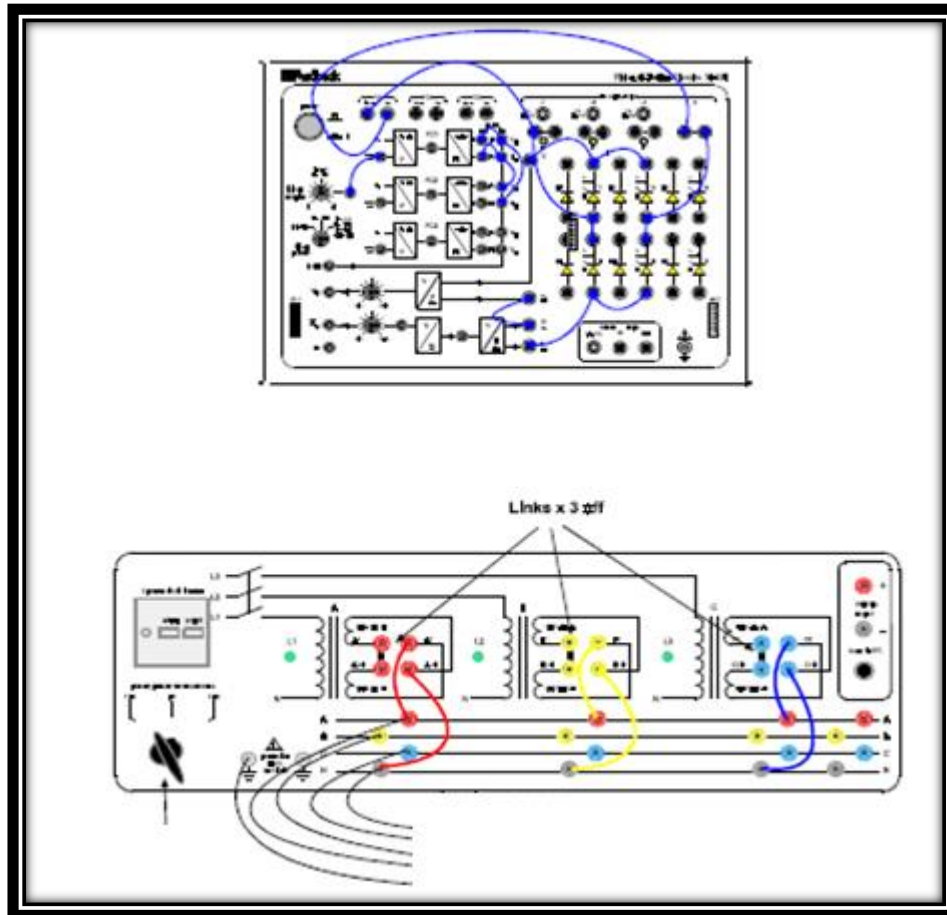


This adjustable speed drive is similar to the single-phase, half-wave controlled rectifier. The single-phase, full-wave controlled rectifier consists of four thyristors. The increase in thyristors provides for better control compared to the half-wave controlled rectifier. The obvious disadvantage of the full-wave rectifier is the increase in price because of the increase in the number of thyristor.

There are three different modes of operation for the single-phase, full-wave controlled rectifier. The first is discontinuous conduction mode (DCM).

## CONTROL SYSTEM LAB REPORT

In DCM, the current  $I_a$  reaches zero and stays at zero for a certain period of time. The next mode is continuous conduction mode (CCM). In CCM,  $I_a$  does not reach zero at any point during the period. The final mode of operation is critically discontinuous conduction mode (CDCM). In CDCM, the current  $I_a$  reaches zero and then immediately starts to increase.





**Calculations:**

Torque (Nm)	Speed (rpm)	Armature voltage (v)	Armature Current (A)	Field voltage (v)	Field current (A)	Input power (W)	output power (W)	Efficiency (%)
0	2165	162	0.32	223	0.3	118.74	0	0
0.2	1693	130	0.52	223	0.3	134.5	35.4	26
0.4	1302	103	0.81	223	0.3	150.33	55	37
0.6	1014	85	1.05	223	0.3	156.15	64	41
0.8	800	75	1.30	223	0.3	164.4	59	34
1	643	72	1.52	223	0.3	176.34	67	38
1.2	553	70	1.80	223	0.3	192.29	69	36

**Conclusions:**

We concluded from this experiment that full wave rectifier has ability to manipulate current when the supply is at negative half cycle. In this experiment conducting angle occurs twice, once when voltage source is positive and once when it is negative. The single-phase, full-wave controlled rectifier consists of four thyristors. The increase in thyristors provides for better control compared to the half-wave controlled rectifier. The obvious disadvantage of the full-wave rectifier is the increase in price because of the increase in the number of thyristor. Efficiency increases with torque increase and speed decrease. Field current almost remains constant.