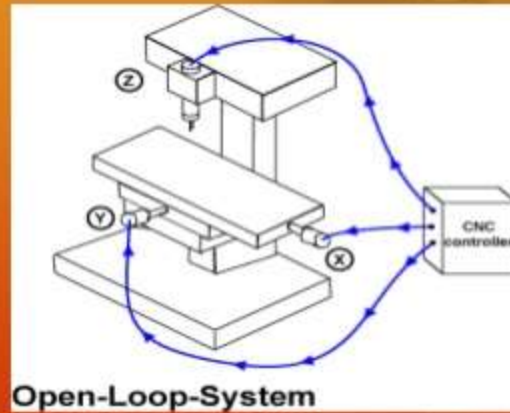


Open loop and closed loop cnc system

Open loop-

Programmed instructions are fed into the controller through an input device. These instructions are then converted to electrical pulses (signals) by the controller and sent to the servo amplifier to energize the servo motors.



System Devices

After going through this chapter students will be able to understand following :-

- ❖ Working of Control Systems.
- ❖ Concept of Actuators, Transducers, and Sensors
- ❖ Tachometer, opto-interferer, LVDT
- ❖ Potentiometer
- ❖ Encoder and Decoder
- ❖ Axis Drives

System Devices

- ❖ Numerical control is based on the use of numerical data for controlling the position of the operative units of machine tool directly during a machining operation.
- ❖ The operative units of the machine tool are controlled in their motion by numbers.
- ❖ These numbers determine the shape and size of the workpiece and consequently fed into control system.
- ❖ During the intervals between command signals, the shape of the workpiece is determined only by method of the travelling operative units and their relative speed of motion.
- ❖ In positioning motions, it is not required to specify the path of motion of the operative units but only its final position is controlled.

System Devices

- ❖ Machine tools equipped with numerical controls are known as NC machine tools.
- ❖ These machine tools are characterized by a system of controls which enable them to be changed over quickly for another job without changing or rearranging any mechanical elements.
- ❖ According to the shape and size of workpiece, the magnitudes of displacements of the operative units are fed into the control system in the form of numbers representing the shape of the path and the magnitude, direction and velocity of motion.
- ❖ This type of control is more flexible, means that if the information fed into the control system is varied then the geometric parameters of workpieces will be changed accordingly.

Control System: Introduction

- ❖ Control system means by which a variable quantity or set of variable quantities is made to conform to a prescribed norms.
- ❖ A control system is an interconnection of components forming a system configuration that will provide a desired system response.
- ❖ It either holds the values of the controlled quantities constant or makes them to change in a prescribed way.
- ❖ A controlled system may be operated by mechanical means, by electricity or by fluid pressure.
- ❖ Whenever a computer is involved in the control circuit, then control system are operated electrically more conveniently.

Fundamental aspect of control system

- In general CNC machines are programmed to accomplish following actions.
 - A) Positioning of tool in 2 or 3 or more axis
 - B) Motion relative velocity of tool with respect to workpiece.
 - C) Switching function i.e. direction of rotation of spindle, coolant on-off etc are to be controlled.
 - D) CNC system require motor drives to control both the position and velocity machine axes. Each axis must be driven separately and follow the command signal generated by NC control system. There are two ways to activate the servo drives: The open loop system and closed loop system

Based upon the nature of the positioning and motion, CNC control is classified into two groups,

1. Point to Point control-it is purely for positioning of the tool at programmed points.e.g drilling,tapping,boring operations
2. Continuous path control- there is a functional relationship between individual coordinate axes. i.e 3 axes,5 axes machining.

5 axes machining- 3 translational and 2 rotational axes.

best suited for doubly curved surface machining.i.e in spacecraft,aircraft and fluid handling devices.

Classification of Control(NC) system

The following are the main classification of NC systems:-

(a) According to the type of control loop

- i. Open Loop System
- ii. Closed Loop System
- iii. Semi-closed System

(b) According to the type of motion control system

- i. Point to point or positioning system
- ii. Straight line or straight cut system
- iii. Contouring or continuous path system
- iv. Combined motion control system

Classification of Control(NC) system

(c) According to the structure of the controller hardware base

- i. NC
- ii. CNC

(d) According to the programming mode

- i. Incremental programming
- ii. Absolute programming

(e) According to structure of control system

- i. Analog system
- ii. Digital system

Classification based on Control Loop

- In CNC machines, it is possible from control point of view to relate particular variable to one corresponding variable. To control the position or velocity of machine slide, a group of electro-mechanical, pneumatic or hydraulic components are employed which are collectively known as “Servo mechanism”.
- The output from data handling equipment is passed through separate channels to servo system, based on feed back control, can be approached in following three ways.
 - i) Open loop control system
 - ii) Closed loop control system
 - iii) Semi- closed loop control system

Open Loop Control System

- ❖ Open loop system is also known as non- feedback control systems.
- ❖ In this system there is no provision to compare the actual position of the cutting tool or workpiece with the input command value(through feedback) i.e. the final output value is not directly measured and checked against the desired value is known as open loop system.
- ❖ In this system there is auto correction of the variation present in its output .
- ❖ The system on its own is not in a position to give the desired output and it cannot take into account the disturbances.

Open Loop System

- ❖ In these systems, the changes in output can be corrected only by changing the input manually.
- ❖ These systems are stable, simple in construction and cheap.
- ❖ But these systems are inaccurate and unreliable.
- ❖ These systems do not take into account external disturbances that effect the output.
- ❖ They do not initiate a controller or control actuator to obtain the desired response.

Example of open loop system

1. Automatic washing machine
2. Traffic signal
3. Home Heating system(without sensing, feedback and control)
4. Electric toaster

Advantages and Disadvantages

Advantages:-

- These are less costly.
- These are simple.
- These are easier to maintain and are popular with smaller NC machines.

Disadvantages:-

The major disadvantage of the open loop system is that there is no way correct any error that might occur during operation because there is no feedback to the controller.

Open loop control system is suitable for applications:

- When machinery is light duty, up to 5KW and with a torque of 200-250 NM.
- Where less money can be spent.
- Too much accuracy not required
- Less maintenance is required.

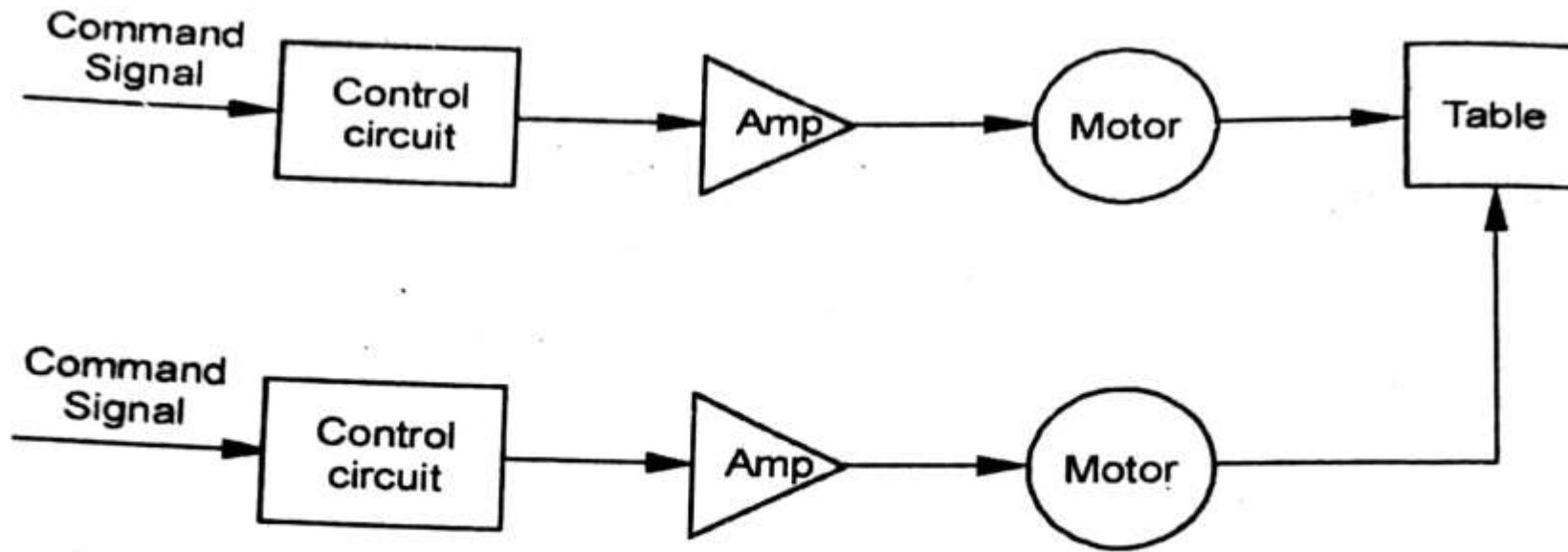
Following are some drawbacks

- Backlash errors are introduced in lead screw due to wear and tear and change in external conditions.
- Periodical adjustments are frequently required so as to compensate the changes in the tool geometry or drive mechanism.
- Relatively less accurate.

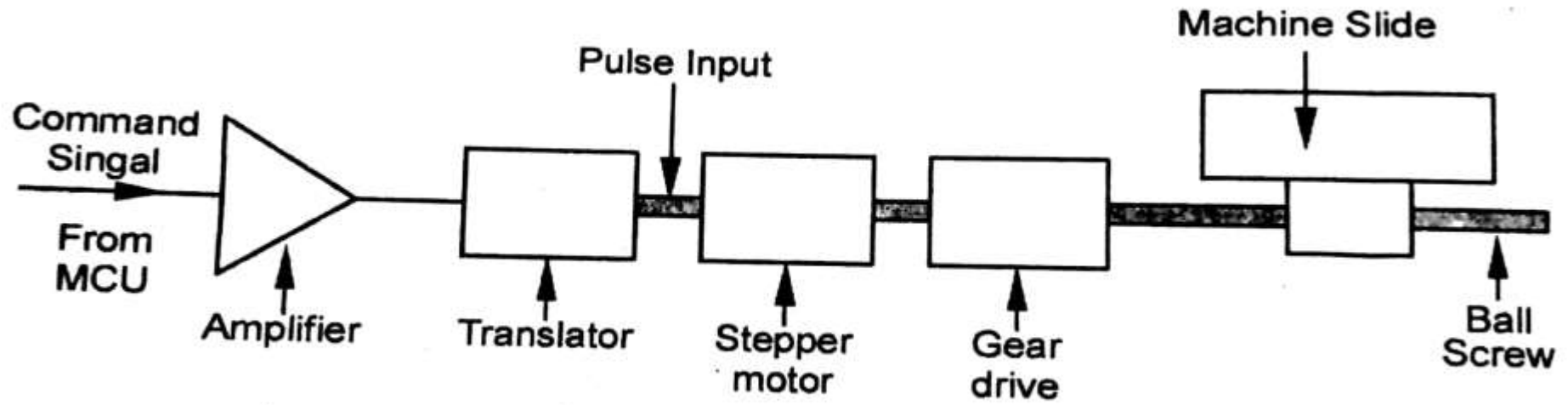
Closed-loop Control System

- ❖ A closed-loop system is also known as feed back control system.
- ❖ Feedback subsystem monitor the actual output and correct any discrepancy from the programmed input.
- ❖ A feed back control system that tends to maintain prescribed relationship of one system variable to another by comparing functions of these variable and using the difference as a means of control.
- ❖ Closed-loop systems are very powerful and accurate because they are capable of monitoring operating conditions through feedback subsystems and automatically compensating for any variations in real-time.

A common example of an closed loop system is a person steering a car by looking at the car's location on the road and making the appropriate adjustments.

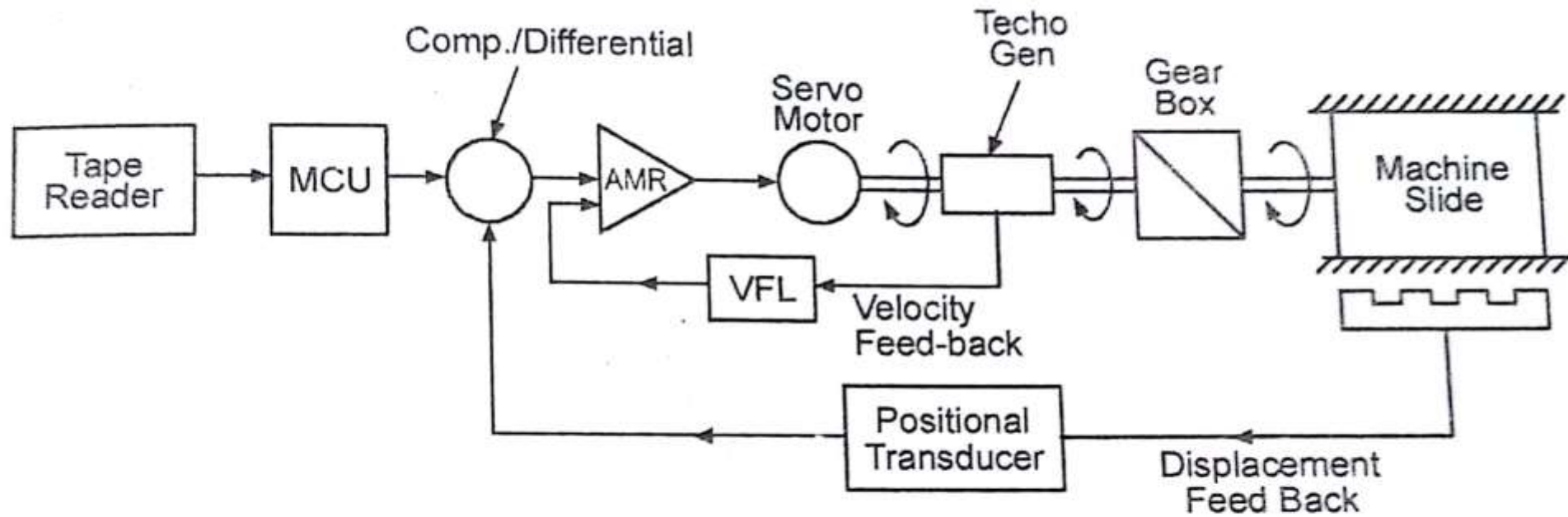


(a) Two Axes Open-loop Control System



(b) One-Axis Open-loop Control System

Closed-loop Control System



Closed-loop Control System with tachometer and encoder

Closed-loop Control System

In order to drive a motor, two input signals are present. One is command signal due to which the servo motor is driven. As soon as the displacement takes place, another signal is generated by the position sensor known as Transducer, to know that whether the position has been achieved or not. This actual position signal is fed to the comparator device known as 'Differential Analyser'. Differential Analyser compares it with the command signal and produces an electrical signal proportional to the difference between the two. This signal is fed to the servo motor through an amplifier to move the machine slide in a direction so as to reduce a difference. This loop is followed again and again till the difference between the two signals becomes the zero. At this point, the output of compactor becomes zero and the machine slide comes to rest in the correct position. This mechanism takes care of the inertia effects of machine slide.

Another feedback transducer to controls the velocity of motor in the case of continuous path system. It is essential to make sure that the cutter follows the path as required by the profile. Such a control can have capabilities of upto 0.0001 mm resolution and speed up to 10 m/min .

Closed-loop control system is used for getting higher degree of accuracy during the machining operation.

Most of the contouring controls are closed-loop system.

Examples of Closed-loop system

- Speed control system
- Pressure control system
- Temperature control system
- Robot control system

Advantages & Disadvantages of closed loop system

Advantages

- Higher accuracy can be achieved.
- There is an automatic compensation for error
- It is more preferred in large NC machines because of higher load.

Disadvantages

- These systems are more complex.
- It is more expensive .

Difference between closed loop and open loop system

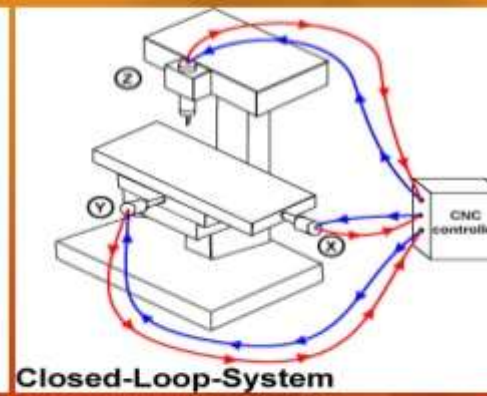
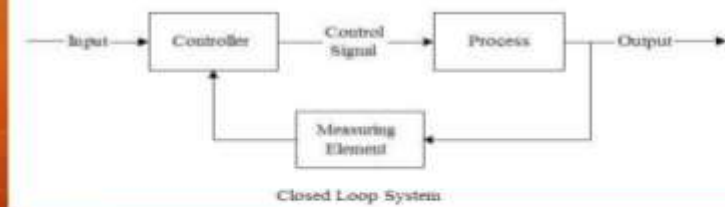
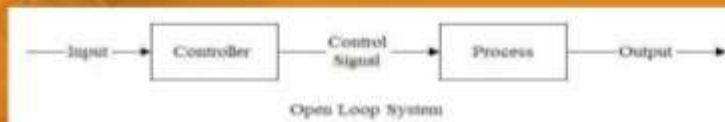
Closed Loop System

1. A closed loop system has the ability to perform accurately because of the feed back.
2. It is less stable.
3. It is difficult to build.
4. The system operate better than open system.
5. Feed back is present.
6. More Reliable.

Open Loop System

1. An open loop system has the ability to perform accurately, if its calibration is good. If the calibration is not correct its performance will go down.
2. It is more stable as the feed back is absent.
3. It is easier to build.
4. The system operation is not good.
5. Feed back is absent.
6. Less reliable.

Comparison b/w open and closed loop system



Feedback subsystems in closed loop system

Feedback subsystems are of two types-

Analogue feedback system: Variations in physical systems such as position and velocity are being measured as voltage levels in analogue feedback system. Tachometers are typically used to measure the velocity, whereas the *resolvers* are used to measure position. There are two feedback loops in CNC drive systems; position loop and velocity loop.

NOTE-A **resolver** is a type of rotary electrical transformer used for measuring degrees of rotation. It is considered an analogue device, and has a digital counterpart, the rotary (or pulse) encoder.

- **Digital feedback system:** A digital feedback system uses a digital position transducer to measure the position. Encoders are popular digital position transducers. Comparator and amplifier are replaced by up-down counter and digital-to-analogue converter.
- It monitor output variations by electrical pulses.

Feedback for closed loop system

- The feedback in a closed loop system is the information delivered from the CNC machine to the controller.
- Feedback data is data that either confirms or denies that the motors have moved the machining table to the correct position and at the correct speed.

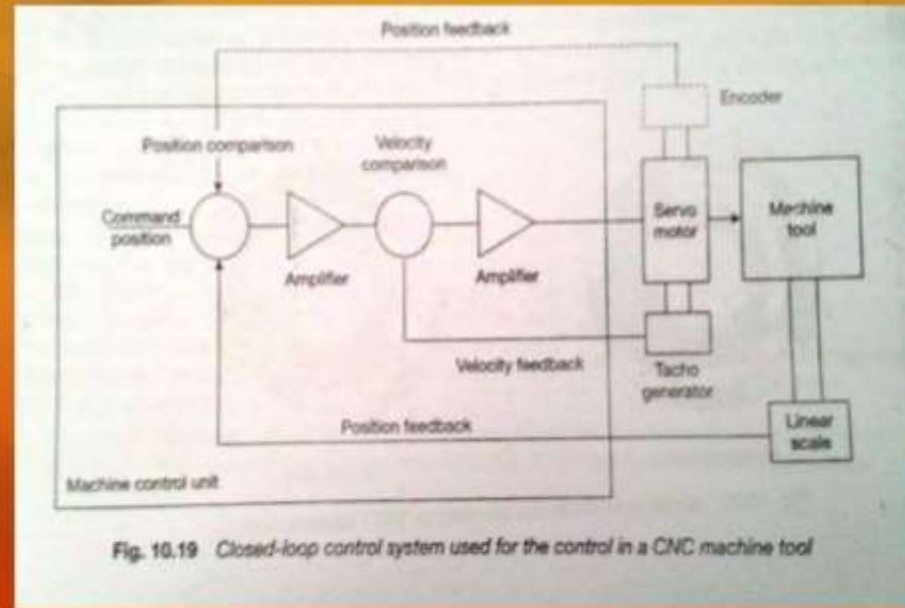


Fig. 10.19 Closed-loop control system used for the control in a CNC machine tool

- Feedback can be accomplished in one of two ways
- **Linear Scales**
- **Encoders**

Note- SERVOMOTOR-it is an automatic device that uses error sensing negative feedback to correct the performance of a mechanism.

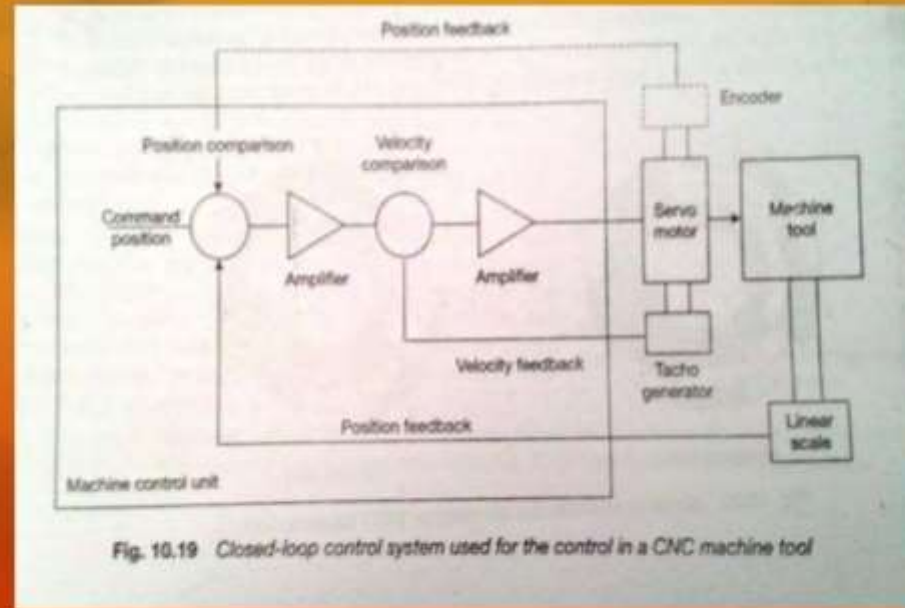


Fig. 10.19 Closed-loop control system used for the control in a CNC machine tool