CLASSIFICATION BASED ON CONTROL SYSTEM –

Some machine tools require that the cutting tool and work piece shall be placed at certain positions and also be moved relative to each other. Based on the relative motion, the NC machines can be classified as :

1-Point to Point Motion Control System :

2-Straight Line Motion Control System:

3-Contouring or Continuous Path Motion Control System:

4-Combined Motion Control System:

1-Point to Point Motion Control System :

For example **drilling, boring and tapping** machines etc, require the cutter and the work piece to be placed at a certain fixed relative positions at which they must remain while the cutter does its work. These machines are known as point-to-point machines. In theses machine tools, each axis is driven separately.

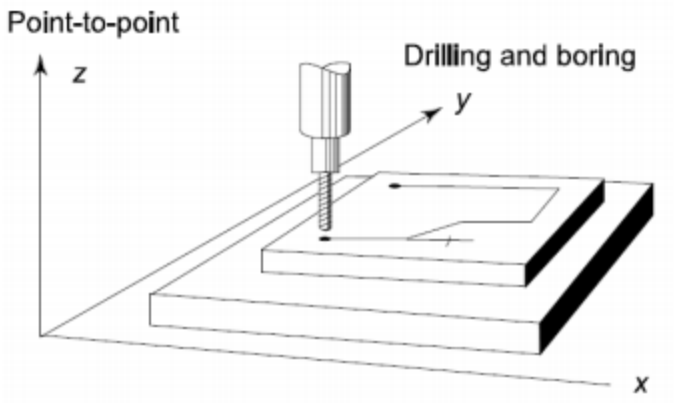


Figure 2.7 : Point-to-Point motion Control System

In a point-to-point control system, the dimensional information that must be given to the machine tool will be a series of required position of the two slides. Servo systems can be used to move the slides and no attempt is made to move the slide until the cutter has been retracted back.

2-Straight Line Motion Control System:

The NC systems, in which the tool works along a straight line in the direction of a major coordinate axis, such as along the direction of feed during **turning, boring or milling** operation at a controlled rate, are known as Straight line control system

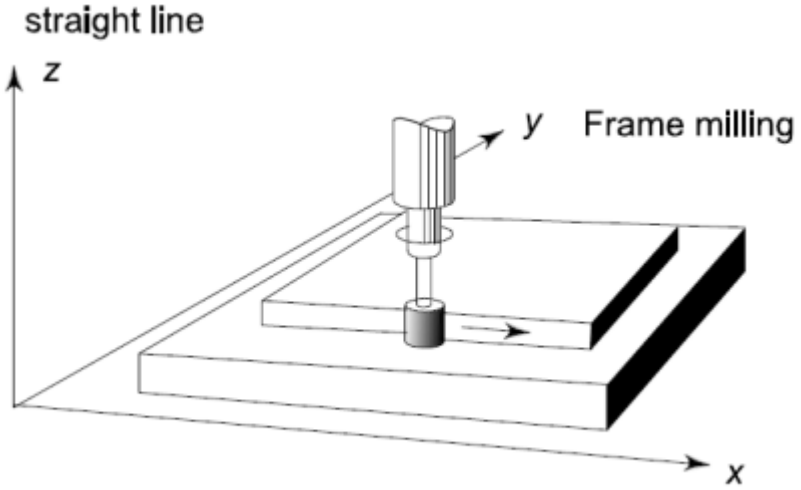
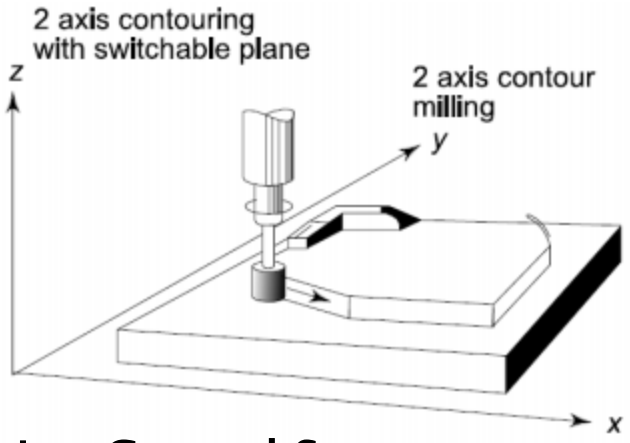


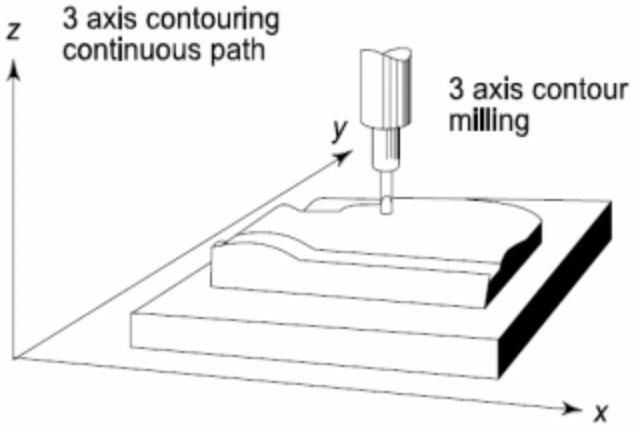
Figure 2.8 : Straight-line Control System

3-Contouring or Continuous Path Motion Control System:

Other type of machine tools involves motion of work piece with respect to the cutter while cutting operation is taking place. These machine tools include milling, routing machines etc. and are known as contouring machines and the controls required for their control are known as contouring control.

These machines require simultaneous control of axes. In contouring machines, relative positions of the work piece and the tool should be continuously controlled. The control system must be able to accept information regarding velocities and positions of the machines slides. Feed rates should be programmed.





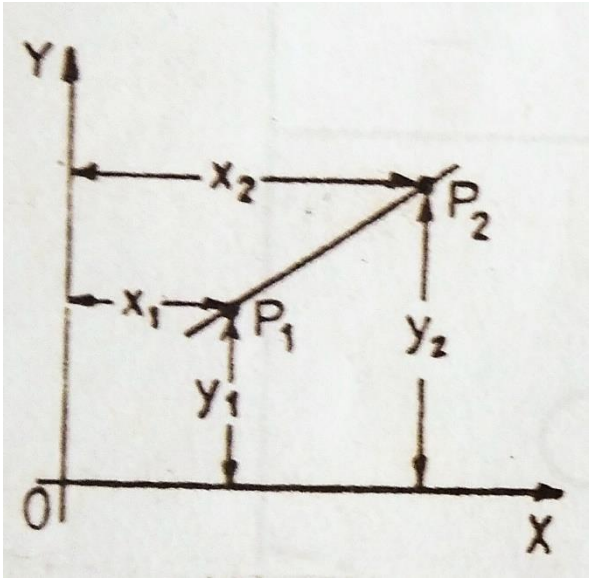
4-Combined Motion Control System:

The above all the control systems are combined as groups. Most of the **Jig boring, horizontal boring and drilling** machines employ this type of control system. This motions controls systems are having 3 or 4 linear axes to be controlled continuously and 2 or 3 rotary movements controlled along with the positioning facility. This combination is used for complex contouring operations, to be carried out on machining centers.

Interpolation:

The method by which a control system calculates theintermediate points and the speed of the motor is called‘ **interpolation’**.

1. **Linear interpolation** Straight line between two points in space



The idea is to approximate a given curved tool path by a set of **line segments** while satisfying desired tolerance and feed rate.

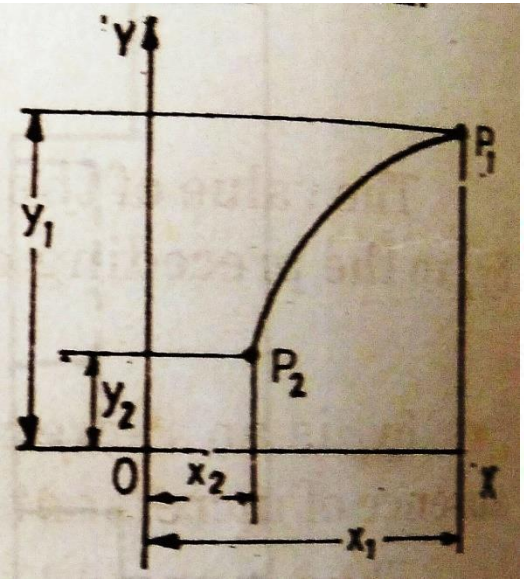
A curved cutter path is approximated by **straight line segments** connecting a finite set of cutter location points on the curve.

Along with other information, such as the **feed rate, spindle speed and lubrication requirements**, these data are sent to the controller of a CNC machine.

Linear interpolation technique has been widely used in CNC machining for its **simplicity.**

Linear interpolation requires **less computation**.

2. Circular interpolation Circular arc defined by starting point, end point, center or radius, and direction .

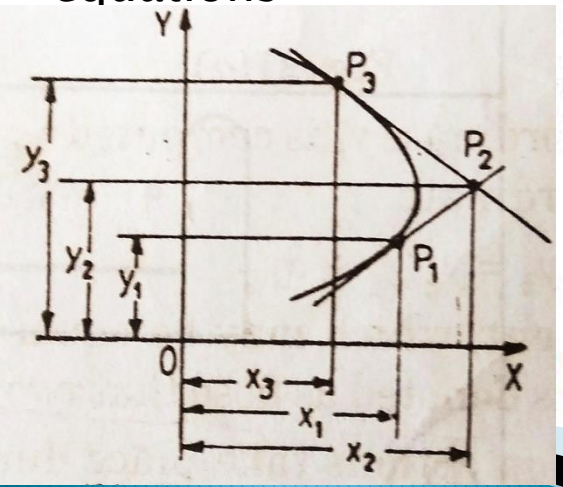


Circular Interpolation is one way, CNC's employ toolpath that are **not straightline**.

When CNC executes circular interpolation blocks, **feed rates of individual axes are not constant**. They vary continuously throughout the move. So, the resulting path of the tool tip traces some portion of a circle. So, **a single block can convey all the information necessary for the move.**

3. Helical interpolation Circular plus linear motion

4. Parabolic and cubic interpolation Free form curves using higher order equations

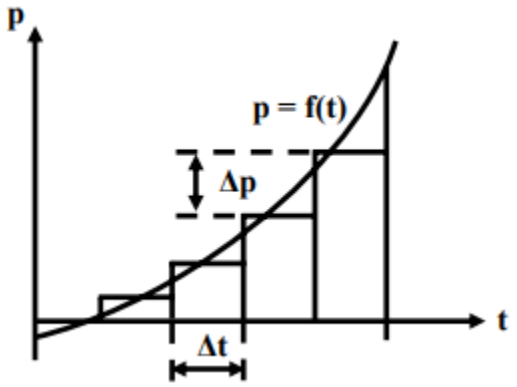


For accurate reproduction, one interpolator has received considerable attention is parametric interpolator.

Unlike other interpolators, **this generates real time position commands that lie on the original curves**.

DDA Algorithm : it is a Digital Differential Analyser (DDA) algorithm.
DDA are the computers, which combine the features of analog and digital techniques. Digital accuracy is achieved by storing variables in digital form and converting them to analog value for getting in continous form. The basic unit of DDA is its integrator.

DDA is essentially an algorithm for digital integration and generates a pulse train varying in frequency. Digital integration is performed by successive additions using an Euler approximation method shown in Fig.



From the above, let,

$$z(t) = \int_0^t p\, dt$$

The value of z at $t = k\Delta t$ is denoted by z_k, which may be written as:

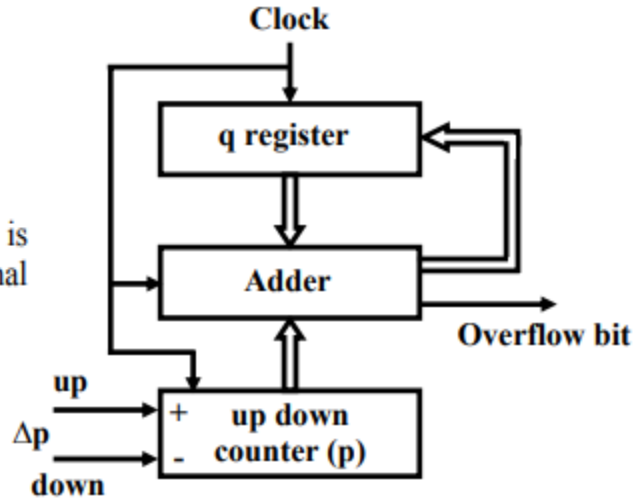
$$z_k = z_{k-1} + \Delta z_k$$

where

$$\Delta z_k = p_k\ \Delta t$$

The value of p_k can in turn be modified by incrementing or decrementing it by Δp, which is either 1 or 0. The DDA integrator operates cyclically at a frequency f provided by an external clock. At each iteration the variable p is added to the register q so that,

$$q_k = q_{k-1} + p_k$$



At intervals this addition would generate an overflow bit, which is fed as the output reference pulse. Obviously, the higher the value of p the higher would be the frequency of generation of an overflow and a reference pulse. Thus the rate of generation of the reference pulse would be proportional to the value of p.

NC COORDINATE SYSTEMS

The distances or angles which specify the position of a point, line, circle or any other geometrical figure with reference to a series of intersecting planes or planes and cylinders define coordinate systems.

There are two methods of listing the coordinates of points in NC systems, which can be used independently or in combination.

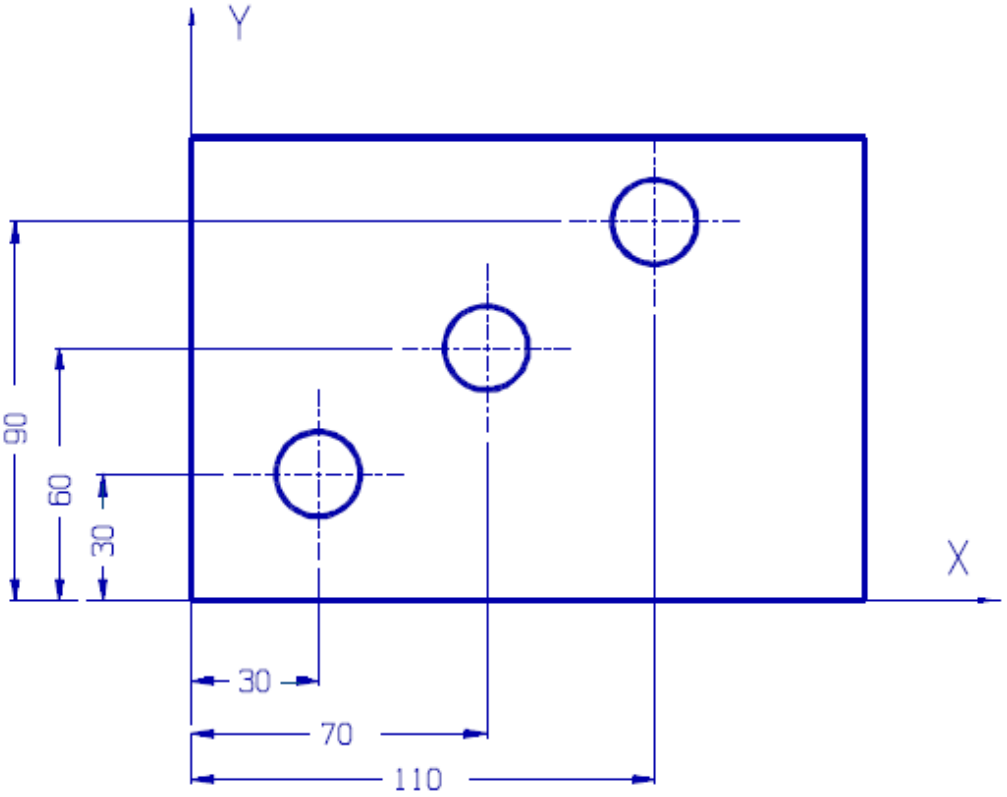
Absolute Coordinate System

Incremental Coordinate System

- **Absolute Coordinate System**

In an absolute system all references are made to the origin of the coordinate system. All commands of motion are defined by the absolute coordinate referred to the origin.

a) Fixed Origin: the origin is always located at the same position on the machine table. Usually, that position is the southwest corner (lower left-hand corner) of the table and all tool locations will be defined by positive x and y coordinates.

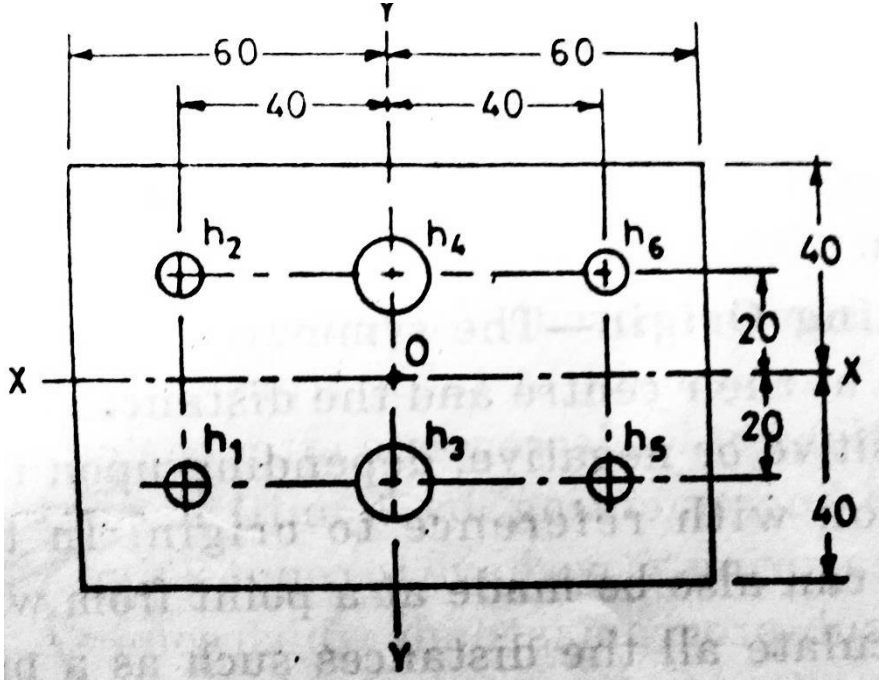


b) Floating Origin: NC machines allows the machine operator to set the zero point at any position on the machine table. This feature is called floating zero. The part programmer is the one who decides where the zero point should be located. The decision is based on part programming convenience. For example, the workpart may be symmetrical and the zero point should be established at the center of symmetry.

When the tool has been positioned at the target point, the machine operator presses a "zero" button on the machine tool console, which tells the machine where the origin is located for subsequent tool movements.

Advantages of absolute programming

- In cases of interruptions that force the operator to stop the machine, the cutting tool automatically returns to previous position. Since it always moves to the absolute coordinate called for and the machining proceeds from the same block where it was interrupted.
- Possibility of easily changing the dimensional data in the part program whenever required.
- When describing contours and positions, it is always preferable to employ absolute dimensioning, because the first incorrect dimensioning of an individual point has no effect on the remaining dimensions and the absolute system is easier to check for errors.



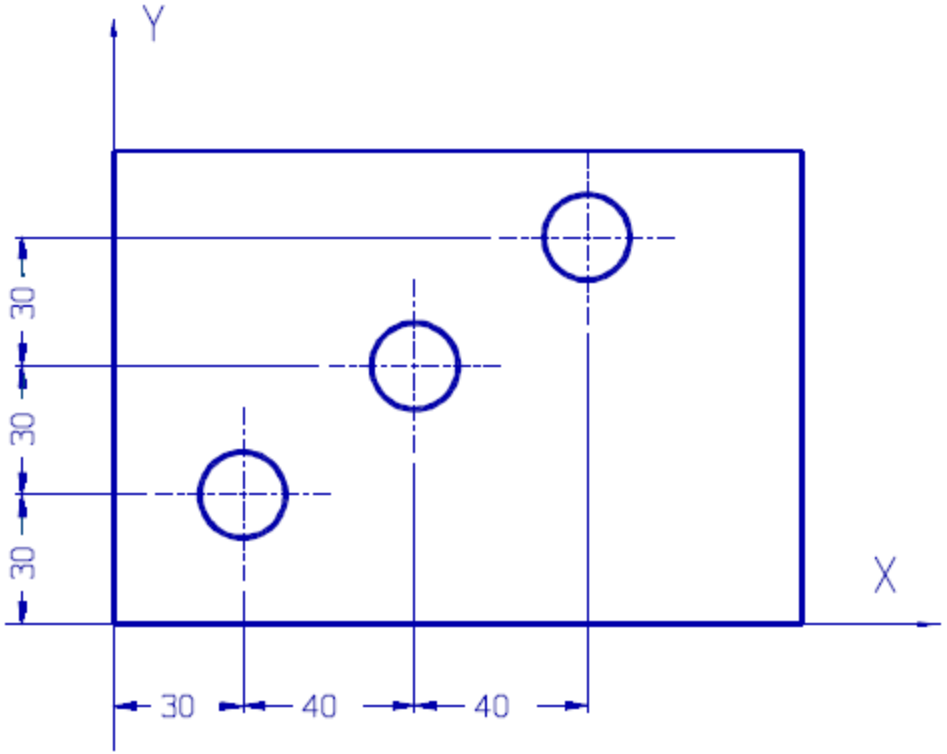
- **Incremental Coordinate System**

This type of control always uses as a reference to the preceding point in a sequence of points. The disadvantage of this system is that if an error occurs, it will be accumulated.

Most of the NC lathes ,follow an incremental Co-ordinates system.

Advantages of incremental programming

▪ If manual programming is used with incremental systems the inspection of the part program, before punching the tape is easy. Since the end point, when machining a part is identical to the starting point, the sum of the position, commands (for each axis separately) must be zero. A non-zero sum indicates that an error exists.



- The performance of the incremental system can be checked by a closed-loop tape. The last position command on the tape the table to return to the initial position.
- Mirror-image programming is facilitated with the incremental systems.
- Incremental dimension programming is advantageous for certain individual partial contours in a work piece are repeated several times, and the associated program sections **can** be employed several times without a coordinate shift.