Trade of Sheet Metalwork	
Module 7:	**Introduction to CNC Sheet Metal Manufacturing**
Unit 3:	**CNC Control Systems**
	Phase 2

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Document Release History

Date	Version	Comments
18/01/07	First draft	
09/04/14	2.0	SOLAS transfer

Module 7 – Introduction to CNC Sheet Metal Manufacturing

Unit 3 – CNC Control Systems

Duration – 3.5 Hours

Learning Outcome:

By the end of this unit each apprentice will be able to:

- State the difference between open and closed loop control systems
- State the range of applications to which CNC systems are applied in engineering and the type of control mode required for each application
- Reproduce block diagrams of open and closed loop systems and applications

Key Learning Points:

D	Block diagram of open and closed loop control.
D	Practical illustrations of common open and closed loop control systems.
Rk	Positional and velocity feedback.
Rk	Point to point positional control - punching, forming, spot welding etc.
Rk	Paraxial control - single axis punching/cutting in straight line, continuous path (contouring control), linear interpolation for angular straight lines, circular interpolation for profiles.
Rk	Range of NC applications - laser, flame cutting, inspection, machining, forming, shearing, spot welding etc.

Training Resources:

- Access to PC with CNC application packages
- Computer peripheral devices

Key Learning Points Code:

M = Maths D= Drawing RK = Related Knowledge Sc = Science

P = Personal Skills Sk = Skill H = Hazards

Open Loop

In this system there is no FEEDBACK from the motor or machine slides to indicate that it has arrived at a certain position. Therefore, very accurate control of the Motor and Slide is required. This may be achieved by the use of "Stepper Motors". The principle of the stepper motor is that when it receives a digital signal (a pulse), the spindle will rotate through a specified angle (The Step). Typical step sizes will be in the range 1.2 to 6.5 degrees. By counting the number of pulses sent to the motor and by knowing the lead of the axis lead screw the distance traversed can be accurately predicted.

The velocity of axis movement is determined by how quickly the pulses are sent to the stepper motor (Pulse Frequency). Therefore, "Feed Rules" are fixed by the speed of the pulses sent from the control unit.

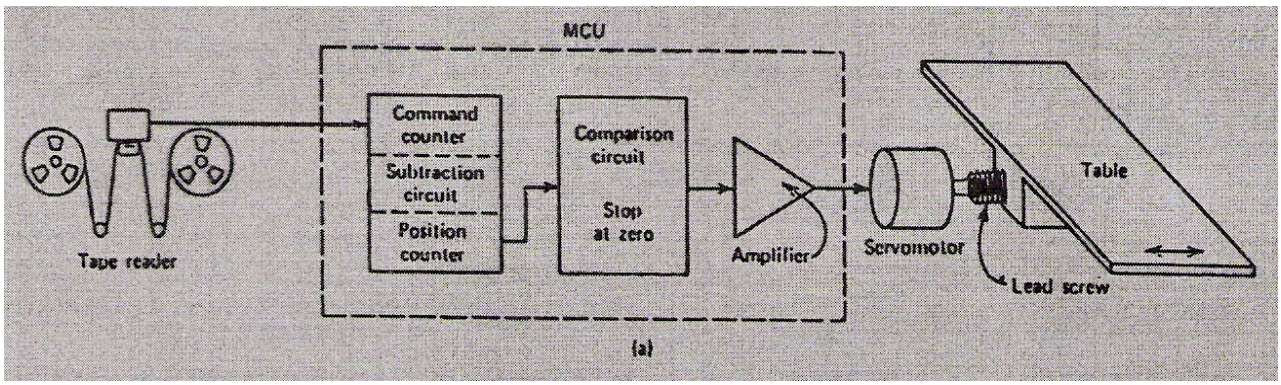


Figure 1 - Open Loop Positioning Control

Closed Loop

This system requires both positional and velocity "Feedback". To achieve this AC and DC Servomotors are used, along with a positional measuring device known as a Transducer. The transducer is attached to both fixed and moving parts of the machine tool. Velocity feedback is provided by employing a Tachogenerator into the servo motor.

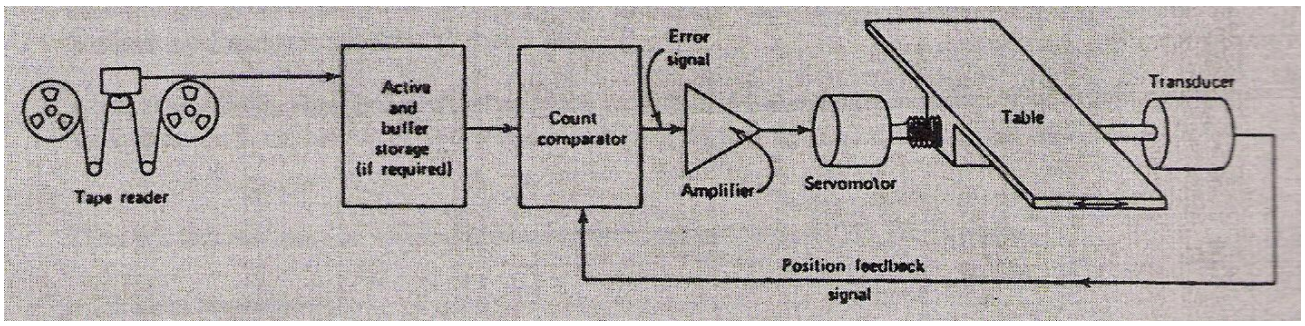


Figure 2 - Closed Loop Positioning Control

Transducers

A transducer is a device that converts one form of energy into another form of energy for example a Tachogenerator is a transducer that converts angular velocity into voltage.

Transducers are employed on CNC machines for positional measurement and can be divided into two groups: Angular transducers and Linear transducers.

Positional Feedback

This concept can be summarised as: instruction – movement – information – confirmation. The crucial feedback information is provided by a transducer.

A transducer can be described as a device which receives and transmits information. This information is received in one form, converted and then transmitted in another form acceptable to the receiver.

There are different ways in which positional transducers can be classified, for example:

- Linear transducers
- Rotary transducers

Linear Transducers

Linear transducers measure the actual movement of the carriage because they move with the carriage and only move when the carriage moves. For this reason they provide more accurate results than rotary transducers, but because they are longer they tend to be more expensive. One of the problems with linear transducers but because they are longer they tend to be more expensive. One of the problems with linear transducers is preventing contamination of the scale and reading heads from oil fumes, coolant and small particles of swarf. Thermal expansion can also cause inaccuracies on long measurements.

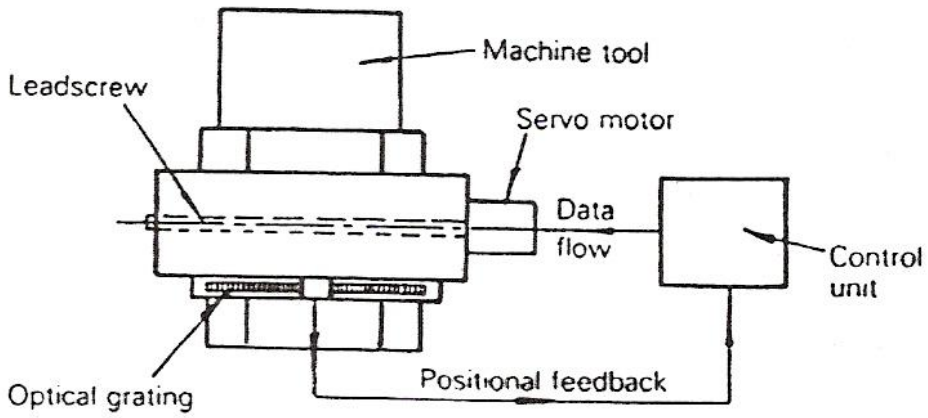


Figure 3 - Linear Transducers

1. **Linear Interpolation or Paraxial Control:**
   Moving from one point to another in a straight line. To program this straight line coordinates of the end position must be given. The Interpolation within the MCU calculates the intermediate points and ensures a direct path is traced by controlling and coordinating the axis motors. Circles may be done by a series of small straight lines.

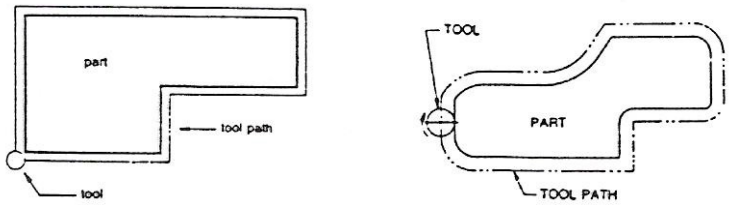


Figure 4 - Linear Interpolation

2. **Circular Interpolation or Continuous Path:**
   This is a mode of contouring control which uses the information contained in a single block to produce an arc of a circle.
   This principle may be strung together to give ½ circles or full circle. The interpolation works from a current programmed position and end point (given x and y) and the arc radius. The circle interpolator converts the arc into small linear moves.

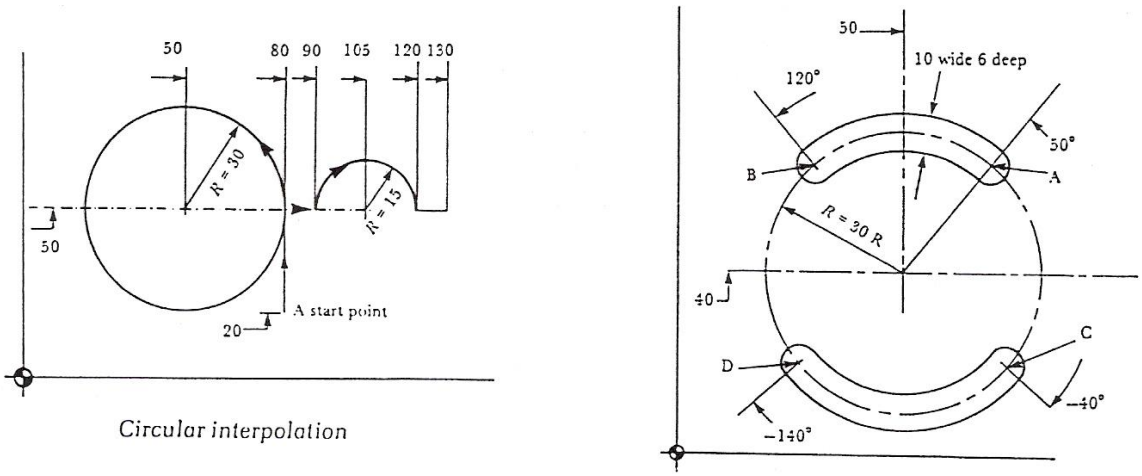


Figure 5 - Circular Interpolation

3. **Parabolic Interpolation:**
   Involves three non-straight line positions in a movement as perhaps with Robotic Paint Spraying or Robotic Welding.

Applications of CNC

1. Punching;
2. Forming;
3. Spot welding;

The above are point-to-point.

1. Punching;
2. Welding;
3. Plasma, laser and flame cutting;
4. Spray painting.

These are line motion/contouring. Also: milling, lathe, inspection, shearing.

Control Modes of CNC

Transducers (feedback devices).
Servo motors (accurate positioning of workpiece and back gauges etc.).
Control amplifier.

Self Assessment

Questions on Background Notes – Module 7.Unit 3

1. Draw a block diagram of a closed and an open loop system.

2. Describe paraxial control and circular interpolation.

Answers to Questions 1-2. Module7.Unit 3

1.

Figure 1: Open Loop Positioning Control

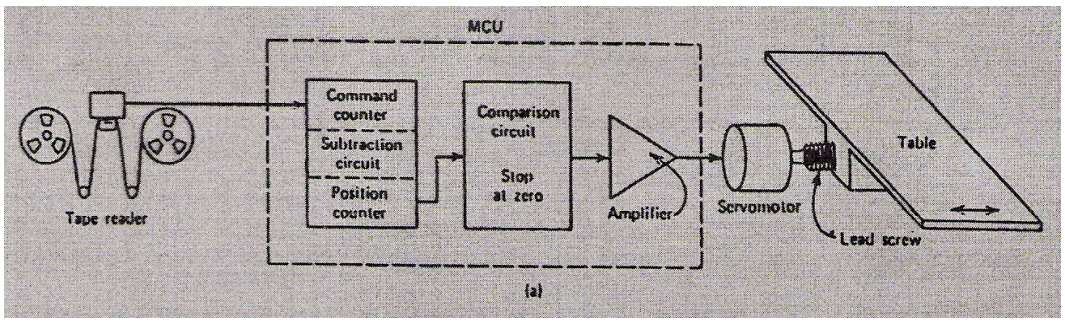
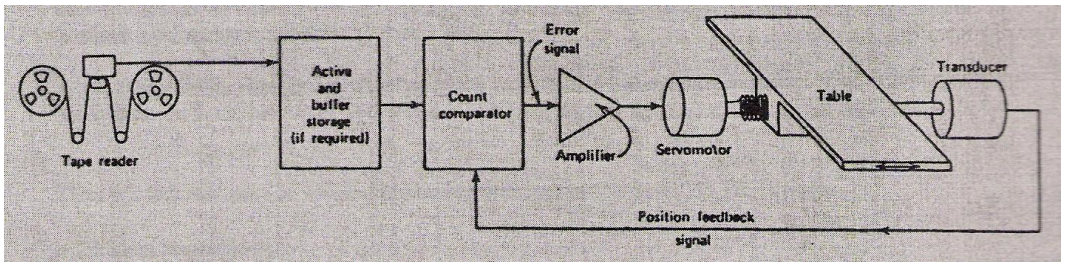


Figure 2: Closed Loop Positioning Control



2.

Linear Interpolation or Paraxial Control:

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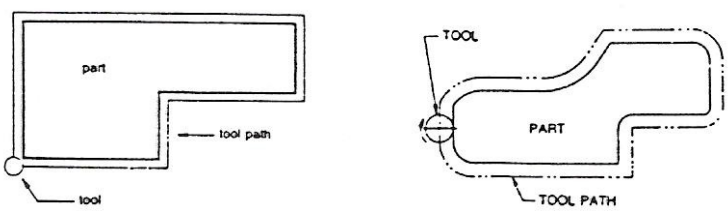

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Circular Interpolation or Continuous Path:

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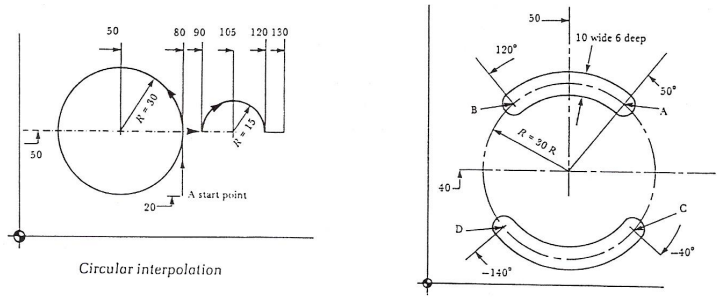

Figure 4: Circular Interpolation

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