Numerical control

L-23

Contents

1)Numerical Control (NC)

- It is a form of programmable automation in which mechanical actions of machine tool or other equipment are controlled by a program containing coded alphanumeric data
- The alphanumeric data represent relative positions between a work-head and a workpart as well as other instructions needed to operate the machine
- The workhead is a cutting tool or other processing apparatus, and the workpart is the object being processed.
- When current job is completed, the program instructions can be changed to process a new job. This capability to change the program makes NC suitable for low and medium production. It is much easier to write new programs than to make major alterations of the processing equipment

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- Numerical control can be applied to a wide variety of processes. The application divide in two categories

(1) Machine tool applications, such as drilling, milling, turning and other metal working

(2) nonmachine tool application, such as assembly, drafting and inspection

- The common operating feature of NC in all of these applications is control of the workhead movement relative to workpart.

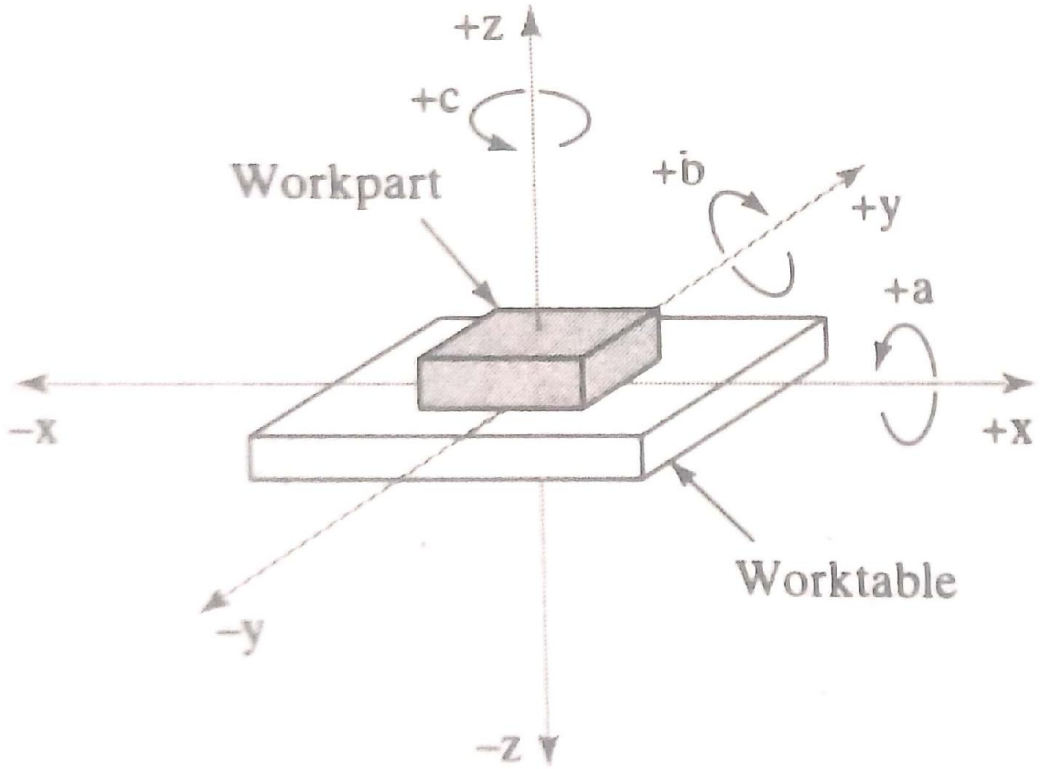
a)Components of NC

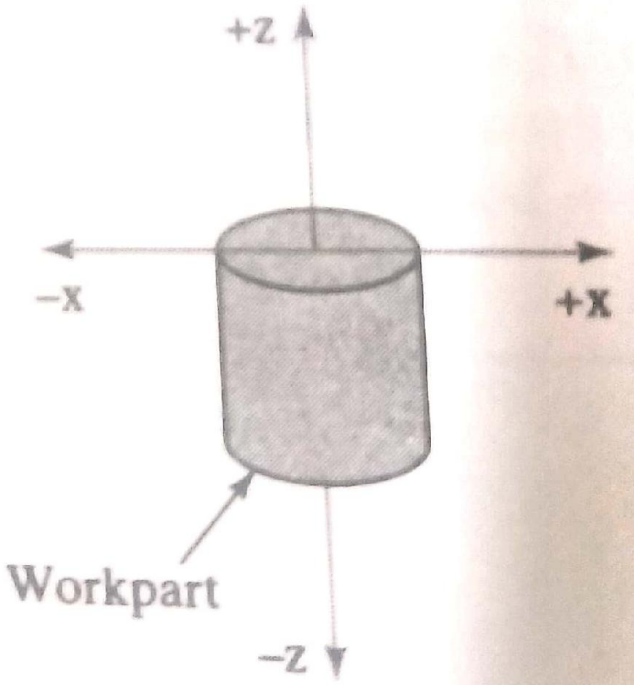
1. Program of instructions: It is detailed step-by-step commands that direct the actions of the processing equipment, In machine tool applications, the program of instructions is called a part program, and the person who prepares the program is called a part programmer. In these applications, the individual commands refer to positions of a cutting tool relative to the worktable on which the workpart is fixtured.
2. Machine control unit: It consist of microcomputer and related control hardware that stores the program of instructions and executes it by converting each command into mechanical actions of the processing equipment, one command at a time.. The hardware of the MCU includes components to interface with the processing equipment and feedback control elements

- MCU also includes one or more reading devices for entering part programs into memory. The type of readers depends on the storage media used for part programs in the machine shop (e.g punched tape reader, magnetic tape reader, floppy disk drive). The MCU also includes control system software, calculation algorithms and translation software to convert the NC part program into usable format for the MCU.

3. Processing unit: It performs the useful work. It accomplishes the processing steps to transform the starting workpiece into a completed part. Its operation is directed by the MCU, which in turn is driven by instructions contained in the part program. The processing equipment consists of the worktable and spindle as well as the motors and controls to drive them

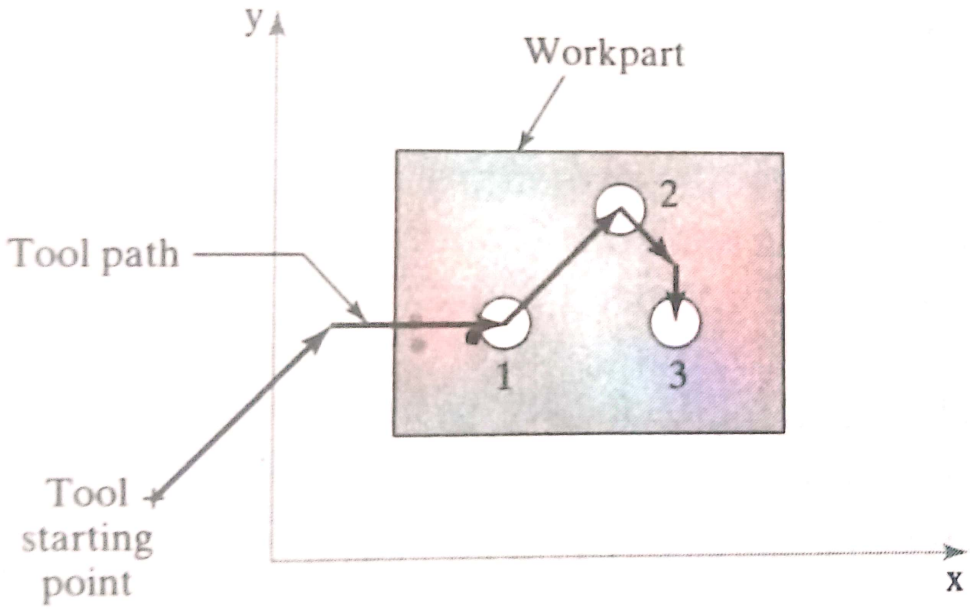
b) NC Coordinate System





c) Motion Control Systems

- Point to point versus Continous Path Control



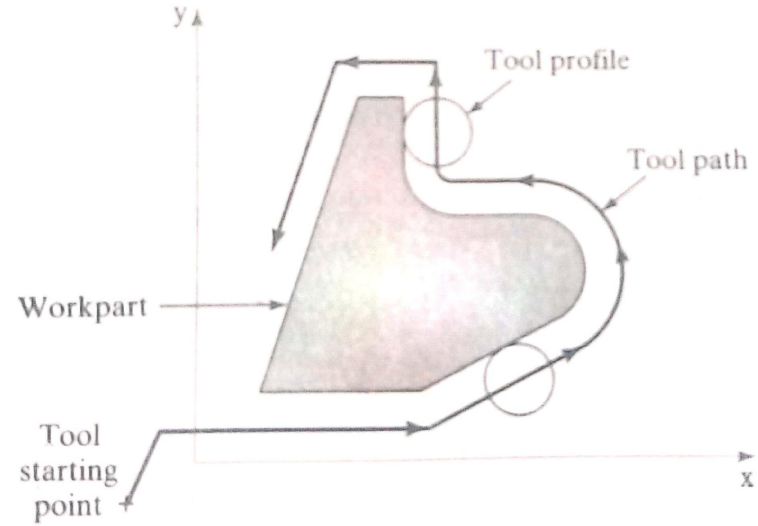


Figure 6.4 Continuous path (contouring) control in NC (*x*-*y* plane only). Note that cutting tool path must be offset from the part outline by a distance equal to its radius.

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Interpolation Methods:

They include

(i) Linear interpolation

(ii) Circular interpolation

(iii) Helical interpolation

(iv) Parabolic and cubic interpolations

2)Computer Numerical Control

- Since the introduction of NC in 1952, there have been dramatic advances in digital computer technology. The physical size and cost of digital computer have been significantly reduced at the same time that its computational capabilities have been substantially increased. It was logical for makers of NC equipment to incorporate these advances in computer technology into their products, starting first with large mainframe computers in 1960s, followed by minicomputers in 1970s and microcomputers in 1980s.
- CNC is defined as an NC system whose MCU is based on a dedicated microcomputer rather than on a hard-wired controller.

Features of CNC

1. Storage of more than one part program
2. Various forms of program input
3. Program editing at the machine tool
4. Fixed cycles and programming subroutines
5. Interpolation i) Linear ii) circular iii) helical iv) parabolic and cubic
6. Positioning features for setup
7. Cutter length and size compensation
8. Accelerations and decelerations calculations
9. Communications interface
10. Diagnostics

Common features of CNC diagnostics system

- Control start-up diagnostics
- Malfunction and failure analysis
- Extended diagnostics for individual components
- Tool life monitoring
- Preventive maintenance notices
- Programming diagnostics

The MCU is the hardware that distinguishes CNC from conventional NC. The general configuration of the MCU in a CNC system is illustrated in Figure 6.7. The MCU consists of the following components and subsystems: (1) central processing unit, (2) memory, (3) I/O interface, (4) controls for machine tool axes and spindle speed, and (5) sequence controls for other machine tool functions. These subsystems are interconnected by means of a system bus, as indicated in the figure.

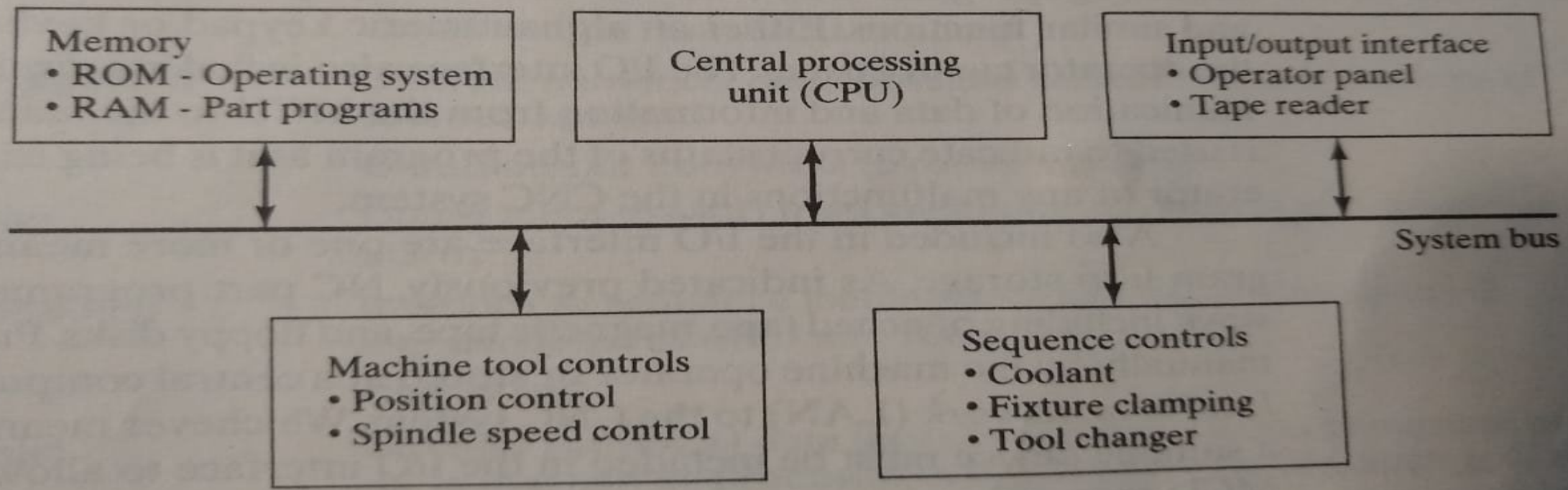


Figure 6.7 Configuration of CNC machine control unit.

TABLE 6.3 Examples of CNC Auxiliary Functions Often Implemented by a Programmable Logic Controller in the MCU

CNC Auxiliary Function	*Type or Classification*
Coolant control	On/off output from MCU to pump
Tool changer and tool storage unit	Discrete numerical data (possible values limited to capacity of tool storage unit)
Fixture clamping device	On/off output from MCU to clamp actuator
Emergency warning or stop	On/off input to MCU from sensor; on/off output to display and alarm
Robot for part loading/unloading	Interlock to sequence loading and unloading operation; I/O signals between MCU and robot
Timers	Continuous
Counters (e.g., piece counts)	Discrete numerical data (possible values limited to number of parts that can be produced in a given time period, such as a shift)

c) CNC Software

(i) Operating system software

(ii) Machine interface software

(iii) Application software

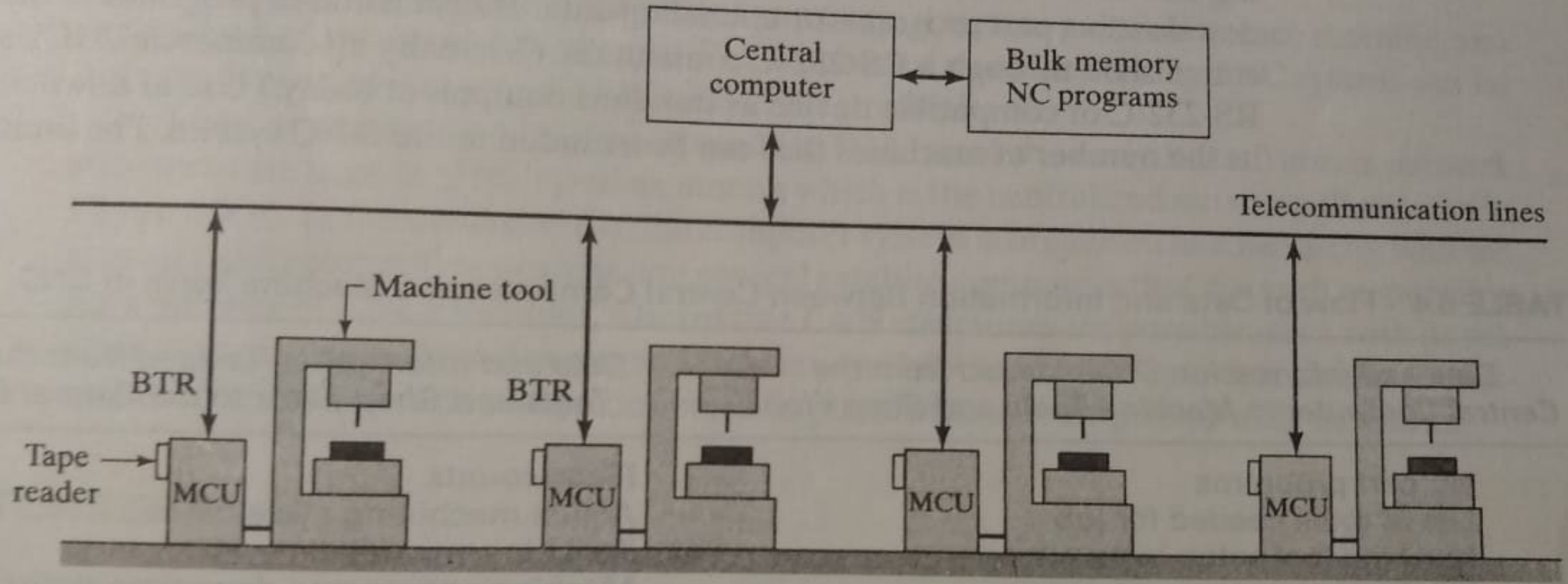
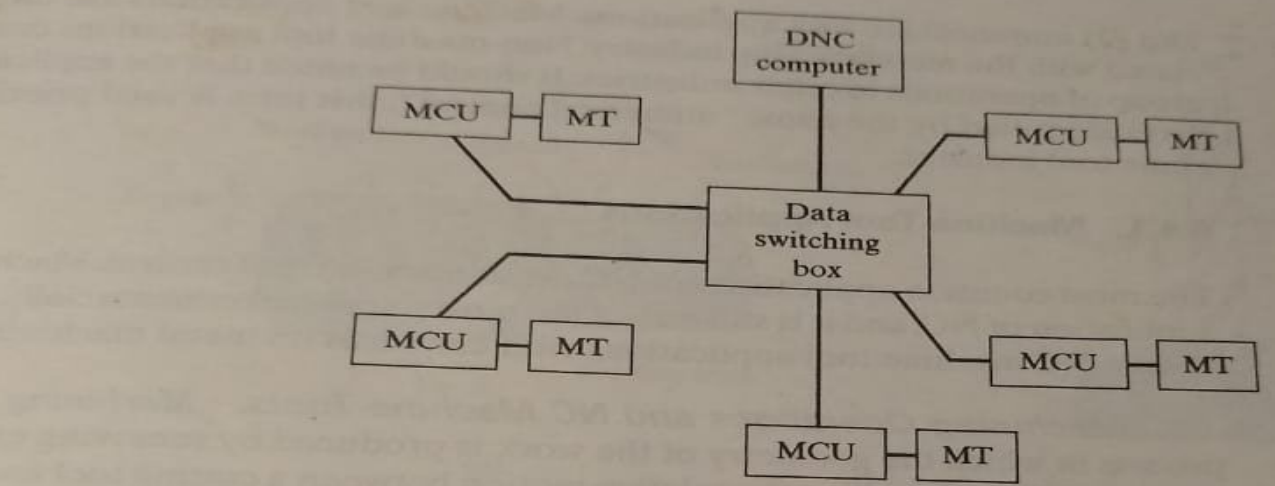
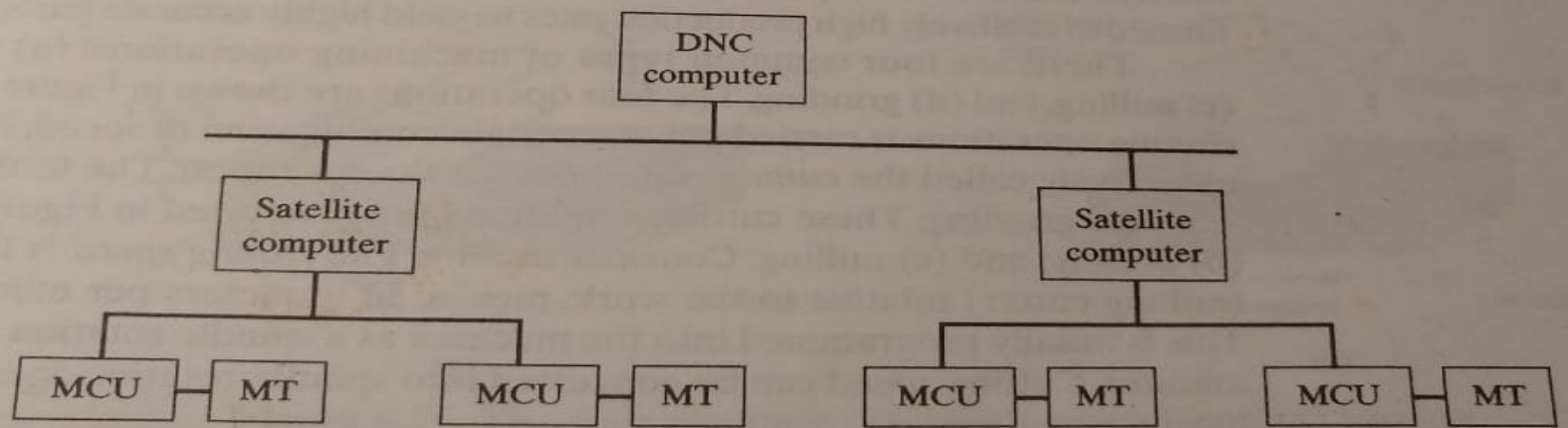


Figure 6.8 General configuration of a DNC system. Connection to MCU is behind the tape reader. Key: BTR = behind the tape reader, MCU = machine control unit.



(a)



(b)

Figure 6.9 Two configurations of DNC: (a) switching network and
(b) LAN. Key: MCU = machine control unit, MT = machine tool

4) Application of NC

(i) Machining operations and NC Machine Tools

NC lathe, NC boring mill, NC drill press, NC milling machine, NC cylindrical grinder

(ii) NC for other Metalworking Processes

Punch presses, presses, welding machines, thermal cutting machines, tube bending machines

(iii) Other application includes

Electrical wire wrap machines, component insertion machines, Drafting machines, Coordinate measuring machine, Tape laying machines for polymer composites, filament winding machines for polymer composites

NC application Characteristics

(i) Batch production
(ii) Repeat orders
(iii) Complex part geometry
(iv) Much metal needs to be removed from the workpart
(v) Many separate machining operations on the part
(vi) The part is expensive

c) Advantages of NC

(i) Nonproductive time is reduced
(ii) Greater accuracy and repeatability
(iii) Lower scrap rates
(iv) Inspection requirements are reduced
(v) More complex part geometries are possible
(vi) Engineering changes can be accommodated more gracefully
(vii) Simpler fixtures are needed
(viii) Shorter manufacturing lead times
(ix) Reduced parts inventory
(x) Less floorspace required
(xi) Operator skill-level requirements are reduced

Disadvantages of NC

(i) Higher investment cost

(ii) Higher maintenance effort

(iii) Part programming

(iv) Higher utilization of NC equipments

NC Part Programming