



Computerized Numerical Controllers (CNC) Mitsubishi Electric CNC Fundamentals (Introduction)

The purpose of this course is to provide users with fundamental prior knowledge of NC (numerical control) and NC machine tools

Introduction Purpose of the course

The purpose of this course is to provide users with fundamental knowledge of NC (numerical control) and NC machine tools. Upon completion of this course, we recommend enrolling in the NC school.

Introduction Course structure



The contents of this course are as follows.

Chapter 1 - Overview of machine tools

Role, structure and machining process

Chapter 2 - History and types of NC machine tools

The history of equipping machine tools with NC units and different types of NC machine tools

Chapter 3 - NC unit configuration

Devices included in the NC unit

Chapter 4 - Mitsubishi Electric CNC lineup

Features of the M800/M80/C80 series

Final Test

Pass grade: 60% or higher

Introduction **How to use this e-Learning tool**

Go to the next page		Go to the next page.
Back to the previous page		Back to the previous page.
Move to the desired page		"Table of Contents" will be displayed, enabling you to navigate to the desired page.
Exit the learning		Exit the learning.

Introduction **Cautions for use****Safety precautions**

When you learn based on using actual products, please carefully read the safety precautions in the corresponding manuals.

Chapter 1 Overview of machine tools

This chapter explains the role, structure, and machining process of machine tools.

1.1 Role of machine tools

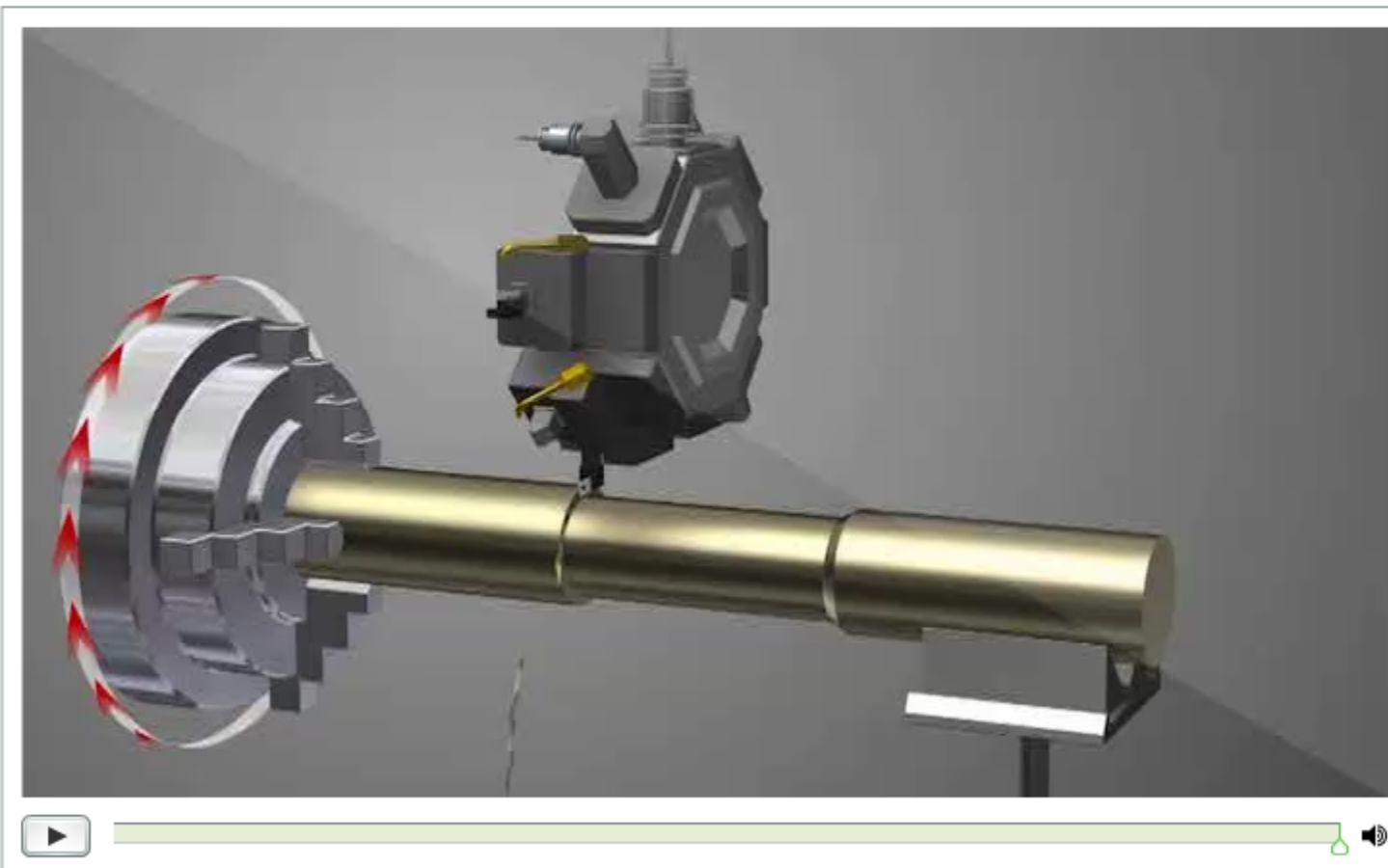
1.2 Structure of a machine tool

1.3 Machining with machine tools

1.1**Role of machine tools**

Machine tools are machines that make parts and products by cutting materials with tools. The cutting and shaping of materials is called machining.

Press the playback button (▶) to see a demonstration of machining.



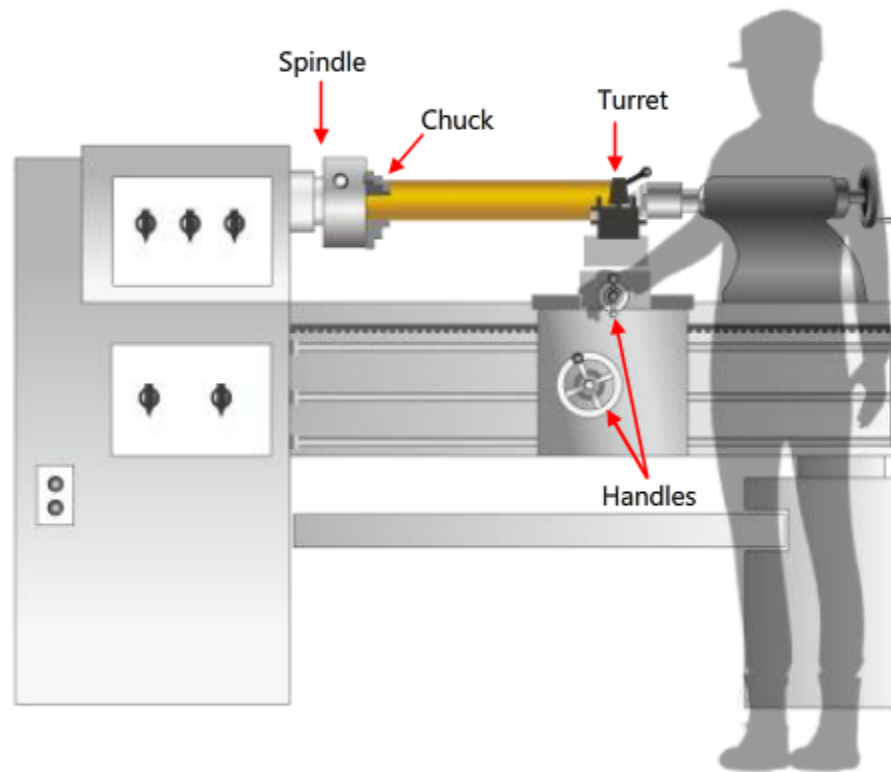
1.2

Structure of a machine tool

This is the structure of a lathe, which is a typical machine tool.

A lathe includes a **spindle** that rotates the material (machining workpiece), a **chuck** that fixes the machining workpiece, a **turret** that holds tools, and **handles** for moving the turret.

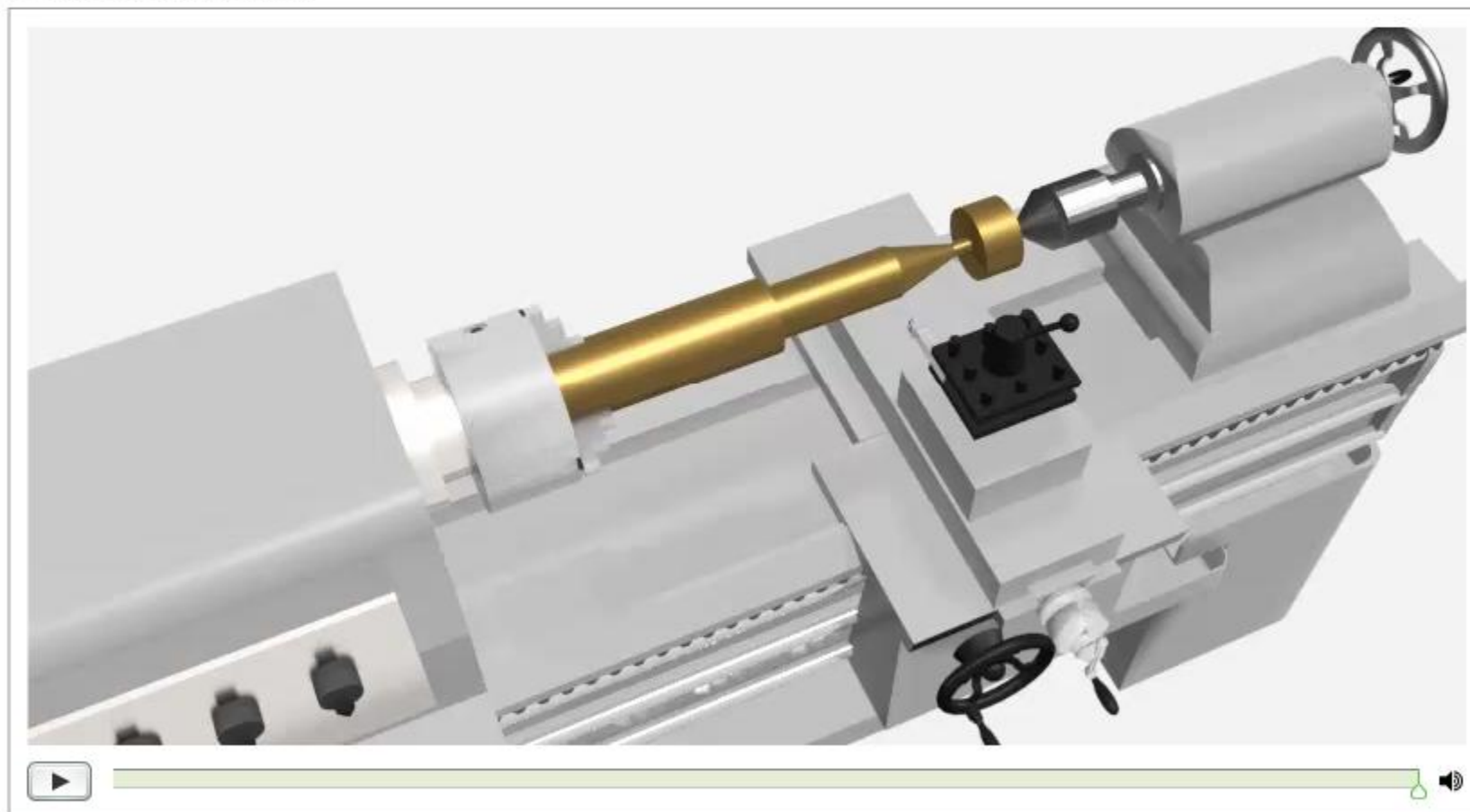
To machine material with a lathe, a person must operate the handle.



1.3 Machining with machine tools

Machine tools are mainly used for making parts for home appliances and automobiles. For these parts, materials must be accurately machined based on design drawings. To machine accurately, a skilled tradesman with vast experience and extensive knowledge is essential. The machining process with a lathe is explained in the video below.

Press the playback button (>).



1.4**Summary**

The contents of this chapter are:

- Role of machine tools
- Structure of a lathe
- Machining procedure

Important points to consider:

Role of machine tools	<ul style="list-style-type: none">• Makes products and parts by cutting materials with tools.
Structure of a lathe	<ul style="list-style-type: none">• Includes a spindle, chuck, turret, handles, and other parts.• A lathe is operated by a person.
Machining with a lathe	<ul style="list-style-type: none">• Machining is performed by a person who operates the handles and moves the turret horizontally and vertically in relation to the spinning material.• Even complicated shapes can be machined by moving both handles simultaneously.

Chapter 2 History and types of NC machine tools

The history of equipping machine tools with NC units and the different types of NC machine tools are explained in this chapter.

- 2.1 History of NC machine tools
- 2.2 Instructions for machining details
- 2.3 Mechanisms of NC machine tools
- 2.4 Types of machining with machine tools
- 2.5 Types of NC machine tools
- 2.6 Coordinate systems for machining directions

2.1**History of NC machine tools**

In recent years, there has been an increasing demand for the mass production of high-precision parts. However, to meet this increasing demand using conventional machine tools, the following issues are present.

- To accurately perform complex processing, a skilled tradesman is essential.
- Manufacturing is limited to a person's output.

Using conventional machines to meet this demand would require many skilled tradesmen to work continuously without rest.

Therefore, around 1950 in the USA, an NC (numerical control) machine tool was developed to automatically control machine tools.

With the advent of the NC machine tool, complicated and high-precision parts could be accurately and continuously manufactured at high volume without the need for rest.

Since 1956, Mitsubishi Electric has been developing NC units, and today, NC units are integrated into many machine tools.

* Although NCs are often called CNCs (computerized numerical controllers), in this course, they are referred to mainly as NCs.

2.2

Instructions for machining details

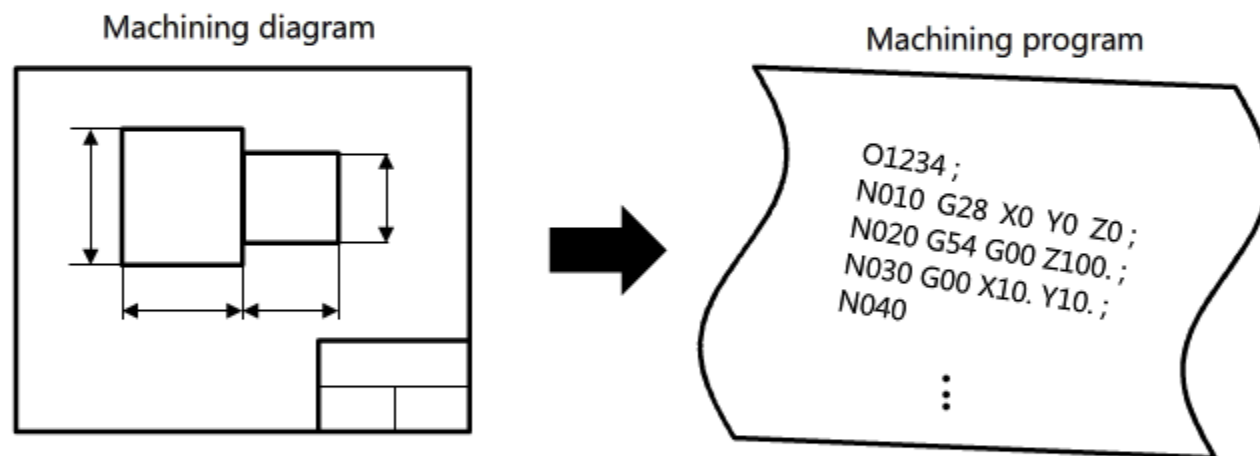
To machine at the same level as a skilled tradesman, the NC unit must be taught the machining details, such as the machining procedure performed by said tradesman and the machining amount.

An **NC language** was developed to convert the machining shapes and margins of error that are listed in machining diagrams into information that the NC unit can analyze.

The NC language is composed of alphanumeric characters.

A sequenced process written using NC language is called a **machining program**.

The NC language is standardized, so basic commands are the same regardless of who manufactured the NC unit.



2.3

Mechanisms of NC machine tools

In this section, the mechanisms of NC machine tools are explained by comparing a conventional **lathe** to an NC **lathe** with a built-in NC unit.

Press the playback button (▶).



You can see that the machine tool operations that used to be performed by a skilled tradesman are being done by a computer controlling the motor.

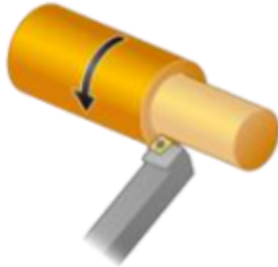
2.4

Types of machining with machine tools

There are just as many types of NC machine tools available as regular machine tools. Before each type of NC machine tool is explained, the types of machining done by the major machine tools are shown here.

Lathes

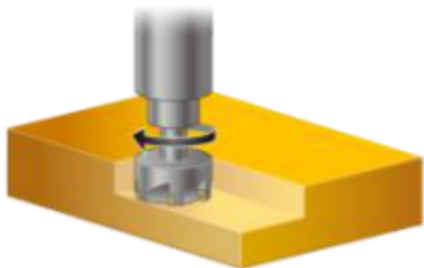
The lathe rotates a cylindrical workpiece and cuts away the material by pressing a tool (turning tool) against the workpiece.

**Drilling machines**

The drilling machine rotates a drill or other bit to drill holes and cutting threads.

**Milling machines**

The milling machine creates curved surfaces, grooves, and other shapes by machining the surface with a rotating cutting tool.



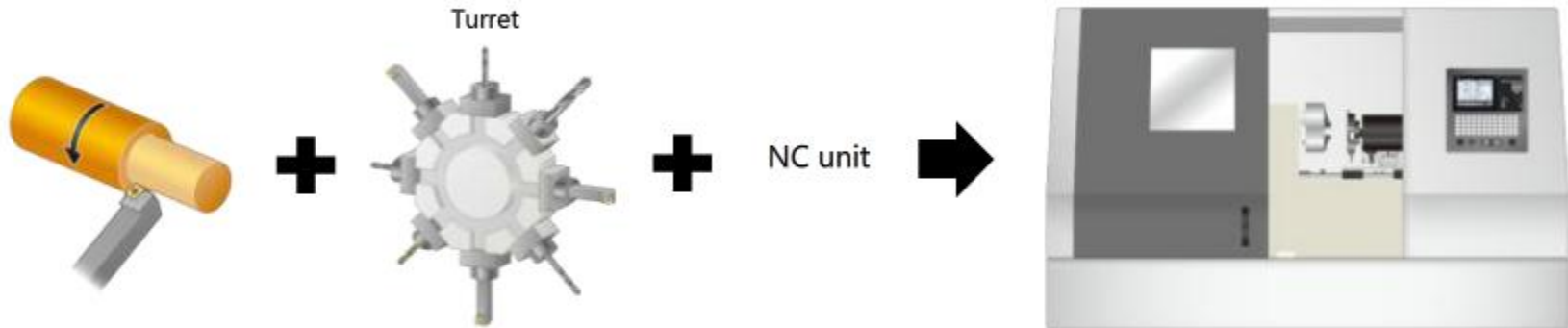
2.5

Types of NC machine tools

NC machine tools can be generalized into two types: **lathe systems** and **machining center systems**.

Lathe system

Enables lathes to be controlled using an NC unit. These systems are ideal for machining cylindrical workpieces. They are equipped with a turret with multiple tools, so operators can select the tool that suits the machining type.

**Machining center system**

A single machining center can work as both a drilling machine and milling machine. These systems are ideal for drilling holes and cutting shapes. They are equipped with an ATC device that automatically changes tools, for continuous machining while changing to the appropriate tools.



The machining programs also differ because the instructions for moving the tool and workpiece differ depending on the tool type.

On the following pages, the differences between the coordinate systems are explained.

2.6

Coordinate systems for machining directions

An NC machine tool is equipped with a **spindle motor** that rotates the tool or workpiece, and **feed axis motors** that move the tool or workpiece according to the machining shape.

The spindle motor exerts powerful force, so it can withstand the load applied when the workpiece is cut.

The feed axis motor precisely moves the tool or workpiece.

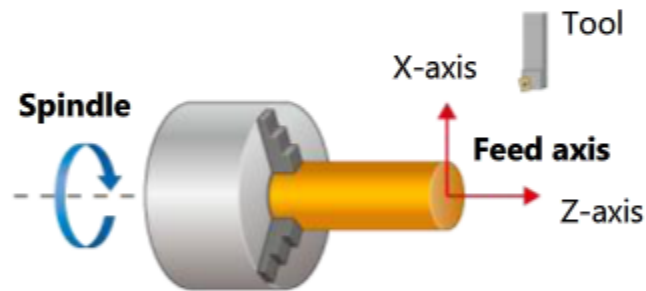
The directions in which the tool and workpiece are moved by these motors are called the X-axis, Y-axis, Z-axis, and so on.

Axes on lathe systems

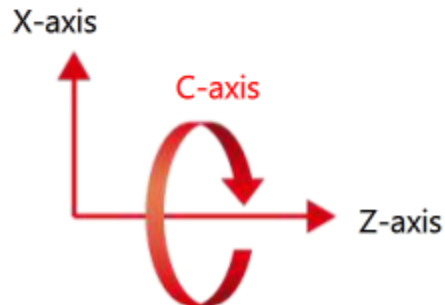
In a lathe system's NC machine tool, the spindle motor rotates the workpiece with enough torque to withstand the force of the tool, and the feed axis motors accurately move the tool.

Two feed axes (X-axis and Z-axis) are necessary to perform standard machining. These are called the basic axes.

The axial direction of the spindle is the Z-axis. The Z-axis motor moves the tool horizontally. The X-axis motor moves the tool vertically.



Giving a rotary axis (C-axis) direction instructions with respect to the Z-axis enables more complicated machining.

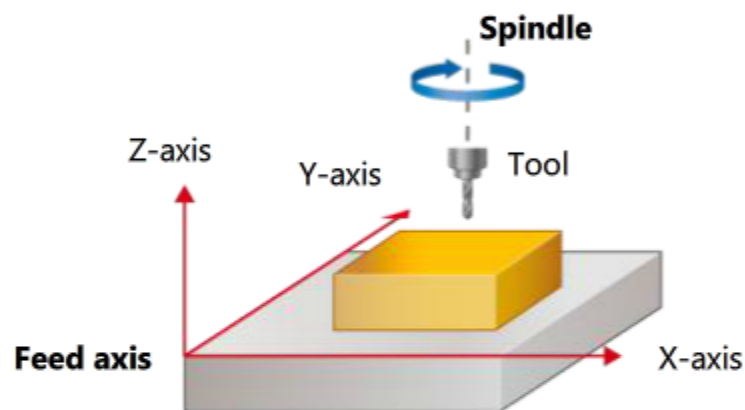


Axes on machining center systems

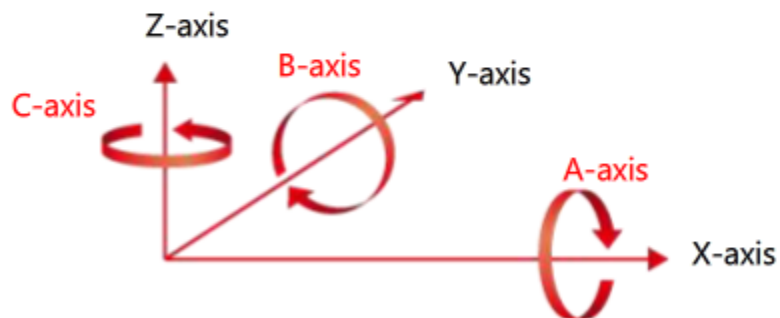
In a machining center system's machine tool, the spindle moves the tool, and the feed axis motors move the workpiece.

Three feed axes (X-axis, Y-axis, and Z-axis) are necessary to perform standard machining.

The horizontal axis for moving the table or the tool is called the X-axis, the vertical axis is called the Y-axis, and the height axis is called the Z-axis (the axial direction of the spindle).



More complex machining can be performed by adding rotary axes (A-axis, B-axis, and C-axis).



By understanding the coordinate system for each type of machining system, machining direction instructions can be given in the NC language.

Notice how more complicated machining can be performed as the number of feed axes increases.

The contents of this chapter are:

- History
- How to give instructions
- Mechanisms and types
- Direction of instructions

Important points to consider:

Issues of conventional machine tools	<ul style="list-style-type: none"> • To accurately perform complex processing, a skilled tradesman is essential. • Manufacturing is limited to a person's output.
Merits of using an NC machine tool	<ul style="list-style-type: none"> • Even complicated machining can be performed accurately. • Unlike with people, because rest is unnecessary, high-volume production is possible.
Instructing machining details to NC machine tools	<ul style="list-style-type: none"> • Machining details are instructed to the NC unit using a machining program. • The machining program is written in alphanumeric characters called the NC language. • The NC language is standardized.
Mechanisms of NC machine tools	<ul style="list-style-type: none"> • The movement of a tool is performed by motors. • The motors are controlled by the NC unit.
Types of machining by machine tools	<ul style="list-style-type: none"> • The lathe rotates a cylindrical workpiece and cuts away the material by pressing a tool against it. • The drilling machine rotates a drill or other bit to drill holes and cut threads. • The milling machine creates curved surfaces, grooves, and other shapes by cutting the surface with a rotating cutting tool.
Types of NC machine tools	<ul style="list-style-type: none"> • The lathe is a lathe that can be controlled by an NC unit and multiple tools can be selected and used. • A single machining center can work as both a drilling machine and milling machine and can continuously machine while changing to the appropriate tools.
Coordinate system	<ul style="list-style-type: none"> • An NC machine tool includes a spindle motor that rotates the tool or workpiece with great force and feed axis motors that move the tool or workpiece with great precision. • The directions in which the tool and workpiece are moved by the motors are called the X-axis, Y-axis, Z-axis, and so on. • In a lathe system's NC machine tool, the spindle motor rotates the workpiece, and the feed axis motors move the tool. • In a machining center system's machine tool, the spindle moves the tool, and the feed axis motors move the workpiece. • When the number of feed axes is increased, complicated machining can be performed.

Chapter 3 Configuration of the NC unit

Devices included in the NC unit will now be explained.

3.1 Configuration of the NC machine tool

3.2 Configuration of the NC unit

3.3 Drive system

3.4 Control unit

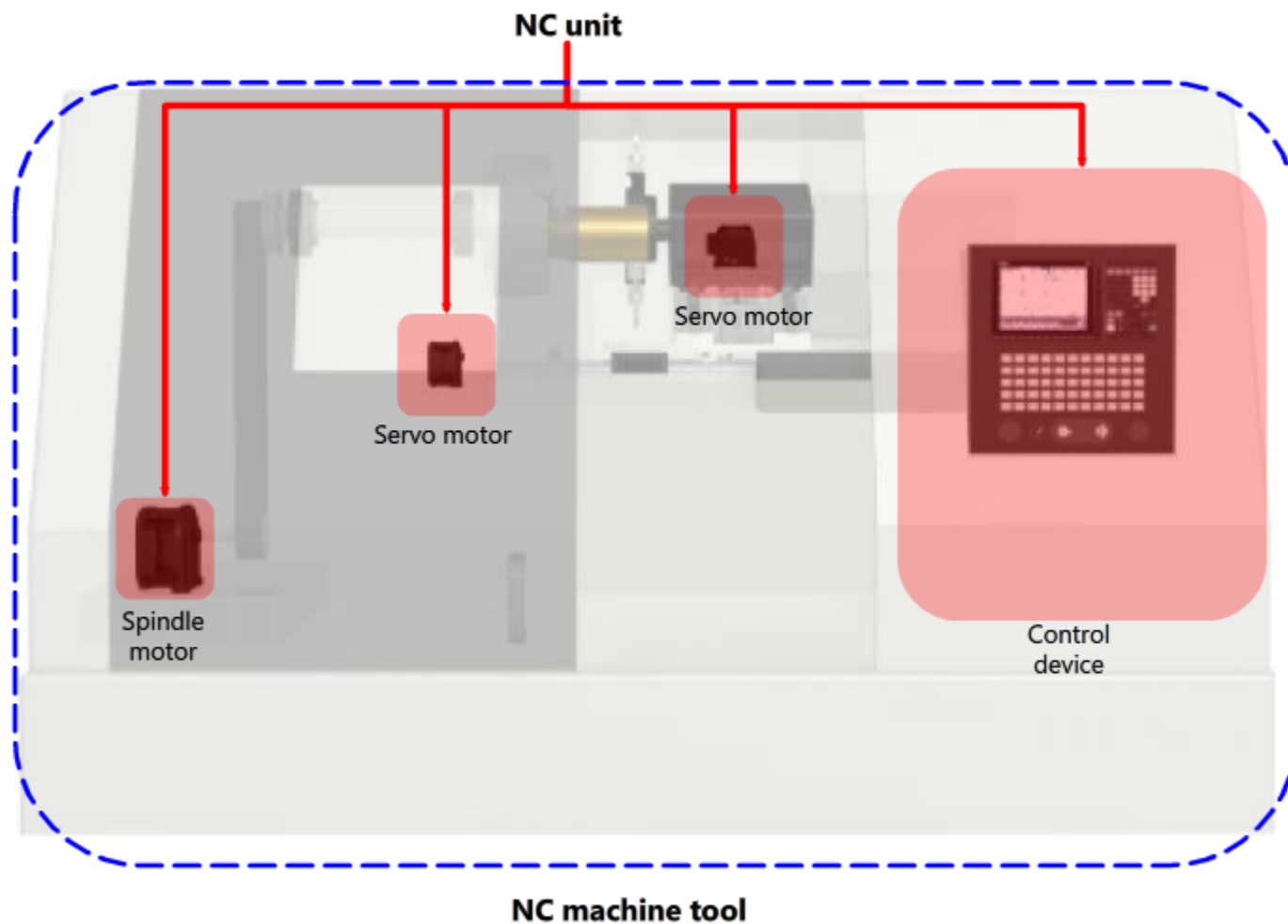
3.5 Display unit

3.6 Other peripheral devices

3.1

Configuration of the NC machine tool

An NC machine tool includes an **NC unit** and a **machine tool**.

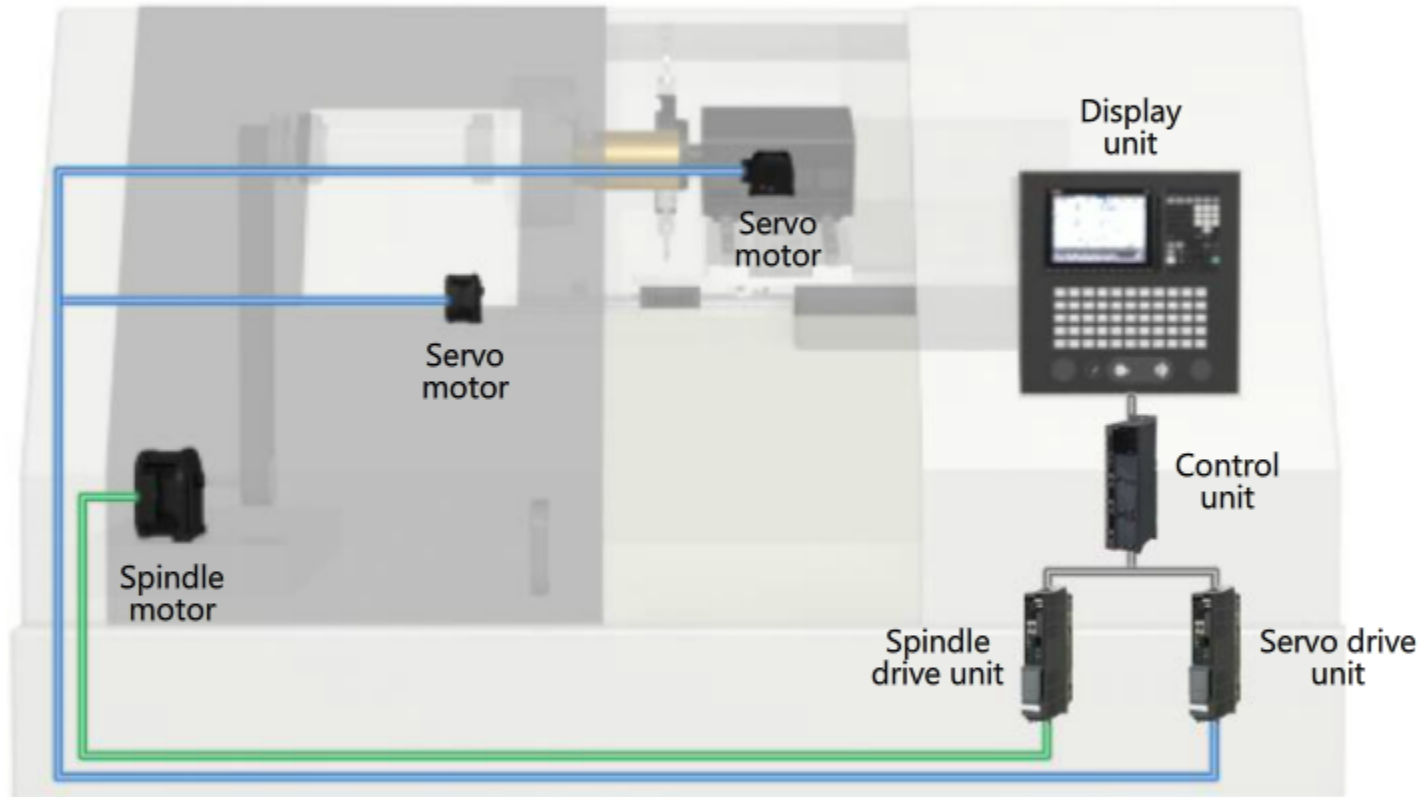


3.2

Configuration of the NC unit

The configuration of the NC unit is shown below.

The NC unit includes **motors**, **drive units** that move the motor, a **control unit** that gives commands to the drive units, and a **display unit** that displays information on the instructions being given to the control unit.

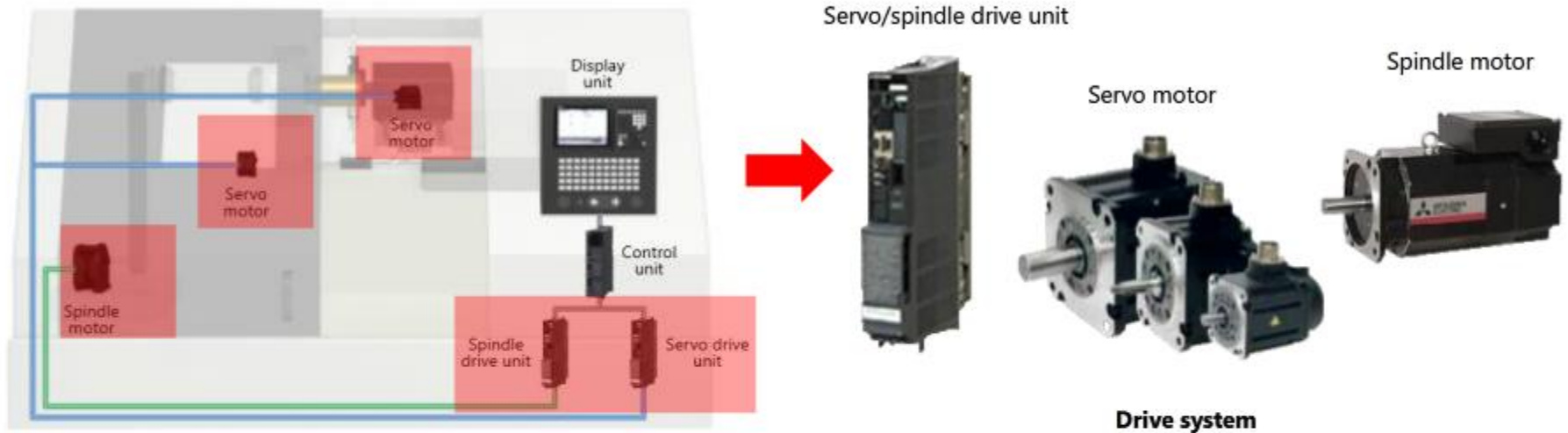


Mitsubishi Electric provides NC units to machine tool manufacturers.

3.3

Drive system

The combination of the motors and the drive unit that drives them is called the **drive system**. Also, the drive unit consists of a **spindle drive unit** that drives the spindle motor and a **servo drive unit** that drives the servo motor.

**Servo drive unit**

Controls the position and speed of the feed axes based on commands from the control unit.

Spindle drive unit

Controls the rotational speed (rotation rate) and the angle of rotation of the tool or workpiece based on commands from the control unit.

Servo motor

Moves the table, turret, or other part via a feed screw or other means, based on commands from the servo drive unit.

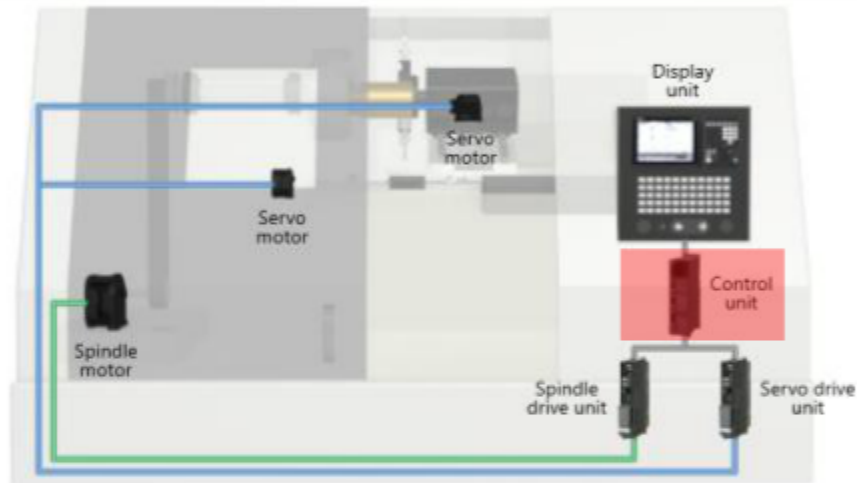
Spindle motor

Rotates the spindle based on commands from the spindle drive unit.

3.4

Control unit

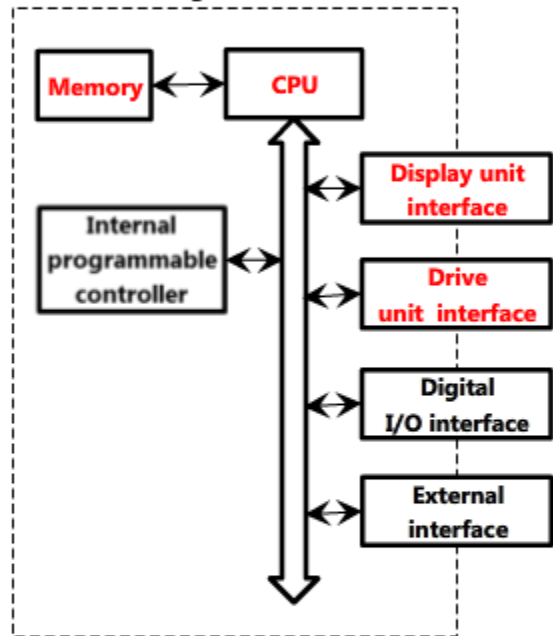
The control unit reads the machining details written in the machining program and transmits instructions regarding the movement amount and movement speed of the tool and workpiece to the servo drive unit and the spindle drive unit. The internal configuration of the control unit is shown below. The control unit has a CPU for control, memory for storage, and an interface for the devices to connect to.



Control unit



Internal configuration

**CPU**

The CPU (Central Processing Unit) acts as the brain, reading the NC language and giving instructions to each of the connected devices.

Memory

Non-volatile memory is used for storing parameters and machining programs, and temporary memory is used for performing calculations.

Display unit interface

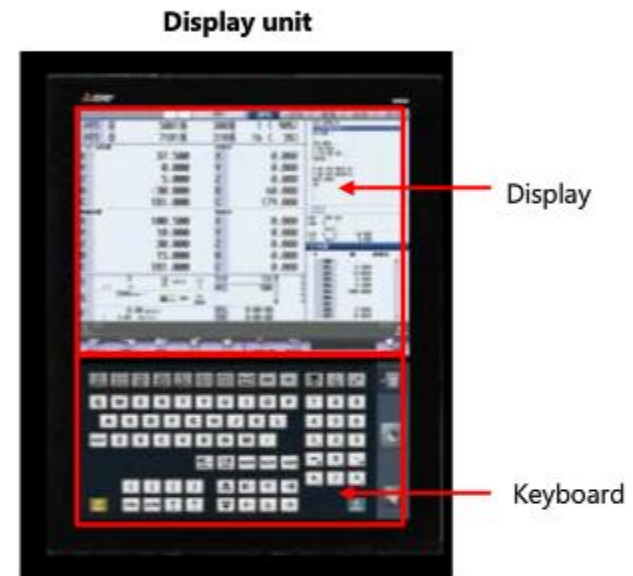
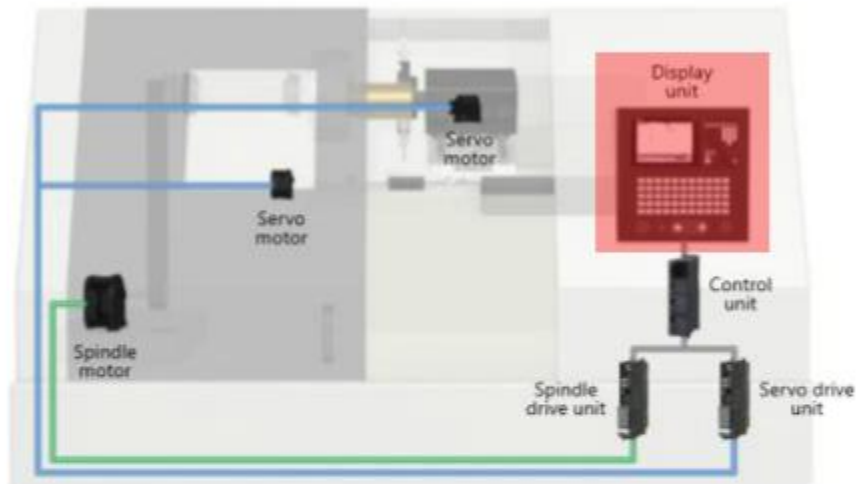
Exchanges data for the display unit.

Drive unit interface

Exchanges data with the drive units.

3.5 Display unit

The display unit displays the status of the NC unit as soon as a person gives an instruction to the NC unit. The display unit includes a display and a keyboard.



Display

The main items that are displayed are as follows.

- Position of the feed axis and rotation rate of the spindle
- Machining program in operation
- Alarm messages
- Status of the drive unit required for maintenance
- Parameter settings

Keyboard

The keyboard has alphabet keys, number keys, and function keys, and performs the following functions.

- Screen switching
- Creating machining programs
- Setting the parameters

3.6

Other peripheral devices

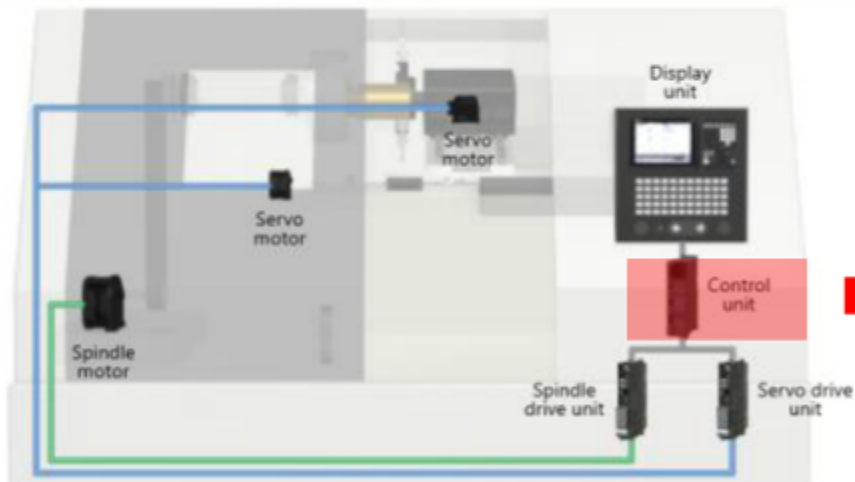
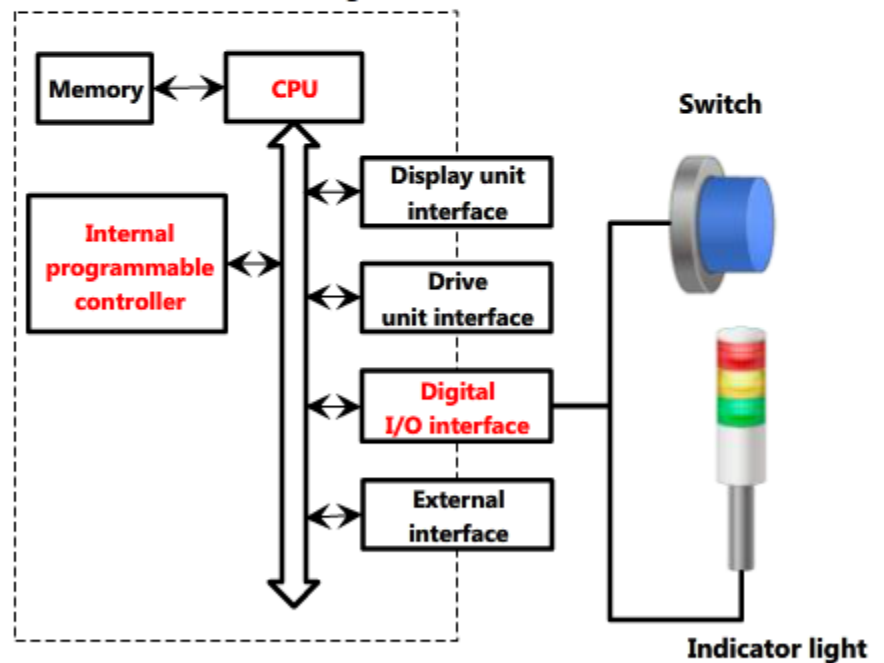
In addition to the basic configuration of the NC unit described thus far, an interface that connects with peripheral devices is provided.

Digital signal I/O

The NC machine tool has a tool operation panel, so the operator can operate the machine tool. Also, a sensor is attached to the machine tool.

Signals from a switch on the machine tool panel or from the sensor on the machine tool are input to the NC unit via the digital signal I/O interface.

Input signals are sequentially processed by the internal programmable controller to provide commands to the CPU of the NC unit and to output to the indicator light, for example.

**Control unit internal configuration**

3.6

Other peripheral devices

Data I/O

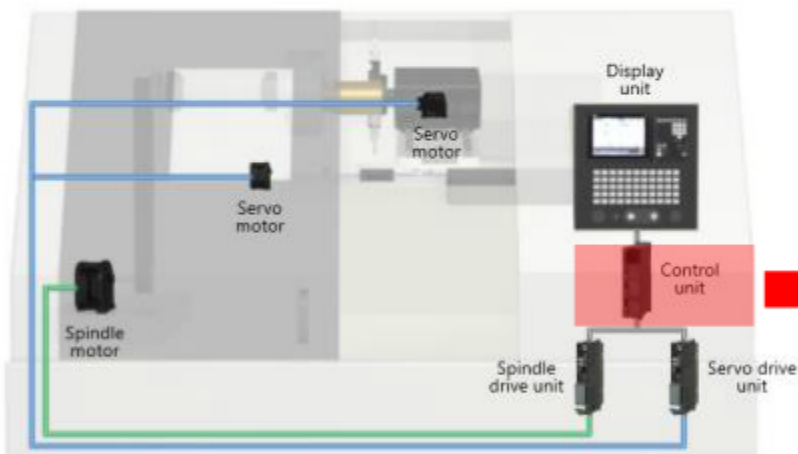
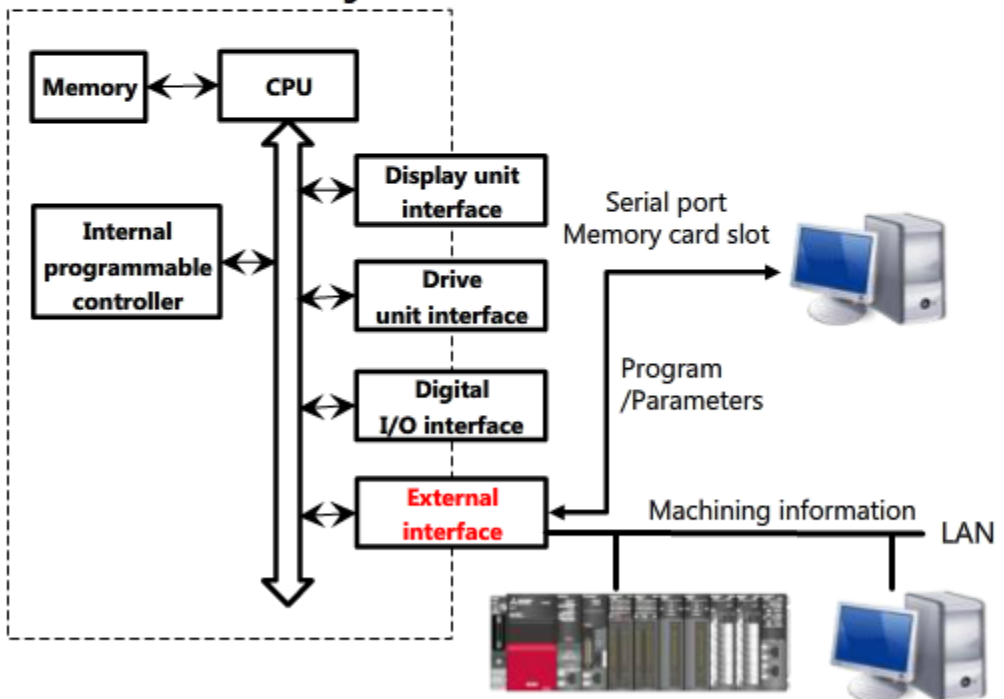
Connecting a computer to the NC unit allows you to save the machining programs and the tool offset data stored in the NC unit onto the external computer.

Machining programs generated by an automatic programming device, for example, can be input to the NC unit. For input and output, a serial port or memory card slot is generally made available.

Network

A network interface is provided and this connects with, for example, a computer or an external programmable controller to enable data transmissions and receipt.

This is useful for automation, maintenance, inspections, and other factory operations.

**Control unit internal configuration**

The contents of this chapter are:

- Configuration of the NC machine tool
- Configuration of the NC unit for the NC machine tool
- Role of the NC unit

Important points to consider:

Configuration of the NC machine tool	<ul style="list-style-type: none"> • Includes an NC unit and a machine tool. • Mitsubishi Electric provides NC units to machine tool manufacturers.
Configuration of the NC unit	<ul style="list-style-type: none"> • Motors, drive units that move the motors, a control unit that gives commands to the drive units, and a display unit that displays information on the instructions being given to the control unit.
Drive system	<ul style="list-style-type: none"> • The drive units control the motors based on commands from the control unit. • The servo drive unit controls the position and speed of the feed axes. • The spindle drive unit controls the rotation of the tool or workpiece. • The servo motors move the table, turret, or other parts. • The spindle motor rotates the spindle.
Control unit	<ul style="list-style-type: none"> • The machining details of the machining program are read and transmitted to the drive units. • Includes an interface that links the CPU, memory, and devices.
Display unit	<ul style="list-style-type: none"> • Includes a keyboard for a person to give instructions to the NC unit and a display for displaying the state of the NC unit.
Peripheral devices	<ul style="list-style-type: none"> • The NC unit has interfaces that enable input and output of digital signals, and sequence processing can be performed by an internal programmable controller. • Connecting with a computer or network enables the exchange of data like machining programs, parameters, and machining information.

Chapter 4 Mitsubishi Electric CNC lineup

The Mitsubishi Electric has a range of products that are tailored for various work sites, including production lines and machining factories.

4.1 M800/M80 series

4.2 C80 series (for production lines)

4.3 Drive systems

4.4 Safety measures

4.1

M800/M80 series

The M800/M80 series is recommended for general machining applications.

More attractive machine tools

The advanced construction and sophisticated flat profile enhance the appearance of the machine tool.

* Winner of the 2015 Good Design Award

Easy to use thanks to intuitive operation

Intuitive touch panel operation makes the machine easy to use.

Extensive lathe system functions

The milling machining functions and multi-part system control functions have been greatly improved. Provides great functionality and makes more complicated machining easy and highly efficient.

Extensive machining center system functions

Includes SSS (Super Smooth Surface) control to achieve high speed, high-precision, and high-quality machining. Also includes a function that optimizes the characteristics of machine tools and a function that shortens cutting time, thus raising productivity.

Screen customization function that improves usability for operators

Enables advanced screen customization for quicker and easier operation.

Highly-expandable hardware and an easy-to-use drawing application increases the additional value of machine tools.

Factory optimization

Information on the manufacturing work site is effectively utilized to aid "Visibility³ (cubed)*" and "Usability" in the factory.

* Visibility³ (cubed): ability to see (visualization), observe (analysis), and examine (improvement)



4.2

C80 series (For production lines)

This series is optimal for cases where machining is incorporated into the control of production lines. It is compatible with the MELSEC iQ-R series.

Five qualities empower production lines with infinite possibilities and innovative value in terms of "advancement", "reliability", and "growth".

Productivity

Improves productivity through its advanced performance and functionality.

Expandability

Combines with the I/O of the MELSEC programmable controller and the intelligent function unit. Enables a system build that is optimized for the work site.

Usability

Provides user-friendliness for all users.

Maintenance

Improvements to the maintenance function reduce downtime and maintenance costs.

Safety

Enables simple implementation of safety functions compliant with global standards.



4.3

Drive systems

The MDS-E series drive systems are optimal for the M800/M80 series and the C80 series.

High-performance servo/spindle drive units, MDS-E/EH series

- Uses a core processor dedicated to servo control for high-speed control and satisfactory basic performance.
- Enhanced resolution on the motor detector and stronger high-speed communications contribute to both high-speed and high-precision control.
- The motor power connector utilizes an anti-misinsertion mechanism to prevent misinsertion.
- Improved diagnostics and preventative safety functions: Safe Torque Off (STO) function and Safe Brake Control (SBC) function guarantee the safety of users.

Multi-hybrid drive units, MDS-EM series

Multi-hybrid drive units can drive up to three servo axes and one spindle. This contributes to the downsizing of machines and supports high-performance.

All-in-one compact drive units, MDS-EJ/EJH series

Ultra-compact drive units with built-in power supplies contribute to smaller device size.

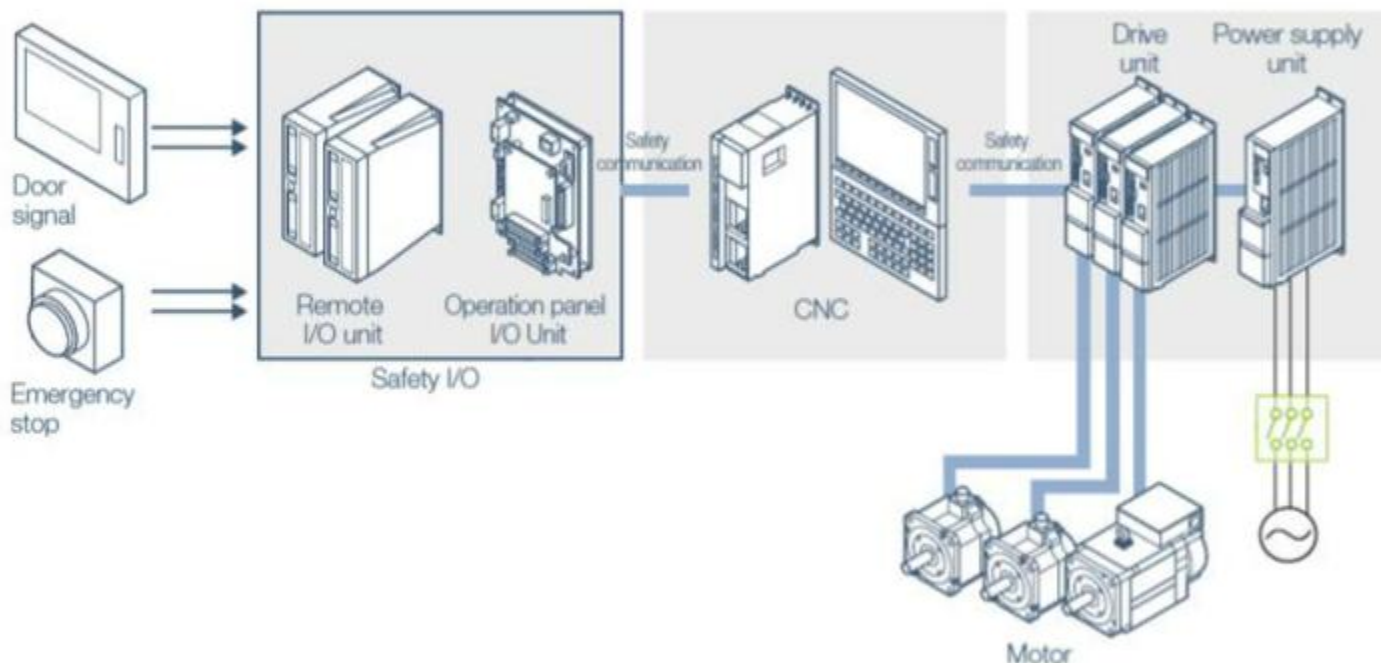


4.4

Safety Measures

The M800/M80 series and the C80 series conform with the safety standards that cover the entire system, including the CNC, drive unit, I/O, sensors, and communication. They provide a range of safety features collectively called the "Smart Safety Observation Function". It enhances safety at the production site and the safety of machine tools.

Functional safety system
can be configured easily.



The "Smart Safety Observation Function" conforms with the European Directives (2006/42/EC) and requirements of all safety standards.

Also regarding conformance with safety standards, model certification has been acquired from the German certification organization (TUV SUD).

4.5**Summary**

The contents of this chapter are:

- Mitsubishi Electric CNC lineup

Important points to consider:

M800/M80 series	<ul style="list-style-type: none">• General machining applications.• Includes a display unit and a control unit.
C80 series	<ul style="list-style-type: none">• For production lines.• Unit type that attaches to the MELSEC iQ-R series base unit.

Test**Final Test**

Now that you have completed all of the lessons of the **Mitsubishi Electric CNC Fundamentals (Introduction)** course, you are ready to take the final test. If you are unclear on any of the topics covered, please take this opportunity to review those topics.

There are a total of 12 questions (20 items) in this Final Test.

You can take the final test as many times as you like.

How to score the test

After selecting the answer, make sure to click the **Answer** button. Your answer will be lost if you proceed without clicking the Answer button. (Regarded as unanswered question.)

Score results

The number of correct answers, the number of questions, the percentage of correct answers, and the pass/fail result will appear on the score page.

Correct answers : 6

Total questions : 6

Percentage : 100%

To pass the test, you have to answer **60%** of the questions correct.

Proceed

Review

- Click the **Proceed** button to exit the test.
- Click the **Review** button to review the test. (Correct answer check)
- Click the **Retry** button to retake the test again.

Structure of a lathe

Select the part of the lathe that corresponds to the following explanation.

- [Q1] Rotates the machining workpiece.
- [Q2] Fixes the machining workpiece.
- [Q3] Holds the tool.
- [Q4] Is operated by a person to move the tool.

Q1

Q2

Q3

Q4

Answer

Back

Qualities of the NC machine tool

Select the choice that describes a quality of the NC machine tool.

- Complicated machining can be performed accurately and continuously without relying on a skilled tradesman.
- Suitable for mass production, but can only perform simple machining.

[Answer](#)[Back](#)

Test**Final Test 3****Instructions for machining details**

Select the correct description of a machining program for an NC machine tool.

- The way that commands are written greatly differs for each manufacturer.
- The NC language is standardized.

[Answer](#)[Back](#)

Types of machining by machine tools

Select the machine tool that corresponds to each of the following descriptions.

[Q1] Rotates a cylindrical workpiece and cuts away the material by pressing a tool against the workpiece.

[Q2] Rotates a drill or other bit to drill holes and cut threads.

[Q3] Cuts curved surfaces, grooves, and other shapes with a rotating cutting tool.

Q1

Q2

Q3

Answer

Back

Types of NC machine tools

Select the choice that describes a difference between the NC lathe and the machining center.

- The coordinate systems are different, so the way that the machining programs are written also differs.
- Only the shape of the tools are different.

[Answer](#)[Back](#)

Test**Final Test 6****Types of axes**

Select the role of each motor provided with the NC machine tool.

[Q1] Spindle motor

[Q2] Feed axis motor

Q1 ▼

Q2 ▼

Function of the axes

Complete the sentences explaining the functions of the axes of NC machine tools.

[Q1] For the NC lathe, the spindle rotates the [Q1], and the feed axes move the [Q2].

[Q2] For the machining center, the spindle moves the [Q2] and the feed axes move the [Q1].

Q1

Q2

Answer

Back

Test**Final Test 8****Number of basic axes**

Select the number of axes (basic axes) that are necessary to perform standard machining.

[Q1] NC lathe

[Q2] Machining center

Q1 ▼Q2 ▼

Number of feed axes

Select the advantage of increasing the number of feed axes.

- More complicated machining can be performed.
- Tools can be replaced without stopping the machining.

[Answer](#)[Back](#)

Test**Final Test 10****Components of the NC unit**

Select the component that is not included in an NC unit.

- Servo motor
- Spindle drive unit
- Display unit
- Control unit
- Turret

[Answer](#)[Back](#)

Control of the NC machine tool

Select the sequence of commands for an NC machine tool.

- Drive unit --> control unit
- Control unit --> drive unit --> motor
- Motor --> control unit

[Answer](#)[Back](#)

Test**Final Test 12****Display unit**

Select the choice that correctly describes the display unit.

- A person cannot directly view or touch the display because the display unit is internally embedded.
- A person can read from the display to understand the status of the NC unit and can use the keyboard to send instructions.

[Answer](#)[Back](#)

Test**Test Score**

You have completed the Final Test. Your results are as follows.
To end the Final Test, proceed to the next page.

Correct answers: **12**

Total questions: **12**

Percentage: **100%**

Congratulations. You passed the test.

You have completed the **Computerized Numerical Controllers (CNC) Mitsubishi Electric CNC Fundamentals (Introduction) Course.**

Thank you for taking this course.

We hope you enjoyed the lessons and the information you acquired in this course will be useful in the future.

You can review the course as many times as you want.

Review

Close