

***ELECT*GO**

# AN INTRODUCTION GUIDE

ABOUT

**Programmable Logic  
Controllers (PLC)**

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# CHAPTER 1



## PROGRAMMABLE LOGIC CONTROLLERS

Its introduction, definition,  
main components

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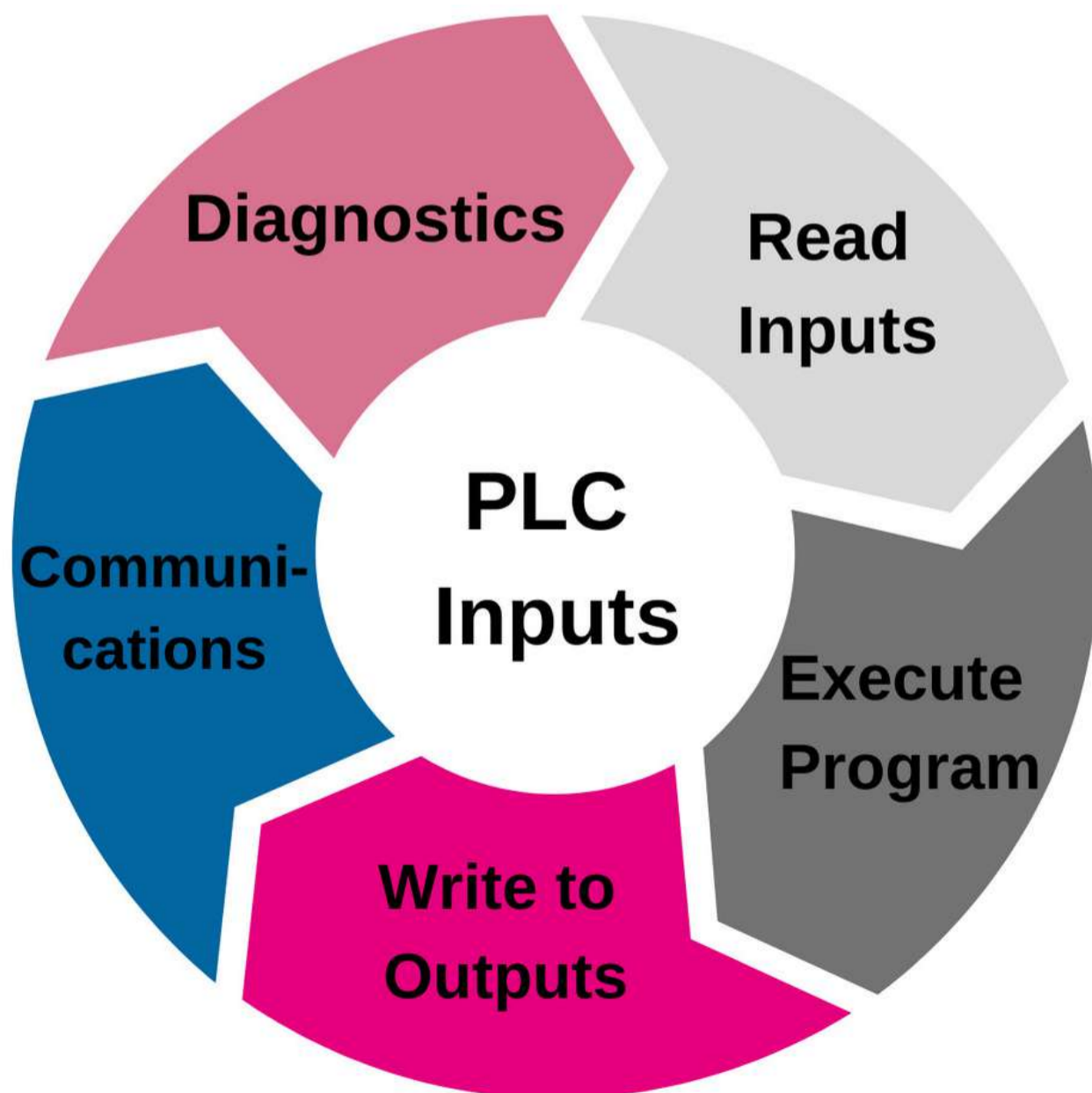


# INTRODUCTION

The evolution of the human race has not been without quite a number of inventions. Whether to make life simpler, work easier or get results faster, several machines, devices and gadgets have been invented over time.

The thing with inventions is this, so many devices (micro and macro) are usually utilized. One central to almost every machine gadget being used today is the programmable logic controller (PLC).

Despite how widely used it is across different industries, there's still a mystery about PLC and PLC programming. If you have been wondering, this article will help you to understand PLC and PLC programming.



# DEFINITION

If you are familiar with industrial automation, you may have heard of PLCs. So what are PLCs and why are they important in today's automation? PLC (full form: Programmable Logic Controllers) in electrical terms can be described in many words. Some say it's a device that modifies the operation of a control system. It has also been described as a digital computer that is designed to perform control functions.

All the above definitions are right. PLC is a system that constantly monitors input devices to make decisions based on customized PLC programming to control the state of output devices of machinery used in manufacturing, plants, or other automation environments.

PLCs come in various forms of size and factor. Some of them are as small as a pocket-size while others are huge enough that require their own racks to mount. Depending on requirements, PLCs can be customized with backplanes and functional modules to fit different industrial needs.

Many industries have implemented PLCs due to their fast and easy operation. It can be programmable in various ways easily as well.



# ADVANTAGES

As technology advances, PLCs offer more advantages over the traditional hardwired relays in terms of reliability, flexibility, cost-effectiveness, speed, communication and advanced data processing capabilities. The utmost advantage of a PLC system is the ability to be able to reprogram them. Hence, they're highly adaptable in changes of processes or monitoring the application requirements.

Furthermore, the features of a PLC have several diagnostic tools that can facilitate easy troubleshooting such as :

- Report generation
- Fault Logs
- Step-by-step program simulation
- Manually run inputs/outputs

## Reliability



- When a program has been developed and implemented by a PLC, it can be easily duplicated for other PLC devices. These programs can be saved easily in the PLC memory.
- The program has replaced the use of exterior cabling from the controller of different processes.
- It offers reliability-related solid-state elements like electronic components.

## Flexibility



- Uncomplicated to develop the program and amend any changes within the PLC, unlike in a relay system.
- Simple update of system

## Lower Cost



- Uncomplicated to develop the program and amend any changes within the PLC, unlike in a relay system.
- Simple update of system

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# ADVANTAGES

## Communications Capability



- The PLC has the ability to communicate with other PLC controllers or computer devices
- The PLC provides a holistic communication ability with other PLC controllers and computer devices, to retrieve data, monitor the controllers and for sending and receiving of different programs.

## Faster Response Time



- The programmable controller works in real time in any high-speed operation
- PLC's have fast response competency compared to typical machines that work on thousands of substances per second.

## Easier to Troubleshoot



- Users can simply identify and detect if any problem happened in the program or circuit.
- Upon resolving, it will be reflected on the monitor.



# MAIN COMPONENTS

As a micro-computer, a PLC can only fully operational when all its components are in place. For the PLC programming to operate effectively, a basic PLC system must have the following:

- Processor
- Rack/Mounting
- Input Assembly
- Output Assembly
- Power Supply
- Programming Device/Unit

PLC plays a vital role in various industries due to the ease of controlling different units in an industry with a simple programming logic control. A programmable logic controller is first programmed as per the desired operations and after programming, it is attached to an industrial unit.

The controlling nature of a PLC is varied from different models of PLC. It can include simple pushbuttons as well as dedicated automatic switches. The PLC can be used to control a single appliance to a huge industrial plant automatically. Different sets of instructions are provided to a PLC unit and as per the provided set of instructions, the PLC functions.

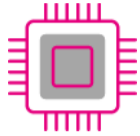
The use of PLC is increased due to various programming techniques used to program a PLC. Each programming technique has its own benefits and drawbacks. Each PLC comes with its own software which is used to program a PLC. PLC provides ease of programming, ease of wiring, ease of changing, and ease of installations.

Different sizes and ranges of PLC are available in the market but there are some common components in PLC which are used in most of the PLC units. The common components of the PLC unit are discussed here:





# MAIN COMPONENTS

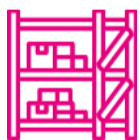


## Processor

The processor is also called the CPU which is known as the central processing unit. It is the most important component of a PLC. Similarly, the processor is the core component of a PC. Without a processor, a PLC cannot perform its action. If the processor of PLC stops working, then the PLC is of no use anymore.

Different techniques are used to fully utilize a PLC processor. If the processor of PLC remains idle then the efficiency of the PLC is compromised which is not bearable in large industries. Different PLCs comes with a different processor. The type of processor varies from device to device. If the PLC is being used at a big scale then a PLC with a big processor is used and if the processor is being used at a small domestic level or in a small processing unit then a PLC with a small processor is purchased.

The CPU or the processor of the PLC is used to determine the different aspects of a PLC like memory available, different programing functions available, processing speed, and the size of the application logic available. Understanding a processor is a difficult task, however, the working algorithms and the topologies of a processor can be mastered to use it efficiently.



## Rack / Mounting

A PLC unit is formed by combining a number of components. Sometimes two or more components are combined together to form a working block. All the components used to form a block need to be attached with each other as per the designed mechanism.

A rack is used to assemble different components of a PLC at one place. The racks of a PLC are also called housing as it provides space for different components of a PLC. In smaller PLCs, if there is only one component then it is also called a brick or a shoebox. The rack of the PLC is designed carefully as it handles the different components of PLC. The rack should be strong enough to hold various bricks of a PLC.



# MAIN COMPONENTS



## Input Assembly

Input assembly is used to transmit the input signals from the processor of the PLC to the controller of the PLC. Input assembly includes various switches, operator inputs and pressure sensors.

This assembly can be termed as the senses of the PLC which is used to sense different inputs. Different kinds of inputs can be provided to the PLC as per the programming of the PLC. The input of the PLC can be also divided into the analog and digital categories. Each category is handled by its own specific class.



## Output Assembly

Output assembly is used to transmit the executed data from the PLC to the outside world. The outside world can be any application of the PLC. This assembly is called the actuator of the PLC. Outputs from the PLC are received in different forms at the receiving end. The output can also be of analog or digital type depending upon the input type.



## Power Supply

A power supply is used to provide the essential power to the PLC. Different kinds of power supplies are used in different PLCs. The power supply provides enough current to the PLC in order to operate different components of the PLC. The different power supplies used in the PLC range from 24VDC and 100-240VAC.

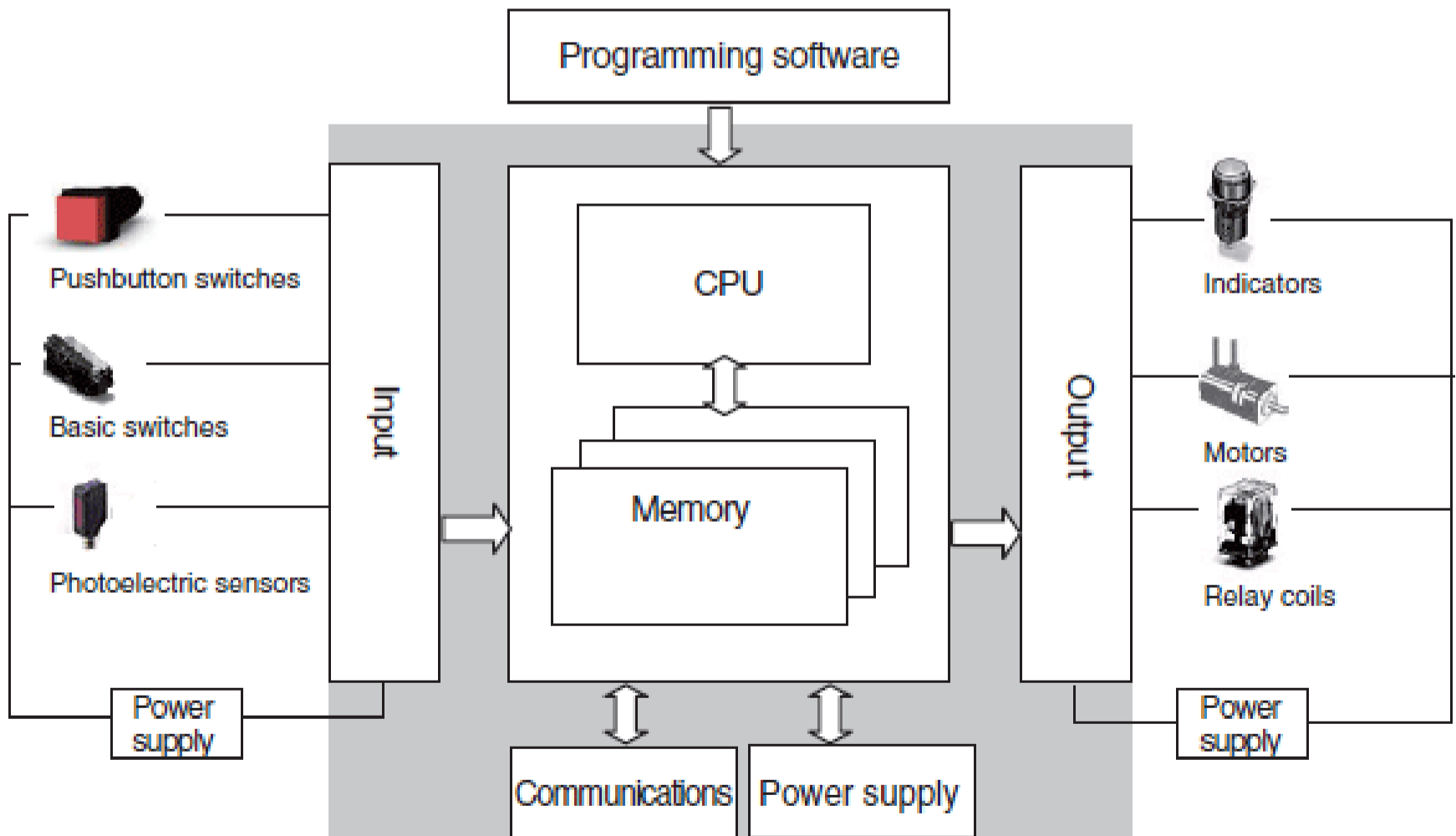


# MAIN COMPONENTS



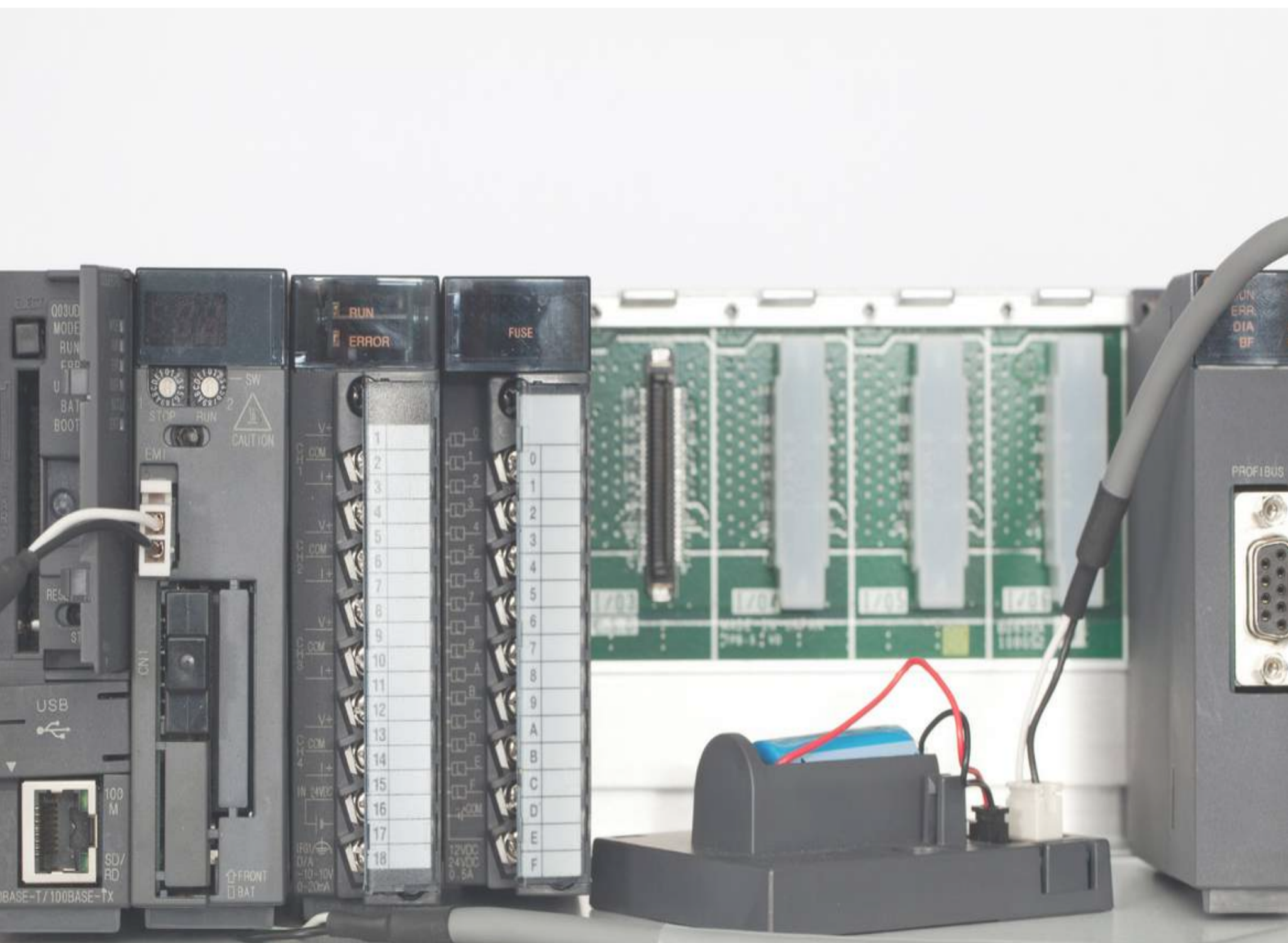
## Programming Device / Unit

The programming device of unit is the device which is used to program a PLC. Each PLC comes with its own programming software and code. The programmer programs the PLC with the help of the programming unit. The different logics for the PLC are made by the programmer and then implemented to different units. The PLCs are programmed using personal computers or laptops with the help of provided software for the programming.



# CHAPTER 2

## Its operations, programming, and applications



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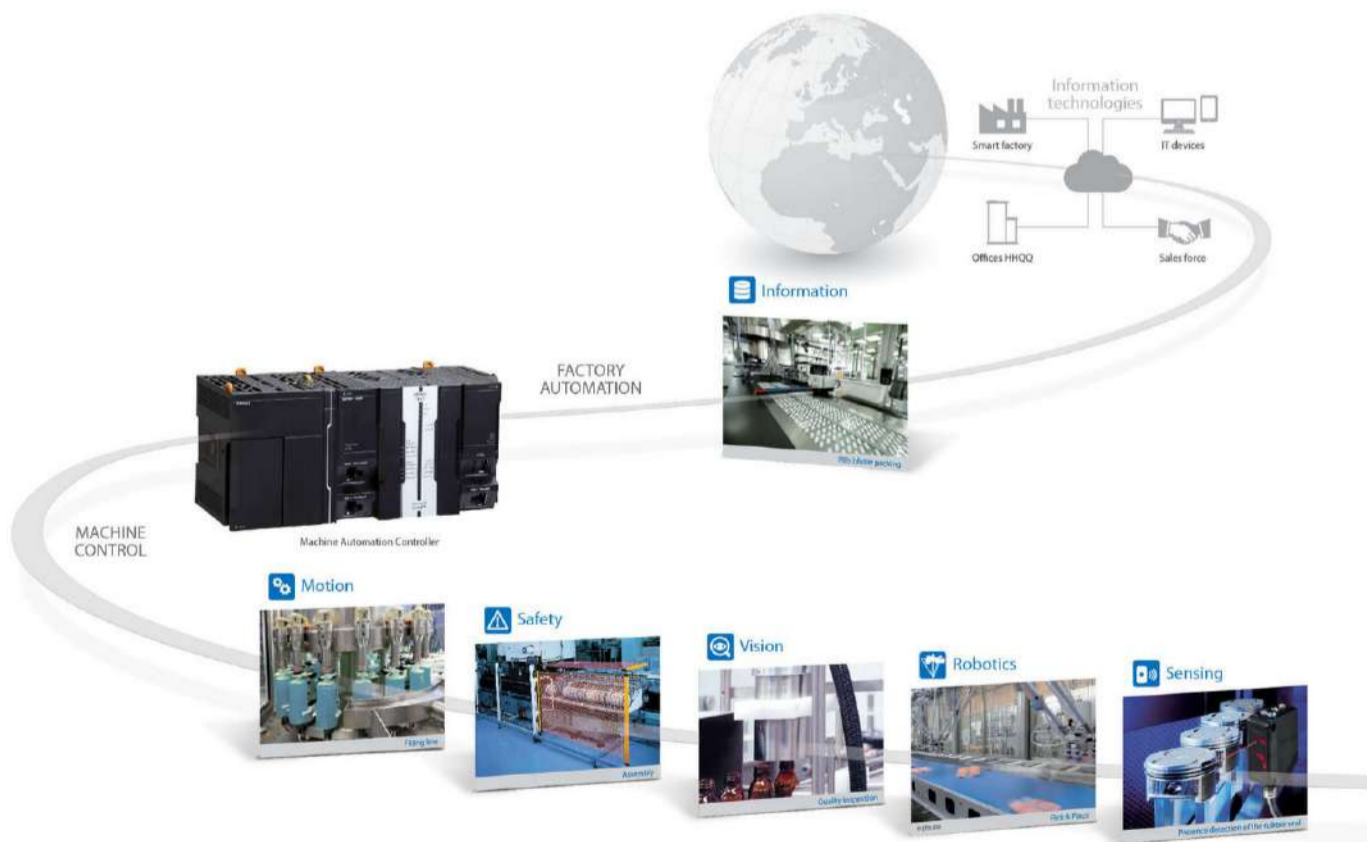


# OPERATIONS

The PLC programming is the control logic or technique with which the PLC operates.

For any machinery, their input devices accept signals from multiple sources that are sent to the PLC through the connector rails to internalize them. These signals are then stored in locations known as bits in the PLC memory. The PLC programming device is the one on which the program is written by the user to enact the desired outputs. Thereafter, it will communicate the necessary information to the control network. The CPU then takes the instructions from the memory and processes, an operation which is used to control the output devices. The main function of a PLC is to ensure that the series of diagnostics are in order, before it scans the inputs again.

This entire process is a cycle as shown in the diagram below



The larger the inputs, the bigger the PLC program, hence, longer the cycle will be. Depending on the applications, if some applications are not fast enough, an additional a single system to provide parallel processing, or customized processing for different aspects of the application.



# PROGRAMMING

The programmable logic controller is used in various industries to run different push buttons as well as dedicated automatic switches. The PLC can be used to control a single dc motor to a huge industrial plant automatically.

A different set of instructions is provided to a PLC unit and as per the provided set of instructions, the PLC functions. The set of instructions are provided to a PLC unit with the help of programming. A specific programming language is used to program a PLC. PLC programming software comes in with each PLC unit which is used to program the PLC. Different programming software is introduced to provide a different plants and units automatically with a proper sequence.

A programmable logic controller is first programmed as per the desired operations and after programming, it is attached to an industrial unit. There are various shapes and sizes of the PLCs which are used in various sections of an industry or a processing plant. The most important parameter in a PLC is the programming of a PLC. If a PLC is not programmed efficiently then the PLC doesn't perform well.

The controlling nature of a PLC is varied from different models of PLC. It can include a simple way between the PLC programming. The user application is developed with the help of PLC software.

The software for the programming of the PLC is a Human Machine Interface which provides different connectivity means between the programmer and the PLC unit which is being programmed. After the programming of the PLC, the PLC is subjected to RUN mode and once activated the RUN mode of the PLC continues until the operation is completed or terminated by the operator through any condition. The basics of programming for the PLC are discussed before jumping towards the programming of the PLC.



# PROGRAMMING BASICS

The PLC's CPU runs two different programs which are:

## The Operating System

- Downloading and executing user programs e.g. Ladder Logic
- Communicating with devices :
  - I/O modules and Other PLCs on a network
- Holding configuration data such as :
  - Number and type of I/O modules present in PLC system
  - Status information

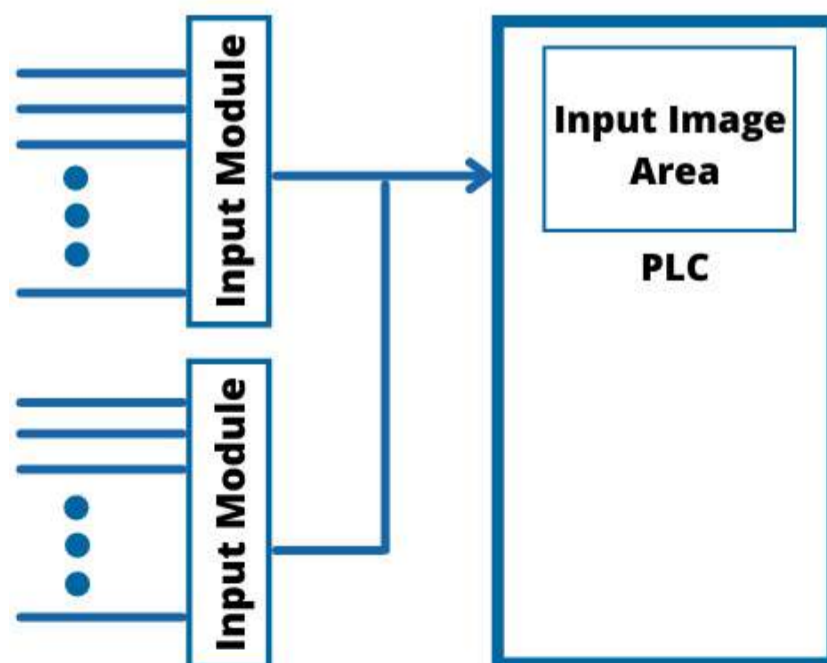
## The User Program

When an initialization step is in a 'run mode', it will repeatedly execute a scan cycle sequence.

The basic PLC scan cycle consists of three steps as shown:

### 1 Input scan

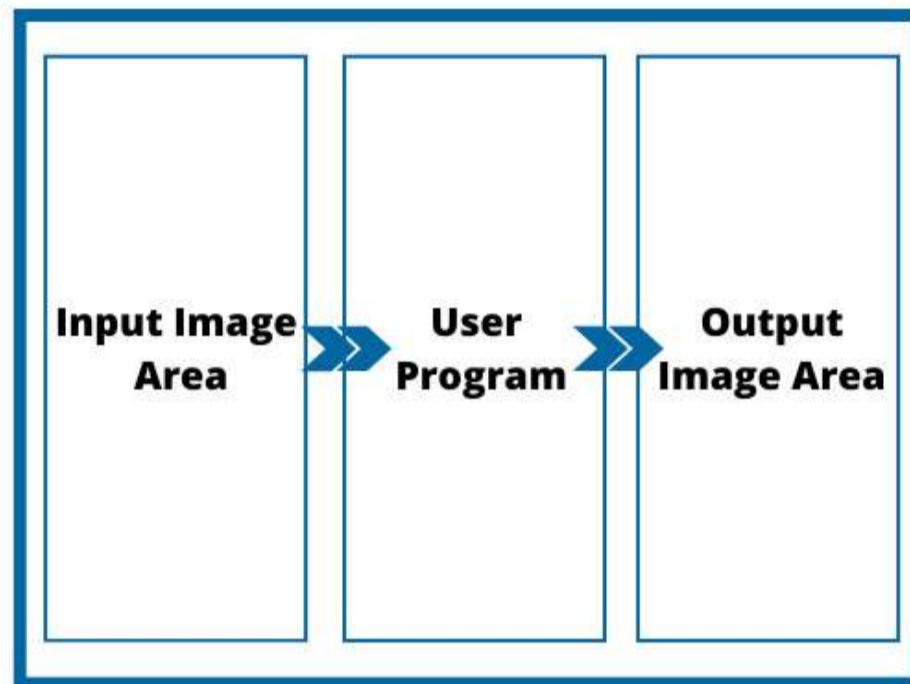
During the input scan, the data is taken from all input modules in the system and transferred into PLC memory, which is also known as input image area. The input terminals will be read and the input image area will be updated concurrently.



# PROGRAMMING BASICS

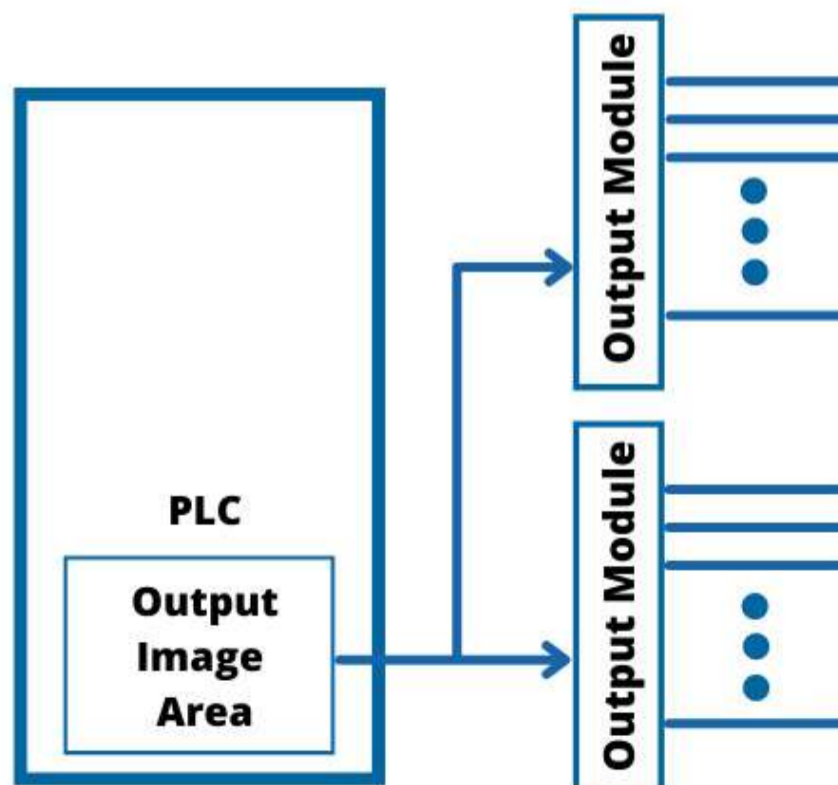
## 2 User Program Scan

During the program scan, data in the input image area will be applied to the user program, the user program has been executed and the output image area will be updated as shown.



## 3 Output scan

During the output scan, data is taken from the output image area and sent to all output modules in the system as shown.





# PROGRAMMING BASICS

All the operations, sequences, and functions of a CPU that are not linked with the control task are sorted out by the operating system.

Different functions that are required during the process of a task are sorted out by the user program. The user program handles a number of tasks like handling and specifying output signals, handling the interrupts in the commands and tackling different errors.



# APPLICATIONS

**TRAFFIC  
CONTROLLER**



**MACHINERY  
AUTOMATION**



**WASHING  
MACHINES**



**AMUSEMENT  
PARKS**



**ELEVATOR  
CONTROL**



**PACKAGING  
LINES**



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# CHAPTER 3

## Programming Languages



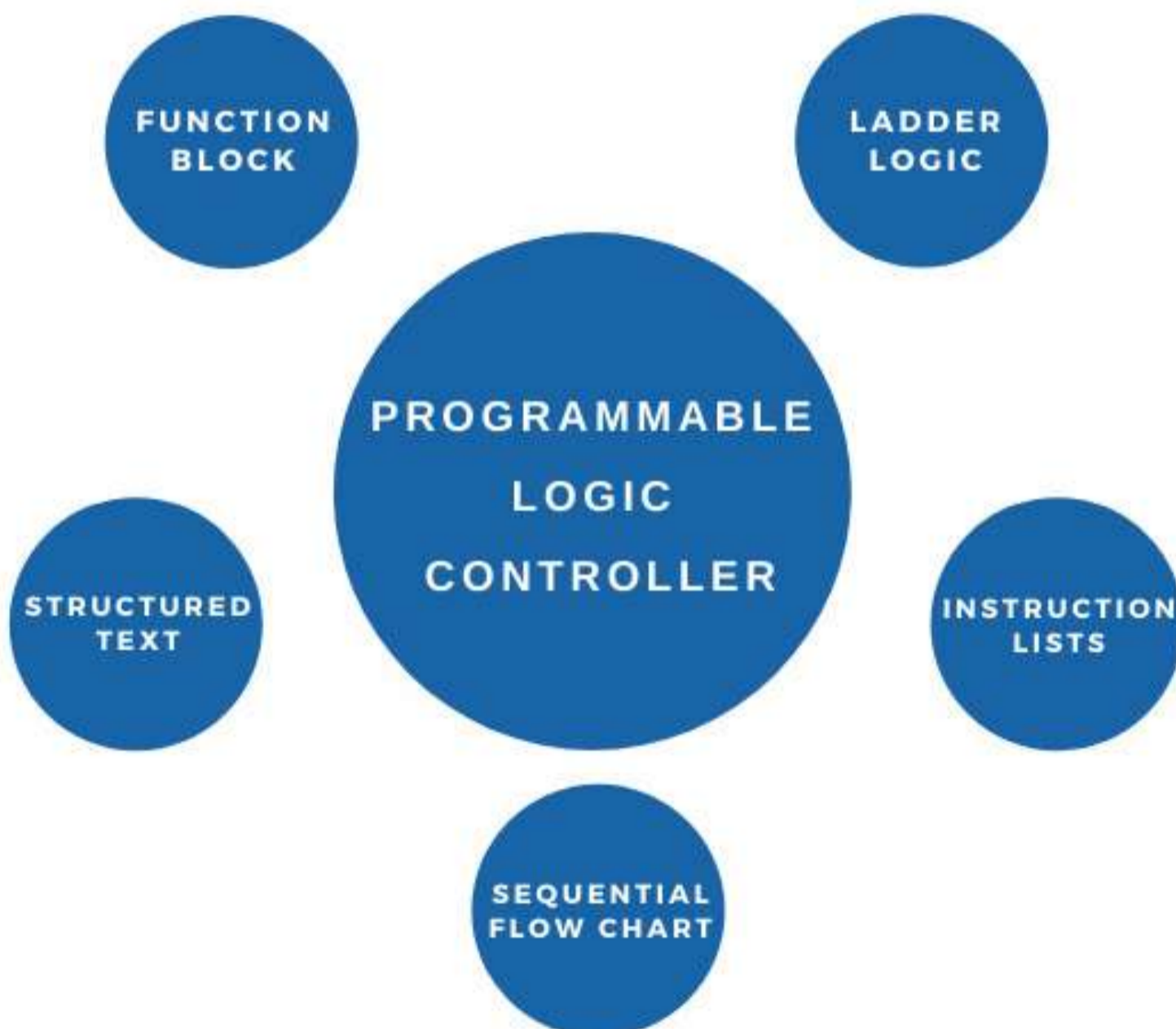
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# 5 PROGRAMMING LANGUAGES

The PLC is a complex device which major industries depend on for the smooth running of their plants, factories, etc. This is because of its controlling capabilities that are very reliable and its easy-to-use hardware.

That said, no PLC can function effectively without PLC programming. And no PLC programming can be effective without PLC programming languages. Let's quickly take a look at the 5 main PLC programming languages in use today:



# 5 PROGRAMMING LANGUAGES

## SEQUENTIAL FLOW CHART

**Sequential flow chart**, which also referred as graphical programming language, is a type of programming involves the use of symbols to represent instructions. It has been referred to as the simplest form of programming which uses only logical decisions.

It is made easy for users to understand and visualise what and when has happened during the procedure of the code. Hence, making troubleshoot easier to change if any problem occur.

When it comes to this type of PLC programming language, a number of symbols can mean various things like terminator, connector, input/output etc.

## LADDER LOGIC

**Ladder logic** is the oldest and most important programming language in a PLC. Because of its importance, it includes a number of terminologies which need to be known in order to know how it operates. It was specifically designed to replace hardwired relay control systems.

Ladder logic programming as another name, known as graphical programming language. It is relatively easy to read, understand, comment and debug while your system is online. However, the ladder diagram still has its limitations as you can only use the blocks that have been defined, it is not suitable if you have a complex system.

One of those terminologies is 'Rung.' It is the basic statement in this PLC programming language. Others include: Y- Normal Output signals, M – Motor symbol, T – Timer,



# 5 PROGRAMMING LANGUAGES

## STRUCTURED TEXT

**Structured text programming**, which is also referred to as ST or STX, the set out instructions are in a statement list. It is usually used for high-level programming language syntax. This syntax of ST consists of loops, variables, conditions, and operators. This type of programming is only available on a few brands of PLCs.

What's more?

This type of programming is the most flexible for any user. However, they are not as easy to follow as ladder diagrams or logic symbols. The latest programming style is called in-lone structure text which is a hybrid between ladder and structured text

## INSTRUCTION LIST

**Instruction list**, which is also referred as Mnemonics, are instructions written in symbolic form. It takes up less memory than the other PLC programming languages. They are also referred to as Opcode and they are used in handheld programming devices. Just like other programming languages, different symbols are used, some of which are:

- For Omron, Input = I, Output = Q, Internal relay = W, Timer = T, Counter = C.

Instruction lists are not a graphical programming language, but a series of instructions, listed in the same ways as an assembly program. Instruction lists have the benefit of faster execution than graphical languages and tend to take up less memory space. However, Instruction lists are uncommon language as the majority of the users will tend to prefer visual programming.



# 5 PROGRAMMING LANGUAGES

## FUNCTION BLOCK

**Function block** uses a graphical language for PLC, similarly to Ladder Diagram, which is very popular and easy to write programs. They can easily identify the function between input variables and output variables, which consist of a number of lines of code. A function is described as a set of blocks, whereas, the input and output variables come in place to connect the blocks by connection lines or links. Depending on your program, there are many variations to connect the variables to the blocks.



# CHAPTER 4

## Programming Softwares

### Sysmac Automation: A Fully Integrated Platform



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# PROGRAMMING SOFTWARES

PLC programming softwares still emerges as the world's commonly used automation technology in the manufacturing world today. These softwares are known for their flexibility, adaptability, scalability, suitability, and reliability in all programming fields. PLC reflects real time outputs and owing the different inputs that will be received by the computers.

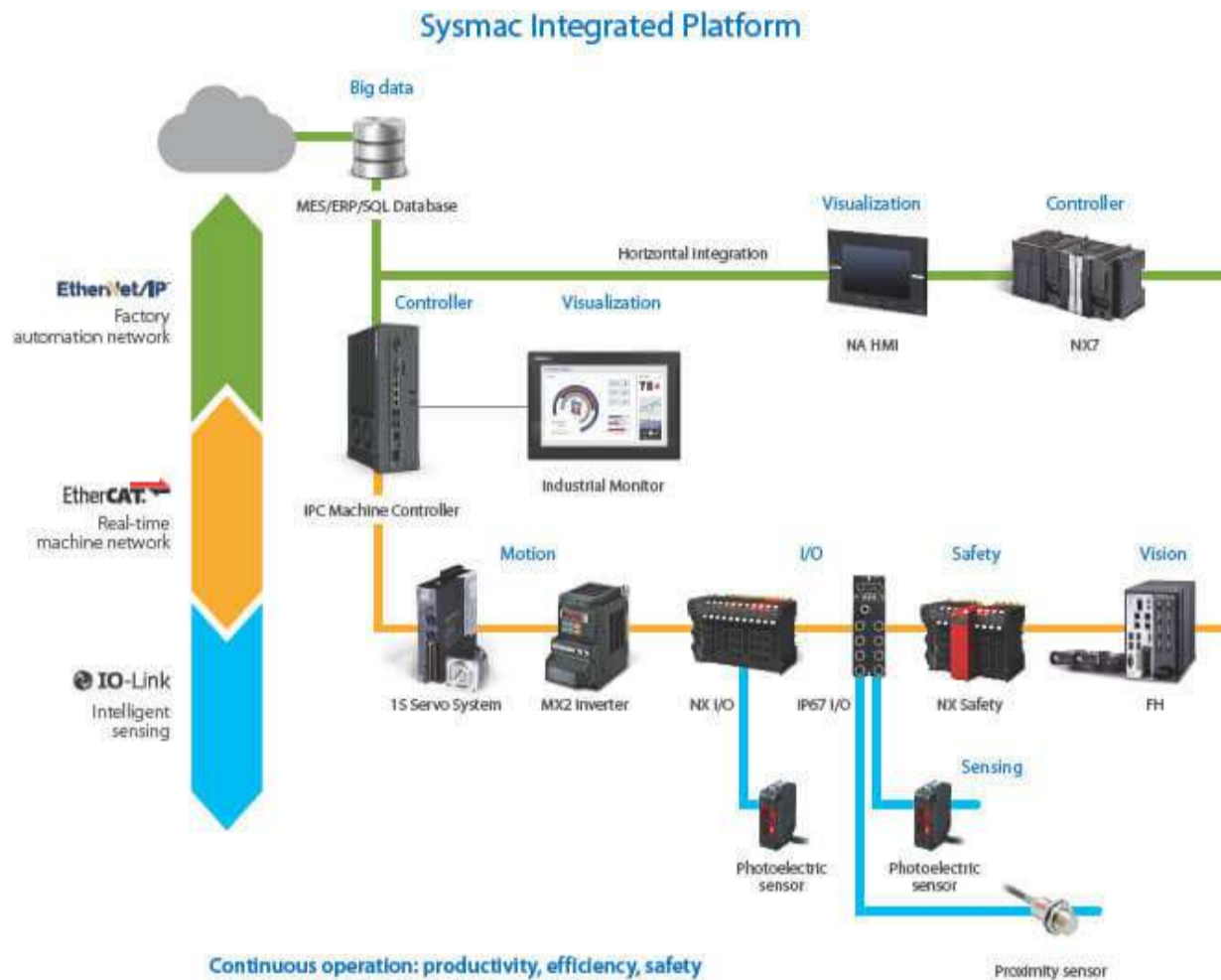
PLC are made to withstand the complexity of a user's requirements, from different output and input activities, range of temperatures, impact of the vibrations and electrical noises.



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# SYSMAC



This software combines configuration, programming, simulation, and monitoring in what has been described as a simple interface. Sysmac is very popular and widely regarded because it enables users and engineers to manage all necessities for a machinery, including safety and control in a system

Sysmac is the latest automation machine that is used for the automation of various controllers. The latest sysmac automation platform developed by Omron comes with the throughout integration from the controller to the software. The features are better than the other automation platforms available. The feature of the Omron Sysmac includes single control for the entire unit or the machine. Better harmony between the people or the operator and the machine. It also provides open communication between the user and the machine. Similarly, the automation platform provides open programming standards which make the programming of the automation platform much easier. The other automation platforms have complex programming standards which are difficult to be understood by a beginner level programmer. The Omron Sysmac automation platform provides a good programming atmosphere.

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# ADVANTAGES

- The Omron Sysmac Automation provides a greater and reliable machine control. The machine is automated with reliable techniques with better results.
- Seamless machine control is guaranteed with the Omron Sysmac automation platform.
- The automation platform uses the Sysmac Studio software to integrate various systems such as logic, safety, motion, robotics, information, vision, visualization, and networking.
- The software of the Omron Sysmac automation platform provides easy monitoring of the different systems integrated with the platform.
- Standard connectivity protocols are used.
- The Omron Sysmac automation comes with built-in EtherCAT and EtherNet/IP standards.
- The Omron Sysmac automation provides fast real-time control of the machine.
- The Omron sysmac automation platform provides data plant management as well.
- The custom software of the Omron sysmac automation platform provides a better interface for the operation and control of the different components attached to the system.

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# FEATURES

Omron has been developing the Sysmac from the late 1970s. The Sysmac is being used with the different PLCs from 1971. The sysmac system has shown key features like fast control, reliability, and robustness. With the advancements in the technologies, the key features of the Omron sysmac automation platform have been improved.

The machine network is the key feature in various automation platforms. If the automation platform has not a reliable machine network the efficiency and the performance of the automation platform are compromised. The Omron Sysmac automation platform uses the latest machine network which is the EtherCAT machine network. The EtherCAT machine network is considered to be the fastest machine network. This machine network is used for the motion, IO, vision and safety purposes. The cabling of the platform is simplified with this machine network also the performance of the system is improved.

Different old PLC platforms are using the traditional architectures for the manufacturing and development of the platforms which are complex and their modelling is also difficult. In Omron sysmac automation platform, the modelling of the system is simpler which utilizes the Intel architecture and uses the i7 processor. The real-time operating system is used in the development of the automation platform which reduces the development time and also increases the reliability of the automation platform. The performance of the system can be adjusted as per the capability of the machine.



# FEATURES

The One machine controller features of the Omron Sysmac automation platform are:

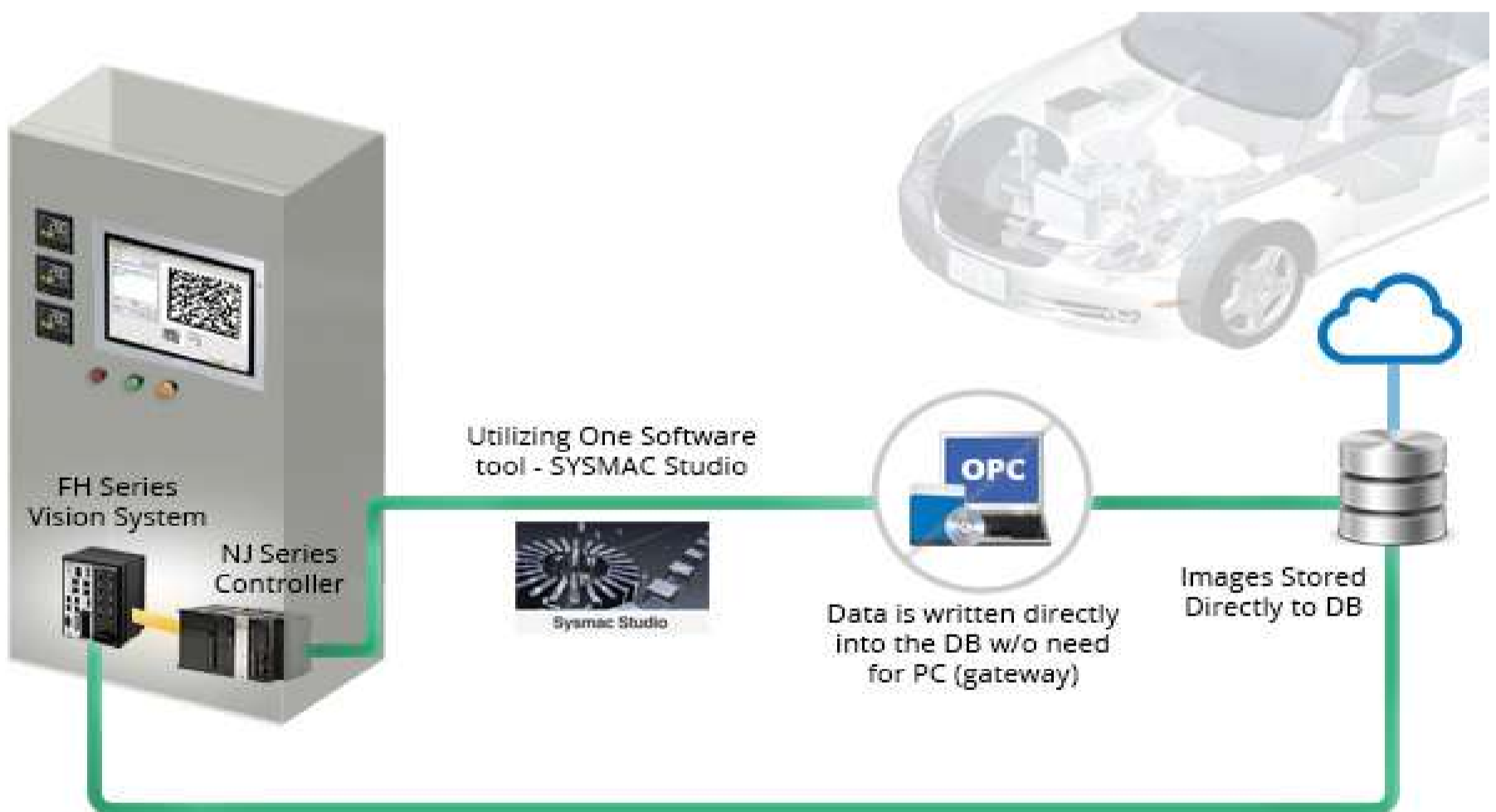
- Standard IEC 61131-3 programming feature is included in the automation platform.
- EtherNet/IP and EtherCAT ports are embedded in the automation platform. Certified PLCopen function blocks are utilized in Omron automation platform for motion control.
- Global standards for CE, NK, cULus, and LR are followed in Omron sysmac automation platform.
- The automation platform comes with seamless integration of motion and logic.
- The automation platform provides the synchronous control of all machines with different network devices.
- It is compatible with the CJ PLC series modules.
- The motion control feature includes circular and linear interpolation.
- The motion control feature can control up to 256 axes of the motion.
- Motion control feature also includes the gearing and the electronic cam.
- The one machine network features for the Omron sysmac automation platform include.
- Fastest network with a refreshing time of about 100  $\mu$ s and a jittered time of about less than 1  $\mu$ s.
- IEEE standard 802.3 frames for the industrial Ethernet.
- Flexible network topology.



# FEATURES

- Peer-to-peer controller communication feature.
- FTP feature.
- Interface with SCADA software and with the NA HMI series.
- Support for Simulink/MATLAB simulation software.

The Omron Sysmac automation platform can be summarized as a robust and powerful automation platform with an advanced machine automation controller. It can handle a variety of sensors in it with great efficiency and reliability.



Read more about Omron Traceability Solution [here](#)

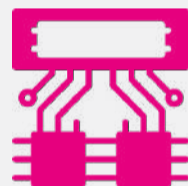
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# CX-ONE PROGRAMMER

The CX-One software suite allows users to build, configure, and program a host of devices such as PLCs, HMIs, motion-control systems and networks using just one software package with one installation and license number. This greatly reduces the hassle of software maintenance and management at both the End-User and OEM level. Omron is the only automation software provider that employs an online AutoUpdate system, allowing users to easily download and install updates for FREE.

CX-One is an FA Integrated Tool Package that integrates Support Software for OMRON's PLC and other.



## Components

To construct an FA System based mainly on PLC, traditionally it was necessary to purchase and install individual Support Software compatible with each Unit, start the software individually, and then connect to PLC and individual components. Installation of this FA Integrated Tool Package "CX-One" on a personal computer allows integrated operation from setup of OMRON's CPU Bus Units and Special I/O Units (SIOU) and Components to network start-up/monitoring and improving efficiency of PLC System start-up.

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# FEATURES

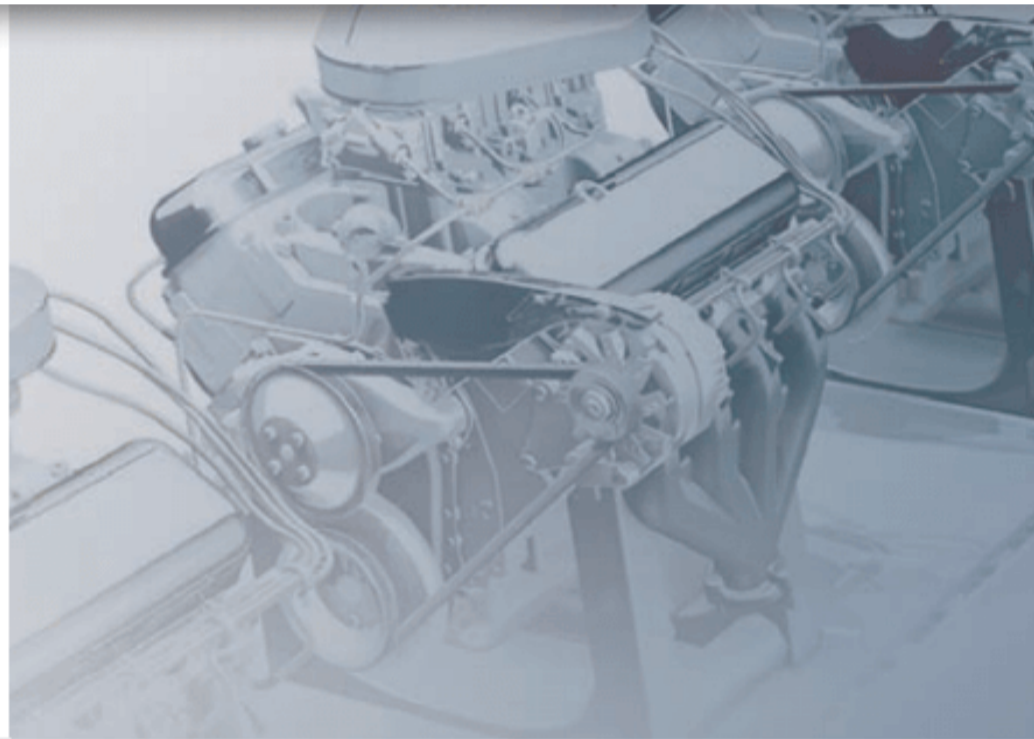
- CX-One allows integrated management of Support Software for OMRON's PLC/Components.
  - Installation on only one personal computer allows a user to handle Support Software for OMRON's products.
  - Only one licensing key is required to install all Support Software.
  - It allows integrated management of one save location for files created by Support Software.
- Support Software dedicated to CPU Bus Units and Special I/O Units can be started on the I/O Table.
  - The appropriate dedicated Support Software can be automatically started by specifying a registered Unit in the I/O Table (Unit configuration table attached to a PLC). In addition, setup information such as PLC model can be passed to the dedicated Support Software at start-up, allowing easier switching between Support Software.
- The following functions are available by the introduction of the ID information file (CPS) for OMRON Components.
  - Setup of CPU Bus Units and Special I/O Units without manual setting and address recognition. (Parameter and selection item names as well as available range of setup are automatically displayed)
  - CPU Bus Units and Special I/O Units setting on personal computer and data on actual PLC (CPU Unit ) can be verified online, and unmatched item/readout data is displayed graphically.
  - Unit configuration is displayed on the I/O Table based on Unit model.
  - Device type on the network can be checked for its Unit model, allowing exact verification of network configuration.





# CHAPTER 5

## MAC vs PLC



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# MAC VS PLC

The machine automation controller, programmable logic controller, and programmable automation controllers are industrial computers that are used as the brains of the industry.

The whole industry runs on these automation tools. However, each automation tool differs from each other in various aspects and below we will discuss MAC vs PLC.

## MACHINE AUTOMATION CONTROLLER (MAC)

The machine automation controller is usually termed as MAC. The machine automation controllers (MAC) are a new invention in the industrial sector. The machine automation controllers are introduced in the market by Omron Industrial Automation.

Omron has several industrial controllers which have been used in various industries for a long time. But with the invention of new technologies, various automation controllers are introduced by the Omron industry. The traditional controllers like the PLCs and PACs concepts were summed up in the formation of the MACs.

The MAC is formed from the motion control from the ground up. Other functionalities are also integrated into the formation of a MAC. It includes integrated factors like networking and sequencing. The machine automation controller is a real-time scheduler that schedules motion updates from time to time.

All the updates of the system in the machine automation controller are refreshed with every passing second. The motion of the system is updated with the machine automation controller. The network of the system is also updated with every passing second and all the other applications of the automation system are also handled with the machine automation controller.



# MAC VS PLC

The multiple stage data sharing is easily done with the attachment of the machine automation controller (MAC). In recent years the market for the machine automation controllers has jumped to \$33.7 Billion.

The market is expected to jump to \$41.5 Billion. The growth in the market of machine automation controllers is due to the features of the machine automation controller like reduction in overall operational cost, increasing the productivity of the machine and reliable use of the machine in the industrial sector.



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# MAC VS PLC

## PROGRAMMABLE LOGIC CONTROLLER (PLC)

A programmable logic controller which is usually termed as PLC is used for the automation of the industry. These programming devices are used to automate different sections of industry and sometimes the whole industry. Several sensors are attached to the PLC and the PLC is programmed to control or operate each unit or sensor attached to it in a specific way.

The parameters are attached to the system of the PLC which later on governs the industrial unit. There are different inputs and outputs attached to the PLC. The PLC is capable of recording various parameters of a machine such as the productivity of the machine, it can also record the operating temperature for a machine, it can start a process automatically as per the code in the PLC device, various operations can be stopped with the PLC device upon completion or attaining a specific scale.

The PLC unit can be used to detect various errors in an industrial unit and upon detection, it can trigger an alarm. PLCs have been used in the industry for many years as they are the first known components for the automation of the industry. The effective and easy handling of the industrial units with the help of the PLC makes them popular automation devices. There are many differences between the PLC, PAC, and MAC.



The input and the output protocol of the PLC are different from MAC and PAC. The communication protocols used in the PLC and MAC are different. The main and prominent difference between the PLC and PAC is the programming interface. Each automation technique has its programming class. PLC has limited memory for the execution of various tasks. The latest PLC units are high speed I/O devices and have built-in networks for communication purposes.



# SUMMARY

By the end of this book, you will have fully comprehended the basic understanding of PLC, its components, advantages, programming languages and softwares available to create a full program.

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