CSE-3103: Microprocessor and Microcontroller

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Processor Memory Organization

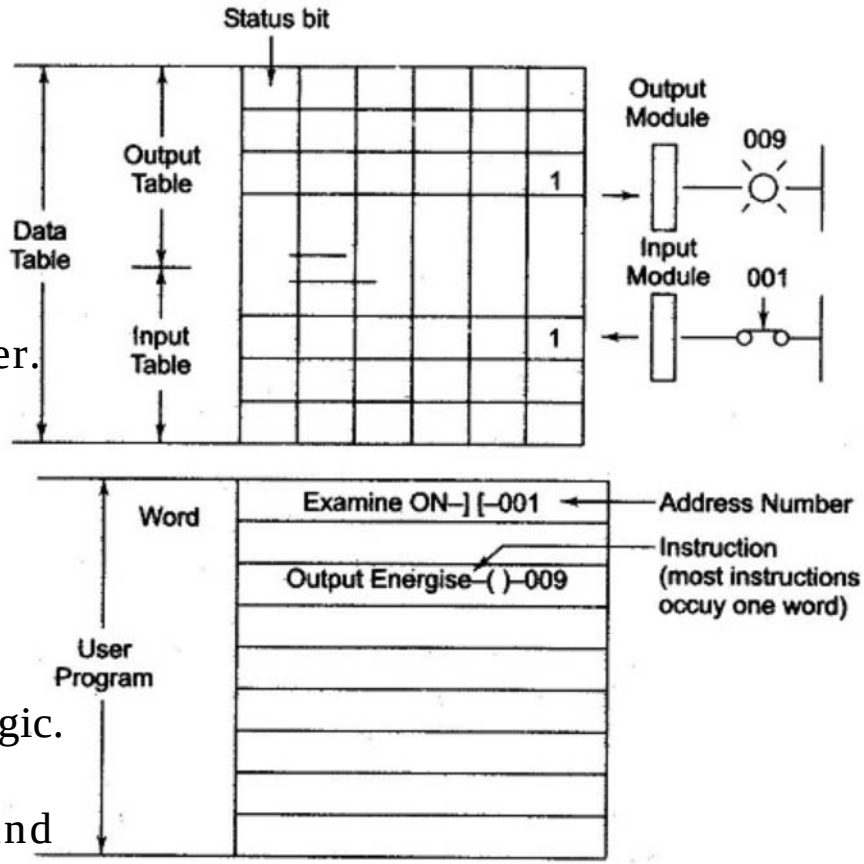
PLC programs are not interchangeable among different models →

- memory organization differences →
  - unique memory layouts,
  - file structures, and
  - addressing methods.
- I/O addressing schemes/formats vary.
- instruction set variations →
  - commands, syntax, and functions differ.

[Allen Bradley PLC Processor]

Memory organization →

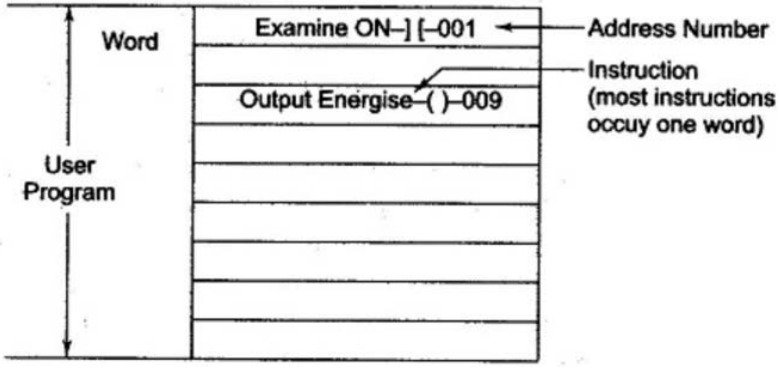
- logically divided into 2 primary sections →
  - 1) program files →
    - contains executable control logic.
  - 2) data files →
    - stores real-time data, status, and values used by program.



Processor Memory Organization

Program files →

stores user ladder logic and system routines,
logic and routines = defines machine operations.
accounts for most of total memory.

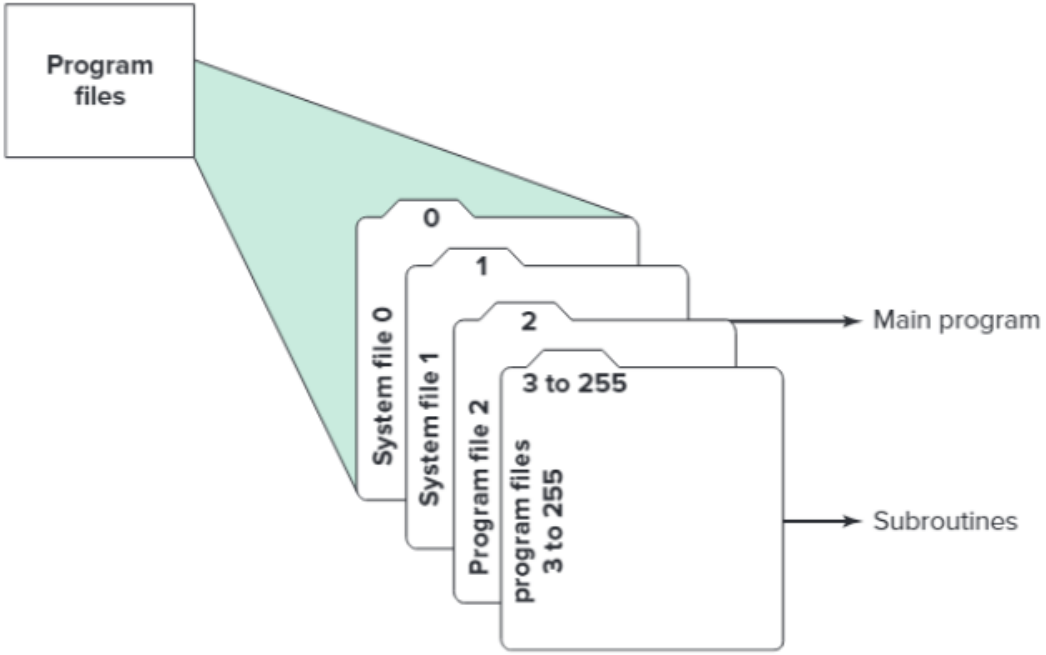


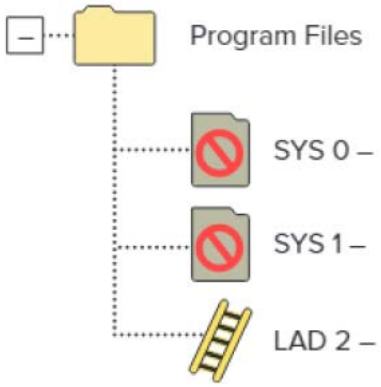
Program files include →

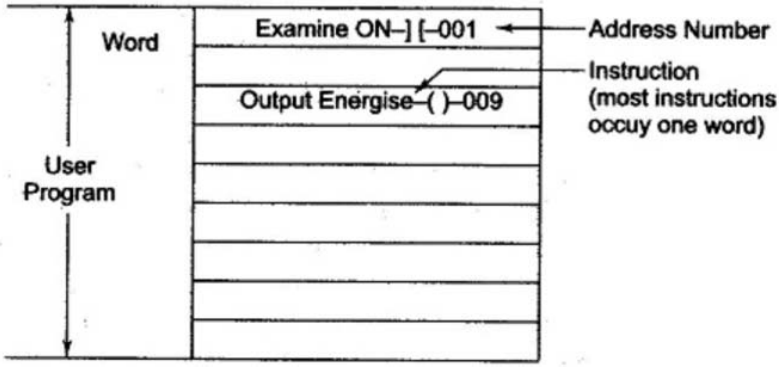
File Number	Type	Description
File 0	System functions	Holds system data: processor type, password, diagnostic info I/O configuration
File 1	Reserved	Used by processor for internal operations; not accessible to programmer
File 2	Main ladder program	Primary user-written logic; scanned repeatedly during operation
Files 3-255	Subroutine programs	Modular subprograms called from File 2 for organized, reusable logic

Processor Memory Organization

Program files →

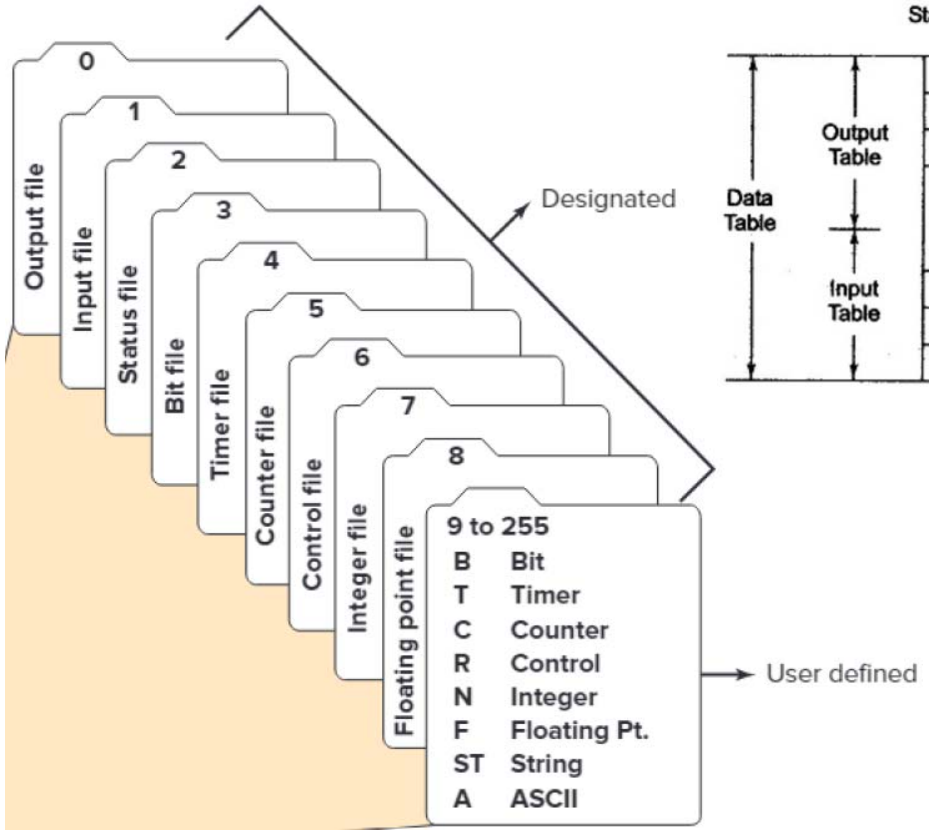


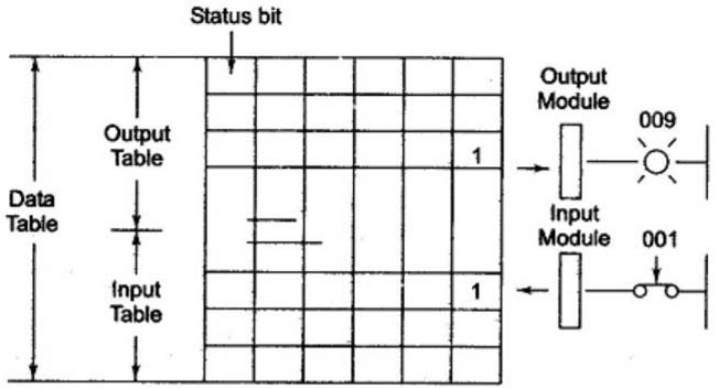


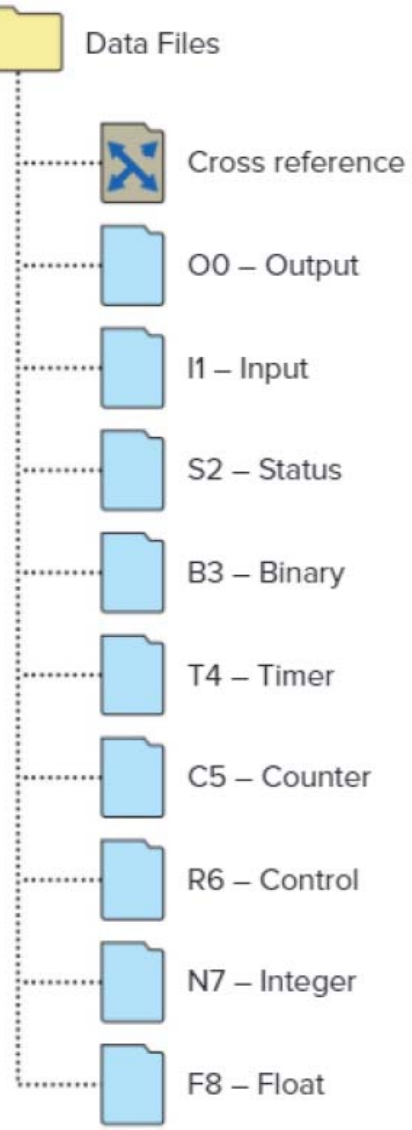


Processor Memory Organiza

Data files →



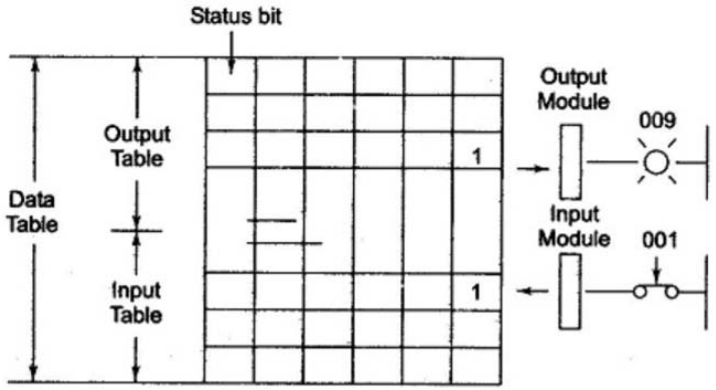




Processor Memory Organization

Data files →

act as PLC's working memory,
hold real-time information that
logic program reads from and writes to.



types of data stored →

input and output status,
timer and counter values,
internal flags (bits),
numerical data (integers, floating-point),
system status information.

access method →

referenced directly in ladder logic instructions.

Processor Memory Organization

Data files include →

File Number	Type	Description
File 0	Output	Stores ON/OFF state of physical output terminals
File 1	Input	Stores ON/OFF state of physical input terminals
File 2	Status	Contains system flags, scan time, error codes, and diagnostic data
Files 3	Bit	Used for internal relay logic; holds intermediate logic states
File 4	Timer	Holds preset, accumulated values, and status bits (EN, DN, TT)
File 5	Counter	Stores preset, accumulated counts, and status bits (CU, CD, DN)
File 6	Control	Tracks position/length for shift registers, sequencers, and FIFOs
File 7	Integer	Stores 16-bit signed integers (-32,768 to 32,767)
File 8	Float	Stores 32-bit floating-point numbers (decimal values)
File 9-255	User-defined data files	Allows programmers to organize custom data types, arrays, structures, and application-specific storage, beyond standard system-defined files (0-8)

Processor Memory Organization

3 parts of I/O address format →

used to identify I/O points in PLC memory.

format → [Type]:[Slot]/[Terminal]

Part 1 →

I for input, O for output.

colon to separate module type from slot.

Part 2 →

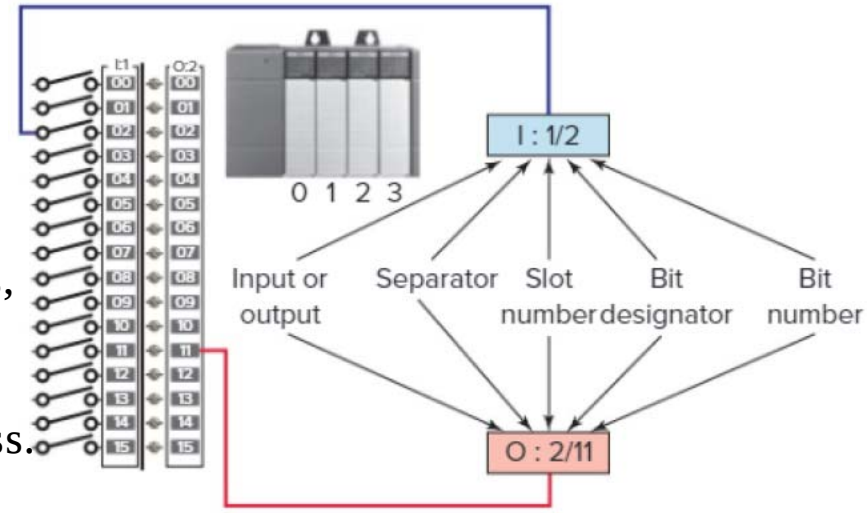
physical or logical slot where I/O module is installed,

forward slash to separate slot from terminal screw.

Part 3 →

specific terminal on module

where device is wired.



Data storage →

PLC stores all data in structured memory areas,

memory areas = Data Tables or Data Files.,

based on 16-bit operations.

data are accessed by specifying memory address.

Processor Memory Organization

Input image table file →

mirror of physical input status,
stored in memory.

Operation →

each connected input →

has bit in input image table,
= terminal to which input is connected.

during I/O scan, PLC reads all input terminals.

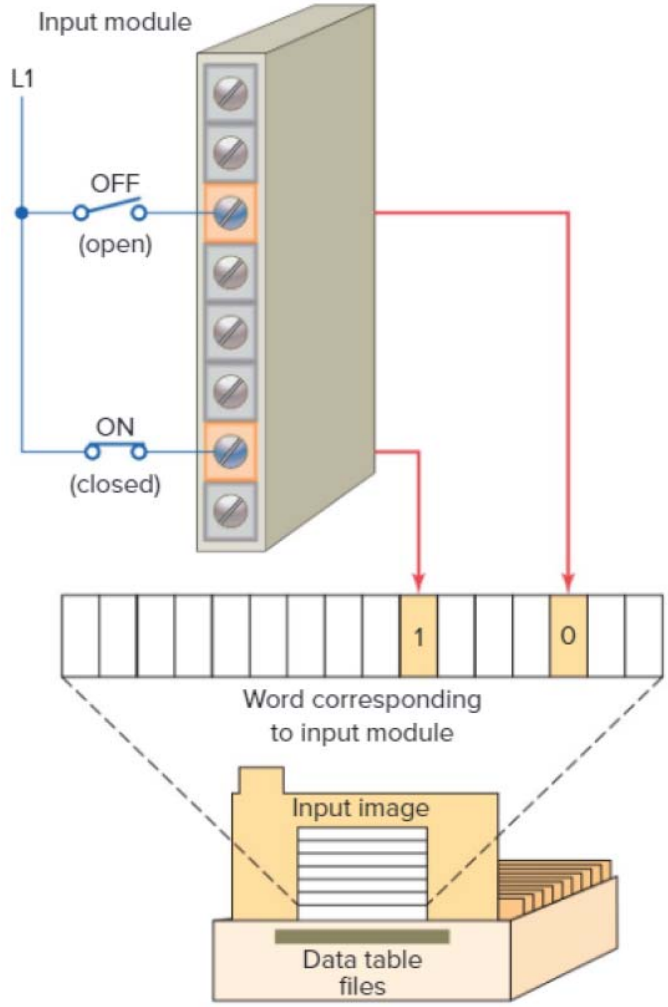
voltage detected →

stores 1 (ON) in corresponding bit,

no voltage →

stores 0 (OFF) in corresponding bit.

table is updated continuously to reflect
real-time input states.



Processor Memory Organization

Output image table file →

holds ON/OFF states that
PLC intends to send to outputs.

Operations →

each connected output →

has bit in output image table,
= terminal to which output is connected.

ladder logic determines desired output states,
program writes 1 (ON) or 0 (OFF) to
corresponding bit in output image table.

during I/O update →

physical outputs are set to match table.

Program Scan

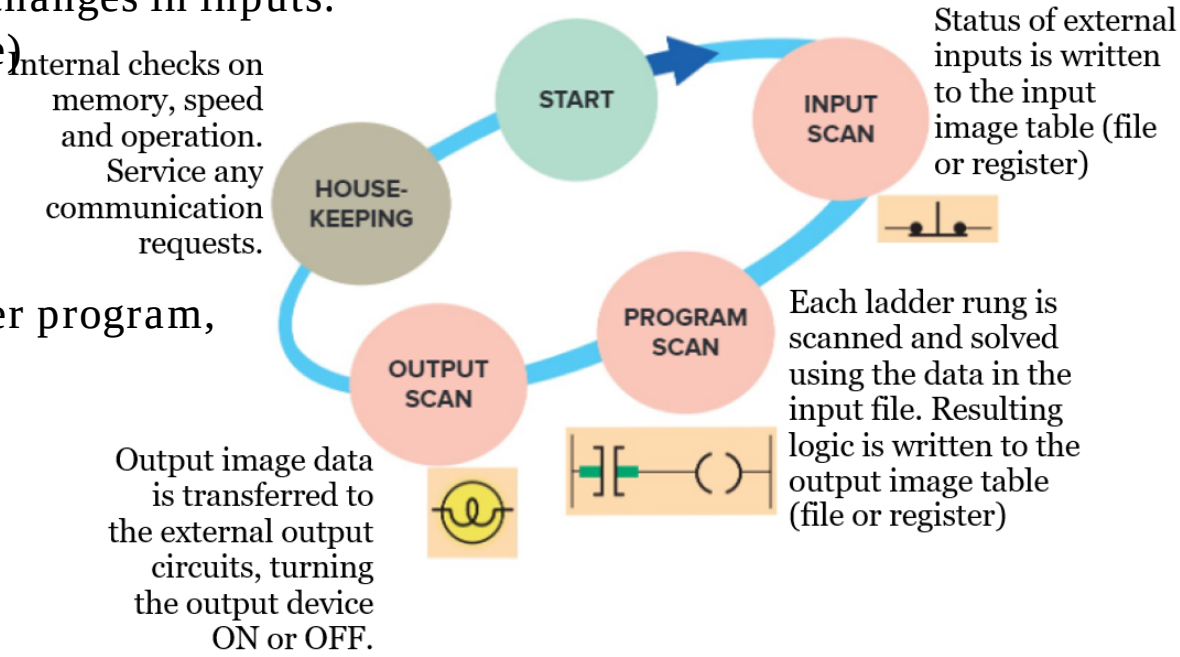
Program scan cycle →
inputs can change at any time.
continually repeats cycle in RUN mode.

scan cycle time →

time to complete scan cycle.
how fast scanner can react to changes in inputs.
< 2×(fastest input change time)
= 1 to 10 ms.

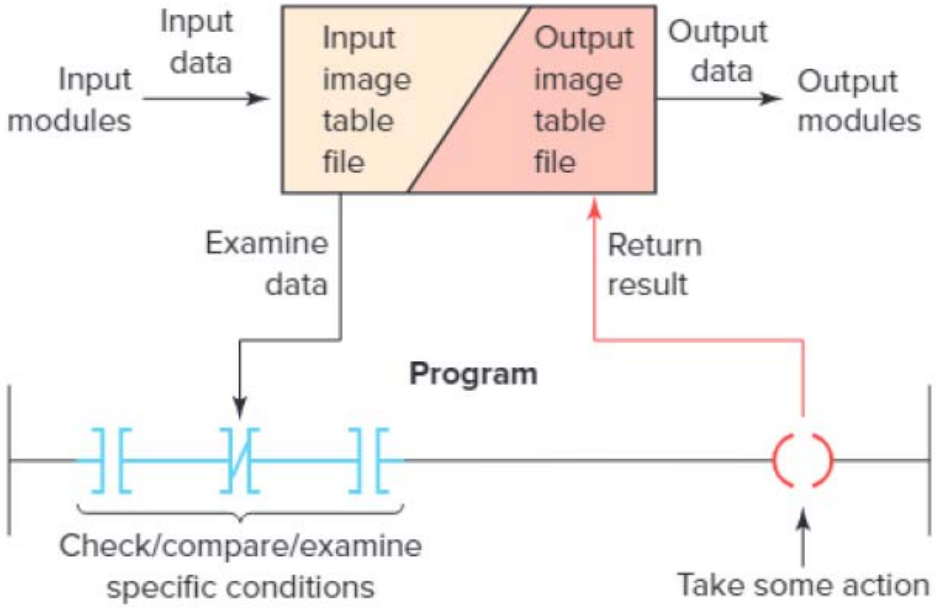
scan time is function of →

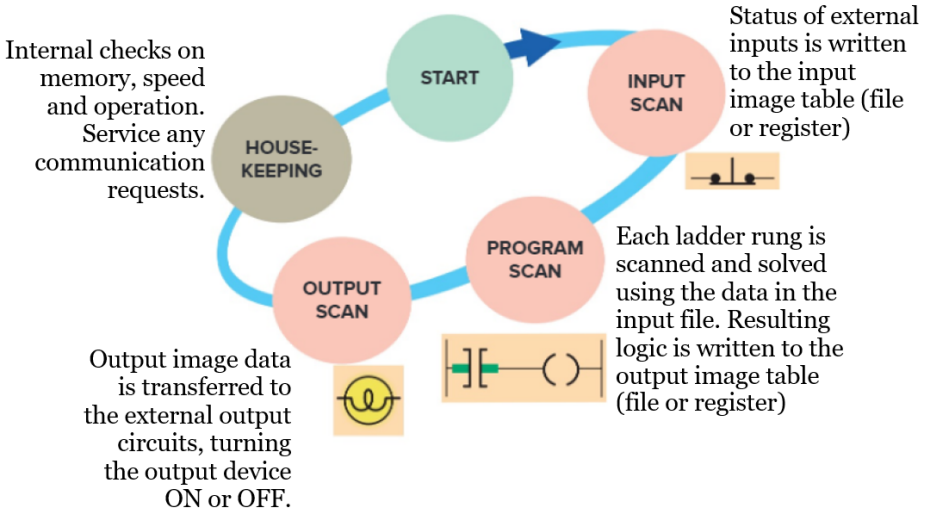
speed of processor module,
length and complexity of ladder program,
type of instructions executed,
number of I/O points.



Program Scan

Overview of data flow during scan process,
= Tasks of PLC processor for each rung execution →





Program Scan

Electrical continuity →

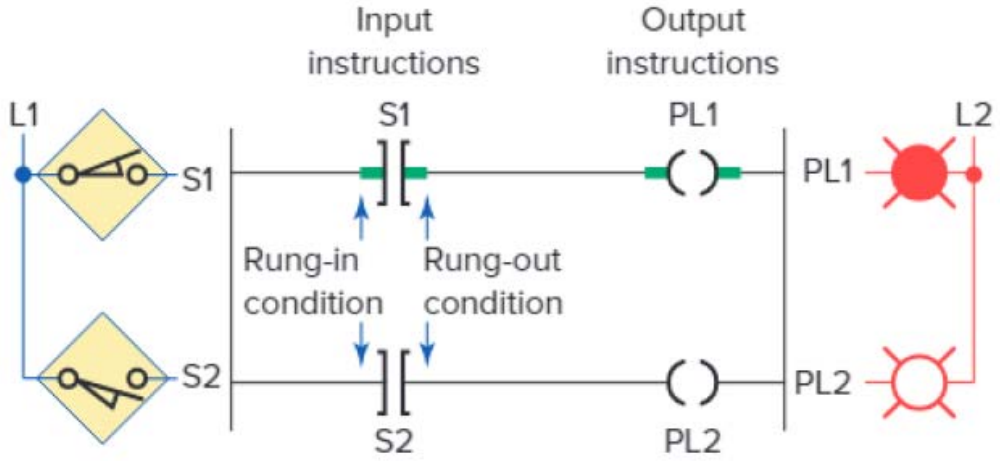
in rung of any hardwired circuit,
required for current to flow and energize load.

Logical continuity →

continuous path of true conditional instructions in rung.
required for output to turn status bit = 1 (ON).

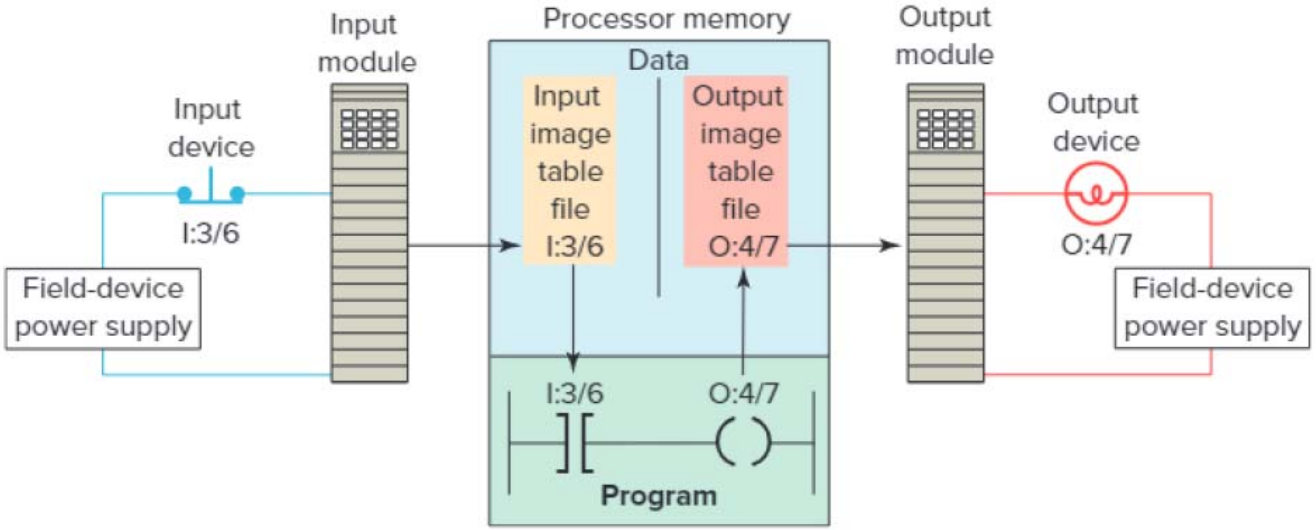
Evaluating ladder logic rung instructions →

controller evaluates instruction rung-condition-in,
sets rung-condition-out to match results of evaluation.



Program Scan

Scan process applied to single rung program →



Step	Action
1	Push button closes, voltage detected at I:3/6
2	Input Scan: I:3/6 bit set to 1 in Input Image Table
3	Program Scan: Evaluate rung, I:3/6 is TRUE
4	Logical continuity exists → set O:4/7 to 1 in Output Image Table

Step	Action	Result
5	Output Scan: Write 1 to O:4/7 terminal	Motor starter energizes
6	Button released → I:3/6 bit set to 0	
7	Next scan: I:3/6 is FALSE → O:4/7 set to 0	Motor turns OFF

Program Scan

Scan process applied to multiple rung program →

PLC processes rungs sequentially from top to bottom.

sense voltage of input terminals,

absence or presence of voltage →

0 or 1 is stored into memory bit location.

location → particular input terminal.

update Input Image Table (all inputs at once).

using input table values →

evaluate each rung in order.

write results to Output Image Table →

conditions controlling output are met =

writes 1 in its memory location,

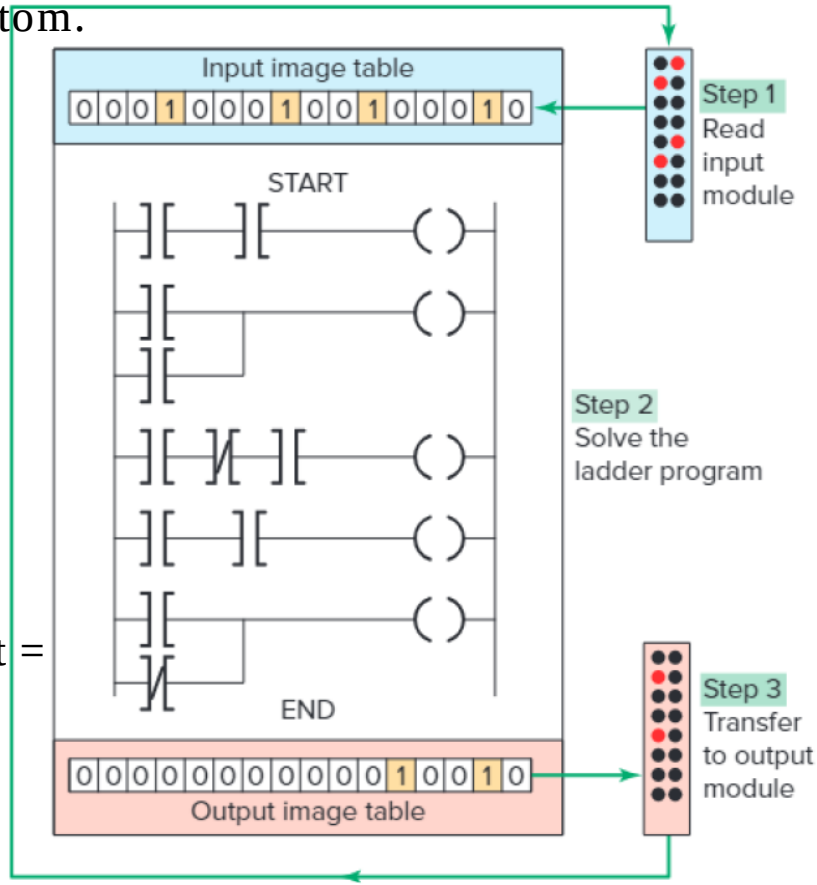
conditions controlling output are not met =

writes 0 in its memory location,

transfer output table results to output module →

update actual states of output devices,

= switching output devices ON (1) or OFF (0).



Program Scan

2 scan patterns to accomplish scan function →

1) horizontal scan by rung method →
processes each rung completely left-to-right
before moving to next rung

2) vertical scan by column method →
processes each column top-to-bottom,
page by page