Programmable Logic Controllers

PLC Basics

Operating systems and application programs

- A PLC contains a basic operating system that allows for:
  - Downloading and executing user (ladder logic) programs
  - Communicating with devices
    - I/O modules
    - Other PLCs on a network
  - Holding configuration data such as
    - Number and type of I/O modules present in the PLC system
    - Status information
Operating systems and application programs

- A PLC retains its operating system, user programs, and some data in retentive (nonvolatile) memory
  - While the PLC is off or is even disconnected from the power supply (given a battery backup)
- A PLC can then resume running a user program as soon as power is restored
  - The PLC may be programmed to require some operator action before resuming user program execution (for safety purposes)

User program execution

- A PLC executes an initialization step when placed in run mode, then repeatedly executes a scan cycle sequence
- The basic PLC scan cycle consists of three steps
  - An input scan
  - A user program scan
  - An output scan
- The total time for one complete program scan is a function of processor speed, I/O modules used, and length of user program
- Typically, hundreds of complete scans can take place in 1 second
**Input scan**

- During the input scan, data is taken from all input modules in the system and placed into an area of PLC memory referred to as the **input image area**.

**User program scan**

- During the program scan, data in the input image area is applied to the user program, the user program is executed and the output image area is updated.
Output scan

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

![Diagram of PLC and output modules]

PLC scanning considerations

- During the input scan, input terminals are read and the input image area is updated accordingly.
- During the program scan
  - data in the input image area is applied to the user program
  - the program is executed (instructions carried out in sequence)
  - the output image area is updated appropriately
- During the output scan, data associated with the output image area is transferred to output terminals.
**PLC scanning considerations**

- It is important to understand that the input, program, and output scans are separate, independent functions
  - Any changes in the status of input devices during the program or output scan are not recognized until the next input scan
- Furthermore, data changes in the output table are not transferred to the output terminals during the input and program scans
- The transfer affecting the output devices takes place only during the output scan

**PLC scanning considerations**

- With all PLCs, there are special processing considerations to note
- First, all PLCs take a specific amount of time to scan their operational programs completely
- Typically, the program scanning takes place left to right across each rung and from the top to bottom rungs, in order
- Usually, the complete ladder scan time is a few milliseconds
PLC scanning considerations

- Another scanning consideration involves proper operational sequencing of events
- An output might not go on immediately in sequence as it would in a relay logic system
- In a relay logic system, an event occurring anywhere in the ladder control system results in immediate action
- In a PLC ladder control diagram, however, no effect takes place until the rung is scanned
- In most cases, the PLC logic delay effect is inconsequential

PLC scanning considerations

- Program (ladder logic) scanning typically takes place left to right across each rung and from the top to bottom rungs, in order
  - Known as rung scanning, it is the method used, for example, by Allen-Bradley
- Another method, used by Modicon/Schneider Automation is known as column scanning
  - Here the processor "looks" at the first contact at the top left corner and reads the first column from top to bottom
  - It next reads the second column from top to bottom, and so on
- Either method, rung or column, is appropriate.
Rung scanning

Column scanning
Two-rung ladder logic program

- On switch
- Part sensor
- Paint empty
- Conveyor stopped
- Spray paint
- Operator alarm

Two-rung ladder logic program

- CPU
- Digital input module
- Digital output module
- Input Image
- User program
- Output image
- Alarm light
- Part sensor
- Spray painter
- Motor
- Paint level sensor
- Zero speed sensor
- Operator control switch
Example Program (In LogixPro Simulator)

[Diagram showing a control system with various components and states like On Switch, Fault Sensor, Spray Point, Freq Limry, Converter Stopped, Operator Alarm, etc.]

Example Program (In LogixPro Simulator)

[Image showing a LogixPro simulator interface with various simulation windows and settings.]
Example Program with Energized Inputs